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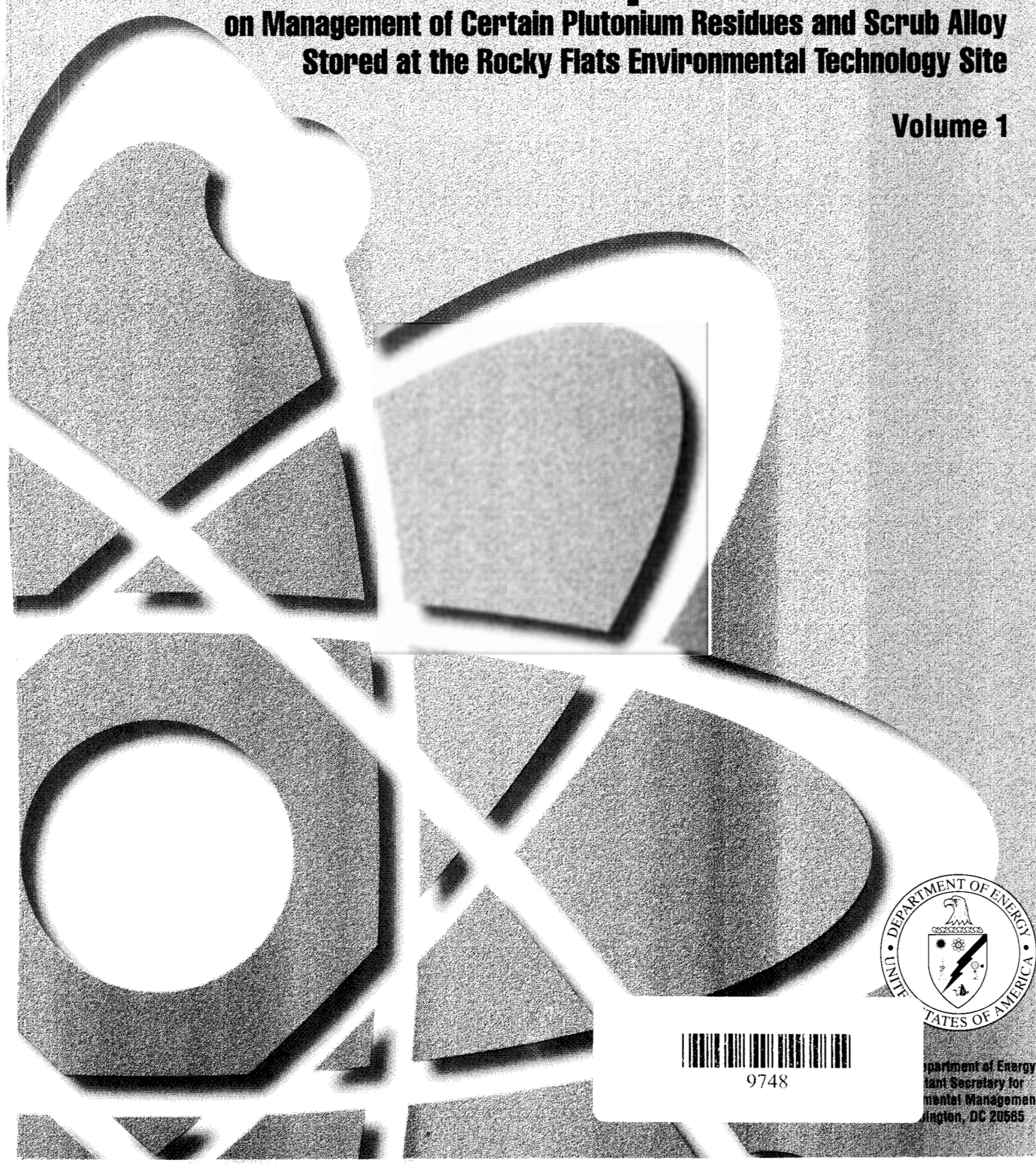
November 1997

Draft Environmental Impact Statement

on Management of Certain Plutonium Residues and Scrub Alloy Stored at the Rocky Flats Environmental Technology Site

Volume 1



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on Management of Certain Plutonium Residues and Scrub Alloy Stored at the Rocky Flats Environmental Technology Site

Volume 1

U.S. Department of Energy
Assistant Secretary for
Environmental Managemen
Washington, DC 20585

COVER SHEET

Responsible Agency: United States Department of Energy (DOE)

Title: Draft Environmental Impact Statement on Management of Certain Plutonium Residues and Scrub Alloy Stored at the Rocky Flats Environmental Technology Site

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Abstract: DOE proposes to process certain plutonium-bearing materials being stored at the Rocky Flats Environmental Technology Site (Rocky Flats) located near Golden, Colorado. These materials are plutonium residues and scrub alloy remaining from nuclear weapons manufacturing operations formerly conducted by DOE at this site. In their present forms, these materials cannot be disposed of or otherwise dispositioned because they contain plutonium in concentrations exceeding DOE safeguards termination requirements. Defense Nuclear Facilities Safety Board Recommendation 94-1 addressed health and safety concerns with the management of plutonium residues and scrub alloy at Rocky Flats. The proposed processing will address the concerns raised by the Board and also will prepare the plutonium residues and scrub alloy for disposal or other disposition.

DOE has identified and assessed three technical alternatives for processing these plutonium-bearing materials: (1) *No Action*, (2) *Processing without Plutonium Separation*, and (3) *Processing with Plutonium Separation*. Under the No Action Alternative, DOE would stabilize the materials for safe storage at Rocky Flats for the indefinite future or for disposal if safeguards termination limit variances can be applied. Under the Processing without Plutonium Separation Alternative, DOE would conduct more extensive operations at Rocky Flats to process the materials for disposal. Under the Processing with Plutonium Separation Alternative, DOE would remove most of the plutonium from the plutonium-bearing materials in preparation for disposal or other disposition. Rocky Flats, the Savannah River Site, and Los Alamos National Laboratory are the reasonable sites for processing with plutonium separation. Any plutonium resulting from separation processes would be placed in safe and secure storage pending disposition in accordance with decisions to be reached after completion of the Surplus Plutonium Disposition Environmental Impact Statement. The remaining material would be prepared for disposal.

Public Comment: Comments on this Draft EIS may be submitted through the end of the 45-day comment period, which will commence with the issuance of a Notice of Availability from the U.S. Environmental Protection Agency. Comments received after the end of the comment period will be considered to the extent practicable. Comments may be submitted in writing to DOE at the address indicated above. Oral or written comments may also be submitted at public meetings to be held during the comment period on dates and locations to be announced in the *Federal Register* and via other public media shortly after issuance of the Draft EIS. All comments will be considered in the preparation of the Final EIS.

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Acronyms and Abbreviations

ACRONYMS AND ABBREVIATIONS

Acronyms and Abbreviations

Board	Defense Nuclear Facilities Safety Board
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
IDC	Item Description Code
NEPA	National Environmental Policy Act
NRC	Nuclear Regulatory Commission
Rocky Flats	Rocky Flats Environmental Technology Site
WIPP	Waste Isolation Pilot Plant

Chemicals and Units of Measure

ac	acre
Al/NO_3	aluminum nitrate
BTU	British thermal unit
Ci	curie
cm	centimeter
Co	carbon monoxide
ft	foot
g	gram
gal	gallon
ha	hectare
HAN	hydroxylamine nitrate
hr	hour
in	inch
kg	kilogram
km	kilometer
km/sec	kilometers per second
KOH	potassium hydroxide
kW	kilowatt
L	liter
lb	pound
m	meter
m/s	meters per second
M	molar
mg	milligram
mi	mile
mi/sec	miles per second
min	minute
mm	millimeter
mph	miles per hour
mrem	millirem
MWe	megawatts electric
MWh	megawatt hours
n	neutron
nCi	nanocuries
oz	ounce
Pb	lead
ppm	parts per million
rad	radiation absorbed dose
yd	yard
yr	year
°C	degrees Celsius
°F	degrees Fahrenheit

Chapter 1

Introduction

1. INTRODUCTION

During the Cold War, the United States Department of Energy (DOE) conducted various activities associated with the production of materials for use in nuclear weapons. Several intermediate products and wastes were generated as a result of those operations, some of which are still in storage at various DOE sites. Now that the Cold War is over and the United States has ceased production of nuclear weapons materials, DOE is conducting activities to safely manage, clean up, and dispose of (where appropriate) those intermediate products and wastes. Among the intermediate products and wastes requiring proper management and preparation for disposal or other disposition are plutonium residues and scrub alloy currently stored at the Rocky Flats Environmental Technology Site (Rocky Flats)[1] near Golden, Colorado. This Environmental Impact Statement (EIS) evaluates the potential environmental impacts associated with reasonable alternatives for management of certain of the Rocky Flats plutonium residues and scrub alloy that require additional processing to allow disposal or other disposition of the material in a manner that complies with applicable laws and national security requirements.

1.1 BACKGROUND

Plutonium residues and scrub alloy were generated during recovery and purification of plutonium and manufacture of components for nuclear weapons. Approximately 125,000 kilograms (kg) (275,600 pounds [lb]) of residues (containing about 5,800 kg [12,800 lb] of plutonium) and approximately 700 kg (1,540 lb) of scrub alloy (containing about 200 kg [440 lb] of plutonium) are currently stored at various DOE sites. Of these totals, approximately 106,600 kg (235,000 lb) of the residues (containing about 3,000 kg [6,600 lb] of plutonium) and almost all of the scrub alloy are stored in various types of containers in 6 former plutonium production facilities at Rocky Flats and will be discussed in this EIS. The remaining approximately 18,400 kg (40,600 lb) of plutonium residues are stored at the Savannah River Site, Hanford Site, Los Alamos National Laboratory, and Lawrence Livermore National Laboratory. Approximately 6 kg (13 lb) of scrub alloy are stored at the Savannah River Site. Stabilization activities for the approximately 18,400 kg (40,600 lb) of plutonium residues and 6 kg (13 lb) of scrub alloy not located at Rocky Flats are analyzed in National Environmental Policy Act (NEPA) reviews that have already been completed or are currently underway. These reviews are listed and summarized in Section 1.6 of this EIS, "Relationship to Other NEPA Documents and Reports." The final approximately 5 kg (11 lb) of plutonium residues are located at several DOE sites, each having an inventory of less than 1 kg (2.2 lb). Processing options for these plutonium residues have been identified or are in the process of being defined by the management of the installations at which these residues are stored.

The plutonium residues at Rocky Flats that require further processing prior to disposal or other disposition consist of four broad categories that were described in the *Environmental Assessment, Finding of No Significant Impact, and Response to Comments—Solid Residue Treatment, Repackaging, and Storage* (the "Solid Residue Environmental Assessment," DOE 1996g): ash, salts, wet residues, and direct repackage residues. The residues were grouped into these categories due to chemical similarities or similarities in the manner in which they could be managed. The approximate quantities in each residue category and scrub alloy

[1]*Rocky Flats was previously known as the "Rocky Flats Plant" while it was being used to produce components for nuclear weapons.*

inventory requiring further processing to meet the requirements for disposal or other disposition are noted[2] and summarized in **Table 1–1**.

Table 1–1 Amounts of Plutonium Residues Categories and Scrub Alloy Inventory Covered under this EIS

Category	*Inventory, kg (lb)*	*Plutonium Content, kg (lb)*
Ash Residues include incinerator ash and firebrick fines; sand, slag, and crucible; graphite fines; and inorganic ash residues.	20,060 (44,200)	1,160 (2,560)
Salt Residues include molten salt extraction salt residues, electrorefining salt residues, and direct oxide reduction salt residues.	14,900 (32,800)	1,000 (2,200)
Wet Residues include wet combustible residues, plutonium fluoride residues, filter media, Raschig rings, sludges, and greases/oily sludges.	4,300 (9,500)	290 (640)
Direct Repackage Residues include dry combustible residues, glass residues, miscellaneous residues, and graphite and firebrick.	2,900 (6,400)	130 (290)
Scrub Alloy	700 (1,540)	200 (440)

1.2 Purpose and Need for Agency Action

The purpose and need for agency action is to process certain plutonium residues and scrub alloy currently in storage at Rocky Flats to address health and safety concerns raised by the Defense Nuclear Facilities Safety Board (the Board) in Recommendation 94-1 and to prepare the materials for offsite disposal or other disposition. These actions should be taken in a manner that supports site closure and limits worker exposure and waste production. The Rocky Flats Solid Residues Environmental Assessment (DOE 1996g) addressed the potential environmental impacts associated with stabilizing the entire 106,600-kg (235,000-lb) inventory of Rocky Flats plutonium residues to allow its safe storage until final disposition of the residues could be decided on and implemented. Because of the need for expeditious action to resolve concerns with storage of the plutonium residues at Rocky Flats, the Solid Residues Environmental Assessment did not address either disposal or other disposition of the residues after these materials were stabilized, or stabilization of the scrub alloy. Furthermore, although stabilization activities to mitigate the risks associated with the current storage condition of the plutonium residues are in progress at Rocky Flats based on the Solid Residues Environmental Assessment, less than 1 percent of the Rocky Flats plutonium residues addressed in this EIS and none of the scrub alloy have been stabilized to date. Accordingly, DOE considers it prudent to consider in this EIS processing alternatives that not only would stabilize the remaining plutonium residues to address the health and safety concerns raised by Board Recommendation 94-1 but also would convert them into forms that would allow for their disposal or other disposition. Issues related to potential disposal of transuranic waste at the Waste Isolation Pilot Plant (WIPP) are the subject of a separate NEPA process in the *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement* (DOE 1997a).

In the process of considering disposal options for the Rocky Flats plutonium residues and scrub alloy, DOE determined that, even after stabilization as discussed in the Solid Residues Environmental Assessment, approximately 42,200 kg (93,000 lb) out of the total 106,600 kg (235,000 lb) of plutonium residues currently stored at Rocky Flats cannot be disposed of or dispositioned because these residues contain plutonium

[2]*As noted previously, a total of approximately 106,600 kg (235,000 lb) of plutonium residues is currently in storage at Rocky Flats. Of this total, approximately 6,600 kg (14,550 lb) is in a residue category designated "Classified Shapes" that does not require processing beyond that analyzed in the Solid Residue Environmental Assessment. This leaves approximately 100,000 kg (220,000 lb) of residues in other categories, a portion of which will need additional processing beyond that analyzed in the Solid Residue Environmental Assessment. This approximately 100,000 kg (220,000 lb) of residues is distributed among the residue categories listed in the first 4 rows of Table 1-1. The scrub alloy discussed in the fifth row of Table 1-1 is not a plutonium residue and, therefore, is not included in the 100,000 kg (220,000 lb) residue total.*

concentrations exceeding DOE safeguards termination requirements for disposal at WIPP.[3] Although these plutonium residues would not be directly usable in nuclear weapons, they would remain in forms containing concentrations of plutonium too high to meet disposal criteria.

The term "safeguards" refers to those measures (e.g., recordkeeping, monitoring, and physical protection) that DOE and other organizations holding nuclear materials must take to ensure that the materials are not stolen or diverted for illicit purposes. The safeguards requirements that are applicable to nuclear materials held by DOE are specified in DOE Order 5633.3B, "Control and Accountability of Nuclear Materials" (DOE 1994c). The term "safeguards termination requirements" refers to those steps that must be taken, or conditions that must exist, before nuclear materials are rendered sufficiently unattractive as a source of fissile material for illicit purposes and may be exempted from further safeguards controls.[4]

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[3]DOE is evaluating WIPP as a potential disposal facility for transuranic wastes. Plutonium residues and scrub alloy and some of the wastes from their processing could be disposed of as transuranic waste, although disposal of transuranic waste generated from processing scrub alloy would require additional NEPA review because the scrub alloy was not included in previous baseline estimates. The process options being considered could result in several material categories subject to different disposal or other disposition options: plutonium oxide, transuranic waste, and low-level waste. Disposal of the transuranic waste is planned at WIPP, so the transuranic waste will be processed to meet WIPP waste acceptance criteria. DOE is evaluating other plutonium disposition options that would be relevant if the materials considered were processed to separate the plutonium from the other constituents of the residues and scrub alloy. Such potential disposition options include using the plutonium in mixed oxide fuel for power reactors and encapsulation of the plutonium in canisters of vitrified high-level radioactive waste which could be disposed of in a deep geologic repository. In this EIS "disposal requirements" for the plutonium residues and scrub alloy refers to the waste acceptance criteria for WIPP that would be applicable should DOE decide to open WIPP for transuranic waste disposal, and any other requirements that must be met to allow disposal in WIPP, such as safeguards termination requirements.

DOE is evaluating plutonium disposition options for the plutonium oxide which could be separated from residues or scrub alloy. "Requirements for disposition options" are being developed as part of detailed NEPA analyses that will be tiered from the "Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement" (DOE 1996a) (see Section 1.6.6).

[4]Although WIPP is being designed to incorporate security provisions appropriate to its function (which includes disposal of materials containing small amounts of plutonium), it is not expected to be capable of meeting nuclear material safeguards requirements. As a result, action must be taken to allow safeguards requirements to be satisfied before any plutonium residue could be disposed of in WIPP. There are two approaches that could be taken to satisfy the safeguards requirements:

- *The materials could be processed as described below (DOE 1994c, DOE 1996e, and DOE 1996d):*
  - *The concentration of plutonium, or other fissile elements, in the material must be very low (e.g., ≤ 0.1 weight percent). Many of the Rocky Flats residues (e.g., the approximately 64,300 kg [141,800 lb]) could be shipped to WIPP after completion of the stabilization processes discussed in the Solid Residue Environmental Assessment because they contain so little plutonium that they already meet the safeguards termination limits. Other residue materials could be processed by either diluting the residues with materials that are similar, or by removing some or all of the plutonium.*
  - *For materials with somewhat higher but still small (i.e., up to 10 weight percent) concentrations of plutonium or other fissile elements (e.g., U-233 and U-235), the material could be immobilized by converting it into a glass or ceramic form, from which it would be very difficult to extract the plutonium or other fissile elements.*
- *In special cases involving materials with very low concentrations of plutonium (such as a portion of the plutonium residues discussed in this EIS) and extenuating circumstances (such as other security requirements in effect and limitations on the amounts or forms of the materials present in accessible locations at any one time), variances from the safeguards termination requirements could be applied. Although such an approach is unlikely to be feasible for any of the Rocky Flats scrub alloy, it might be feasible for some portions of the plutonium residues. Variances for plutonium residues would make it possible to dispose of the affected*

(continued...)

For over 40 years, the United States has supported international efforts to prevent the spread of nuclear weapons to states that do not already have them. Although the cold war has ended, national support for the nonproliferation of nuclear weapons remains undiminished. As one of its fundamental nonproliferation strategies, the United States seeks to prevent the unauthorized acquisition of materials, such as plutonium, that could be used to manufacture nuclear weapons. United States efforts to prevent unauthorized access to plutonium are based on long-standing national policies as well as on our obligations under the Nuclear Nonproliferation Treaty and the Treaty on the Physical Protection of Nuclear Material. DOE is in the process of preparing a study on the nonproliferation implications of various management alternatives, including chemical separation, for spent nuclear fuel. DOE expects to complete this study by the Spring of 1998. Findings of the study could be relevant to decisions to be made regarding the processing of materials considered in this EIS. Plutonium residues and scrub alloy currently stored at Rocky Flats are among those materials that must be protected from unauthorized acquisition by individuals and organizations attempting to develop nuclear weapons.

The concentration of plutonium in approximately 42,200 kg (93,000 lb) of Rocky Flats residues is such that these residues could be attractive for theft as a source of plutonium (about 2,600 kg [5,700 lb]) for use in nuclear weapons or other terrorist devices. Similar concerns exist for the 700 kg (1,540 lb) of scrub alloy containing nearly 200 kg (440 lb) of plutonium currently in storage at Rocky Flats. Diluting these materials could reduce the plutonium concentration sufficiently to meet safeguards termination requirements, but probably would yield a very large waste volume that would be very costly to transport and dispose of. Dilution would also lead to a relatively higher personnel radiation exposure due to additional radiation doses from the dust during packaging, handling, and mixing operations and the additional handling of the resulting larger volume of diluted material. Processing alternatives that would either immobilize the plutonium in a matrix from which it would be difficult to extract or processes that would separate the plutonium from the remaining constituents of the residues and scrub alloy are analyzed in this EIS[5]. The activities discussed in the Solid Residue Environmental Assessment will meet waste disposal requirements for the other approximately 65,000 kg (143,000 lb) of plutonium-bearing residues currently in storage at Rocky Flats and will not be addressed in this EIS.

1.3 SCOPING PROCESS

The preliminary scope of this EIS (see Section 1.4) was specified in the *Federal Register* Notice (see Appendix A) announcing DOE's intent to prepare the EIS (DOE 1996b). This Notice of Intent also announced a 30-day public scoping period (from November 19, 1996, through December 19, 1996) during which the public was invited to submit comments on the preliminary scope. During the scoping period, DOE held two scoping meetings (one on December 3, 1996, near Rocky Flats and one on December 12, 1996, near the Savannah River Site in North Augusta, South Carolina). DOE also received written comments submitted by the public through letters and electronic mail.

DOE received comments from approximately 30 individuals and organizations as part of the scoping process. About half of the public comments received were from individuals and organizations in the Rocky Flats area and half were from individuals in the Savannah River Site area. A few were from national organizations, such

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(...continued)

residues in WIPP without further processing or stabilization beyond that analyzed in the Rocky Flats Solid Residue Environmental Assessment (DOE 1996g).

[5]*Any plutonium separated from residues and scrub alloy would be stored pending disposition in compliance with decisions to be made after completion of the Surplus Plutonium Disposition EIS described in a Notice of Intent issued on May 22, 1997 (DOE 1997c). During storage, any separated plutonium would be protected through use of the same safeguards and security measures being used to protect the much larger amount of plutonium already in DOE's inventory. In accordance with existing DOE policy, any plutonium separated under this EIS would not be used in nuclear explosives (DOE 1994a).*

as the Natural Resources Defense Council and the Military Production Network. In the Rocky Flats area, comments were received (both orally at the public scoping meeting and in writing) from individual citizens and a coalition of organizations concerned with Rocky Flats. These organizations included:

- American Friends Service Committee
- Colorado Coalition for the Prevention of Nuclear War
- Colorado Peace Action
- Greenpeace
- Physicians for Social Responsibility
- Rocky Mountain Peace and Justice Center.

In the Savannah River Site area, comments were received (both orally at the public scoping meeting and in writing) from individual citizens and the Site's Citizens Advisory Board.

Comments were received on management alternatives, as well as on storage; safeguards and proliferation; disposal or other disposition; transportation; environmental, health, and safety issues; and costs. Key comments on the management alternatives include the following:

- **No Action**—Very few commentors supported the No Action Alternative as described in the Notice of Intent, i.e., maintenance of the "status quo" at Rocky Flats. Evaluation of the No Action Alternative is required by 40 CFR 1502.14 (Council on Environmental Quality's NEPA regulations) and is analyzed in this EIS.

- **Processing without Plutonium Separation**—Commentors from the Rocky Flats area were split, with some supporting onsite processing of the residues and scrub alloy at Rocky Flats and some supporting offsite processing to remove the materials from the site in accordance with DOE's commitments regarding cleanup of Rocky Flats. Several organizations supported vitrification, as long as the resulting form of the residues provides sufficient safeguards against theft or diversion.

- **Processing with Plutonium Separation**—Commentors were split on this processing alternative, with most of the Savannah River Site area commentors supporting this option and calling for the processing to be performed at the Savannah River Site. Commentors suggested that the Savannah River Site is the only DOE site that has the necessary experience, knowledge, technology, people, and facilities. Other commentors, including several organizations, were strongly opposed to separation of the plutonium due to concerns about increased proliferation risk.

Discussion of issues raised during the scoping process but not analyzed in detail is contained in Section 2.9.3. The scope of the EIS was determined after consideration of all of the comments, both written and oral, received during the public scoping process.

1.4 SCOPE OF THE EIS

This EIS will evaluate technical alternatives and strategic approaches for management of approximately 42,200 kg (93,000 lb) of plutonium residues containing approximately 2,600 kg (5,700 lb) of plutonium. Three technical alternatives will be evaluated for the processing of each category of residue: (1) no action, (2) processing without plutonium separation, and (3) processing with plutonium separation. The objective is to process the material to a form and concentration that is suitable for disposal or other disposition. Management decisions regarding these materials will be integrated with stabilization decisions resulting from the Solid Residue Environmental Assessment (DOE 1996g). Implementation of these decisions is expected to minimize the need to handle these materials, thereby reducing worker risk and costs associated with achieving a material form suitable for disposal or other disposition.

This EIS will also evaluate management alternatives for approximately 700 kg (1,540 lb) of scrub alloy currently in storage at Rocky Flats (containing about 200 kg [440 lb] of plutonium) to facilitate its disposal or other disposition.

1.5 DECISIONS TO BE MADE BASED ON THIS EIS

To ensure that the plutonium residues and scrub alloy addressed in this EIS are properly prepared for disposal or other disposition and are stored safely before their disposal or other disposition, the following decisions must be made:

- Whether any processing of the plutonium residues and scrub alloy should occur, and if so:
  - How much of the plutonium residues and scrub alloy should be processed.
  - What processing approach should be used for each plutonium residue category and for the scrub alloy.
- Where processing and any subsequent management of the plutonium residues and scrub alloy should occur. Different sites could possibly be chosen for management of different residues and the scrub alloy, or even for different portions of a single residue category if differences in the weight percent plutonium contained in a portion of a residue category, or other detailed differences in the residue chemistry, make such distinctions desirable. (This will include consideration of whether various portions of the plutonium residues and scrub alloy should be processed through DOE's existing chemical separation facilities at the Savannah River Site.)

1.6 RELATIONSHIP TO OTHER NEPA DOCUMENTS AND REPORTS

Completed and ongoing NEPA documents and other reports that may relate to the scope of this EIS include the following:

1.6.1 Environmental Assessment, Finding of No Significant Impact, and Response to Comments—Solid Residue Treatment, Repackaging, and Storage (DOE 1996g, January 1996)

This Environmental Assessment addressed the stabilization of the plutonium residue inventory currently at Rocky Flats. The actions analyzed and selected after the completion of this Environmental Assessment are included in the No Action Alternative.

1.6.2 Rocky Flats Site-Wide Environmental Impact Statement Notice of Intent (DOE 1993c, August 5, 1994)

This Notice announced DOE's intention to prepare a Site-Wide EIS for Rocky Flats. The Notice described the intended scope of the Site-Wide EIS as providing a basis for selection of a site-wide strategic approach for nuclear materials storage, waste management, cleanup, and economic conversion, as well as project-level decisions for management of nuclear materials, deactivation of Rocky Flats facilities, and decontamination and decommissioning of existing facilities. DOE has decided not to complete the Site-Wide EIS because the mission of the site has changed to clean up in preparation for closure and the environmental review for the cleanup will occur under the Comprehensive, Environmental Response, Compensation, and Liability Act.

1.6.3 Interim Storage of Plutonium at the Rocky Flats Environmental Technology Site Environmental Impact Statement Notice of Intent (DOE 1996f, July 1996)

This Notice announced DOE's intention to prepare an EIS to evaluate the alternatives for providing safe interim storage of approximately 10 metric tons (11 tons) of plutonium at Rocky Flats pending implementation of decisions based on the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996a). DOE has decided not to complete the Interim Storage EIS because of the decisions announced in the Record of Decision for the Storage and Disposition Programmatic Environmental Impacts Statement (see discussion below).

1.6.4 Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement (DOE 1997a, September 1997)

This is the second supplemental EIS for WIPP, a DOE waste isolation pilot project that is proposed for the disposal of transuranic wastes. In the Record of Decision for the 1990 Supplemental EIS (DOE 1990), DOE indicated it would issue a second supplemental EIS analyzing the impacts of processing and handling transuranic waste at the generator/storage sites and the long-term performance of WIPP before deciding whether to proceed to the WIPP disposal phase. DOE's proposed action is to dispose of transuranic waste at the facility. The Rocky Flats plutonium residues are considered in the scope of the 1997 Supplemental EIS (DOE 1997a) although the wastes from processing the scrub alloy are not. The Record of Decision is scheduled to be issued in November 1997.

1.6.5 Waste Management Programmatic Environmental Impact Statement (DOE 1997d, May 1997)

The Waste Management Programmatic EIS considered reasonable alternatives for the integrated treatment, storage, and/or disposal of DOE's low-level, low-level mixed, hazardous, transuranic, and high-level waste. The entire inventory of plutonium residues currently stored at Rocky Flats is included in the Waste Management Programmatic EIS under the assumption that it may be managed as transuranic waste. The Waste Management Programmatic EIS analyzes storage and treatment configurations (i.e., centralized, regionalized, and decentralized treatment and storage), including DOE's preferred strategies, for transuranic wastes, including the Rocky Flats plutonium residues. The Rocky Flats Plutonium Residues and Scrub Alloy EIS is being prepared in coordination with the Waste Management Programmatic EIS and applicable Records of Decision.

1.6.6 Surplus Plutonium Disposition Environmental Impact Statement Notice of Intent (DOE 1997c, May 22, 1997)

This Notice announced DOE's intention to prepare an EIS on the disposition of U.S. weapons-usable surplus plutonium. This EIS is tiered from the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996a) issued on January 14, 1997 (DOE 1997f). This Record of Decision (62 *Federal Register* 3014) announced DOE's intention to provide for safe and secure storage of weapons-usable fissile materials and DOE's strategy for disposition of surplus weapons-usable plutonium. The Record of Decision also indicated that plutonium metals and oxides currently stored at Rocky Flats would be moved. The plutonium pits (a nuclear weapons component) would be stored at the Pantex site. The non-pit metals and oxides would be moved to the Savannah River Site for storage if DOE decided that these materials would be immobilized at the Defense Waste Processing Facility at the Savannah River Site.

1.6.7 Final Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory (DOE 1992, August 1992)

This EIS analyzed the potential environmental impacts of the continued operation of Lawrence Livermore National Laboratory and Sandia National Laboratories in Livermore, California. The Lawrence Livermore

National Laboratory Site-Wide EIS also analyzed the potential environmental impacts associated with a No Action Alternative to continue operations at FY 1992 funding levels without further growth, an alternative to modify operations to reduce adverse environmental impacts of operations or facilities, and an alternative involving the shutdown and commencement of decommissioning of the Laboratory. The Record of Decision for the Lawrence Livermore National Laboratory Site-Wide EIS (DOE 1993) announced that DOE had decided to continue the operation of Lawrence Livermore National Laboratory and Sandia National Laboratories. Alternatives analyzed in the Rocky Flats Plutonium Residues and Scrub Alloy EIS that involve treatment of the Rocky Flats plutonium residues at Lawrence Livermore National Laboratory were not analyzed in the Lawrence Livermore National Laboratory Site-Wide EIS.

1.6.8 Site-Wide Environmental Impact Statement Los Alamos National Laboratory, Notice of Intent (DOE 1995c, May 12, 1995)

The Los Alamos National Laboratory Site-Wide EIS will address planned operations and activities at the Los Alamos National Laboratory in the next 5 to 10 years. Alternatives analyzed in the Rocky Flats Plutonium Residues and Scrub Alloy EIS that involve processing of the Rocky Flats plutonium residues at Los Alamos National Laboratory will be coordinated with the Los Alamos National Laboratory Site-Wide EIS.

1.6.9 Final Interim Management of Nuclear Materials Environmental Impact Statement (DOE 1995b, October 1995)

The Interim Management of Nuclear Materials EIS addresses the potential environmental impacts associated with alternatives for the management of a variety of nuclear materials at the Savannah River Site. This EIS also includes an evaluation of alternatives for processing approximately 1,000 kg (2,200 lb) of plutonium residues and scrub alloy currently stored at the Savannah River Site (see *Final Environmental Impact Statement, Interim Management of Nuclear Materials, Savannah River Site, Aiken, South Carolina,* Section 2.3.3, "Plutonium and Uranium Stored in Vaults"), much of which originated at Rocky Flats. Four Records of Decision, each covering different materials, have been issued for the Interim Management of Nuclear Materials EIS (DOE 1995a, DOE 1996h, DOE 1996c, and DOE 1997e). DOE decided to use a variety of technologies to stabilize these residues (repackage and heat treat, dissolve and stabilize) through the Canyon facilities to forms that meet DOE's storage criteria (DOE-STD-3013-94) (DOE 1994b) and to store the plutonium at the Savannah River Site (DOE 1995a).

1.6.10 Discussion Draft of Accelerating Cleanup: Focus on 2006 (DOE 1997b, June 1997)

DOE's Office of Environmental Management is developing a strategy to accelerate site cleanup and to reduce long-term economic and environmental liabilities associated with the cleanup of sites and facilities no longer needed by the Department. The particular focus of this effort is on completing work at as many sites as possible by 2006. The *Discussion Draft Accelerating Cleanup: Focus on 2006*, the "2006 Plan," was issued for public review and comment in June 1997 (DOE/EM-0327). The 2006 Plan is designed to give Tribal Nations, states, regulators, and other stakeholders an opportunity to participate in the development of the Environmental Management program, including helping to define innovative approaches to streamline cleanup and to save taxpayer dollars. The 2006 Plan is not a decision-making document. Decisions on proposed actions to carry out the Environmental Management program, whether the actions are site-specific or national in scope, will be reported in the 2006 Plan. Appropriate NEPA reviews, such as preparation of this EIS, will be conducted prior to making any such decisions. The Office of Environmental Management's strategic goal of accomplishing as much work as possible by 2006 will be one of the factors that will influence decisions being evaluated in this EIS. Subsequent versions of the 2006 Plan will reflect the decisions made as a result of this EIS.

1.7 STRUCTURE OF THIS EIS

The remainder of this EIS is structured as follows:

- Chapter 2 describes the proposed action, alternatives for implementation of the proposed action, and a No Action Alternative.
- Chapter 3 describes the potentially affected environments at the sites that may be involved in implementation of the alternatives for management of the Rocky Flats plutonium residues and scrub alloy.
- Chapter 4 addresses the policy considerations and potential environmental impacts of the No Action Alternative and of each alternative for implementation of the proposed action.
- Chapter 5 describes the regulations governing radioactive materials applicable to actions that DOE might take under this EIS.
- Chapters 6, 7, and 8 contain reference information (i.e., the List of Preparers, Agencies Consulted, and Glossary, respectively).
- The appendices to this document present descriptions of reference technologies, and details and assumptions of the evaluations and analyses performed for this EIS. Appendix A includes the contractor's NEPA disclosure statement for preparation of the EIS.

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Chapter 2

Alternatives

2. ALTERNATIVES

2.1 OVERVIEW OF THE ALTERNATIVES

The U.S. Department of Energy (DOE) proposes to process certain plutonium residues and scrub alloy at the Rocky Flats Environmental Technology Site (Rocky Flats) that have plutonium concentrations above safeguards termination limits (defined in box below). The Defense Nuclear Facilities Safety Board (the Board), in Recommendation 94-1 (DNFSB 1994), addressed health and safety concerns regarding various materials at Rocky Flats, including plutonium residues and scrub alloy. The Board concluded that hazards could arise from continued storage of these materials in their current form and recommended that they be stabilized. Although stabilization of the plutonium residues was addressed in the Rocky Flats Solid Residues Environmental Assessment (DOE 1996j), the processing analyzed in the Environmental Assessment would leave approximately 40 percent of the Rocky Flats plutonium residues (i.e., the plutonium residues covered by this Environmental Impact Statement [EIS]) in a form that could not be disposed of and that did not address stabilization of the scrub alloy. Since less than 1 percent of these Rocky Flats plutonium residues and none of the scrub alloy have been stabilized to date using the processes analyzed in the Rocky Flats Solid Residues Environmental Assessment, DOE considers it prudent to consider in this EIS processing alternatives that not only would stabilize the remaining plutonium residues to address the health and safety concerns raised by Board Recommendation 94-1 but also would convert these residues into forms that would allow for their disposal or other disposition.

The plutonium residues and scrub alloy have been grouped into categories and subcategories that require similar processing technologies. Due to significant differences in the chemical and physical characteristics of the material in the various categories, and in the methods required for processing them, DOE proposes to make processing decisions on each subcategory rather than on all of the materials in a category. The processing technologies being considered for each category are discussed in Sections 2.4.1 through 2.4.10 and in more detail in Appendix C. The environmental impacts from these alternatives are presented in Chapter 4 of this EIS.

The alternatives considered for this EIS are organized as follows:

- **Alternative 1 – The No Action Alternative—** Stabilize and repackage plutonium residues to prepare the material for interim storage as described in the *Environmental Assessment, Finding of No Significant Impact, and Response to Comments--Solid Residue Treatment, Repackaging, and Storage* (DOE 1996j), (the "Solid Residue Environmental Assessment"). Scrub alloy was not addressed in the Environmental Assessment. The No Action

Safeguards Termination Limits

"Safeguards" are part of the process of ensuring that unauthorized persons or organizations do not obtain materials (e.g., uranium or, for this EIS, plutonium) that could be used to manufacture nuclear weapons. Safeguards termination limits are limits on the maximum concentration of plutonium that may exist in a material without causing the material to be subject to the strict material control and accountability requirements applied under "safeguards" requirements. These concentration limits are established based on a determination of how low the plutonium concentration must be for any given material form to make the material unattractive as a source of plutonium. DOE granted a variance to the safeguards termination limits for certain residues when evaluations demonstrated that the proposed processing method for the material, the controls in place for normal handling of transuranic waste, and the limited quantity of special nuclear material present in any particular place and time preclude the need to take additional measures to address threats of diversion and theft. When safeguards termination limits variances are given, the residue material is no longer subject to strict material control and accountability as special nuclear material. The materials, however, are still controlled and guarded based on DOE's management practices and physical security procedures.

Alternative for scrub alloy is defined as continued storage at Rocky Flats with repackaging, as necessary. All of the activities discussed under Alternative 1 would be performed at Rocky Flats.

Subsequent to the publication of the Notice of Intent to prepare this EIS, DOE determined that the threats of diversion and theft for some of the residues covered in the EIS were sufficiently low that processing beyond stabilization would not be required. Accordingly, DOE granted a variance to the safeguards termination limits requirement for these materials. They would be stabilized as described in this EIS under the No Action Alternative but rather than being placed in interim storage at Rocky Flats pending further processing, the stabilized residues would be sent to the Waste Isolation Pilot Plant (WIPP). The residues receiving safeguards termination limit variances are identified in the appropriate subsections of Section 2.4 and in Section 2.5.2.

- **Alternative 2 – Process without Plutonium Separation**—Processes that convert the material (including scrub alloy) into a form that meets safeguards termination limits for disposal at WIPP without removing plutonium from the material. All of the activities discussed under Alternative 2 would be performed at Rocky Flats.

- **Alternative 3 – Process with Plutonium Separation**—Processes that separate plutonium from the material and concentrate it so that the secondary waste meets the safeguards termination limits for disposal at WIPP while the separated and concentrated plutonium is placed in safe and secure storage pending disposition by immobilization or conversion to mixed oxide fuel in accordance with decisions reached under the Surplus Plutonium Disposition EIS (DOE 1997b). The processing and storage activities under Alternative 3 could be performed at Rocky Flats or at other DOE sites.

For this EIS, the "proposed action" is to process the plutonium residues and scrub alloy to prepare them for disposal as transuranic waste or for other disposition. The proposed action could be accomplished by either Alternative 2 or Alternative 3, or by some combination of those alternatives.

DOE initially considered processing for all of the plutonium residue categories and scrub alloy at Rocky Flats, the Savannah River Site, Los Alamos National Laboratory and the Lawrence Livermore National Laboratory. However, after conducting the alternative technology screening and evaluation process implemented for this EIS, DOE determined that the two national laboratories have constraints that either precluded further consideration (Lawrence Livermore National Laboratory) or limit consideration to only two processes (Los Alamos National Laboratory). As a result, DOE has limited its consideration of processing sites to Rocky Flats for processes with and without plutonium separation, the Savannah River Site for processes with plutonium separation, and Los Alamos National Laboratory for two processing technologies involving plutonium separation. The applicability of the various sites to the three major alternatives analyzed in this EIS is portrayed in **Figure 2-1**, and discussed further in Section 2.9.2.

Processing of the Rocky Flats plutonium residues and scrub alloy at Rocky Flats would be done primarily in two buildings at the site, Building 371 and Building 707. Building 371 would be used for processes that involve aqueous processing steps including mediated electrochemical oxidation, neutralization, sonic wash, cementation, acid dissolution, water leach, catalytic chemical oxidation, thermal desorption/steam passivation, and some blend down, cementing, and repackaging operations. Building 707 would be used for processes that are primarily thermal or physical operations including immobilization, pyro-oxidation, calcination, salt distillation, and some blend down and repackaging operations.

An issue has recently arisen concerning seismic events and Building 707. The Building 707 Final Safety Analysis Report does not adequately model the actual construction of the facility. A recent seismic analysis of Building 707 revealed the facility was less seismically qualified than assumed in the Final Safety Analysis Report and there is increased risk to the public resulting from seismic events (i.e. an earthquake of a less return

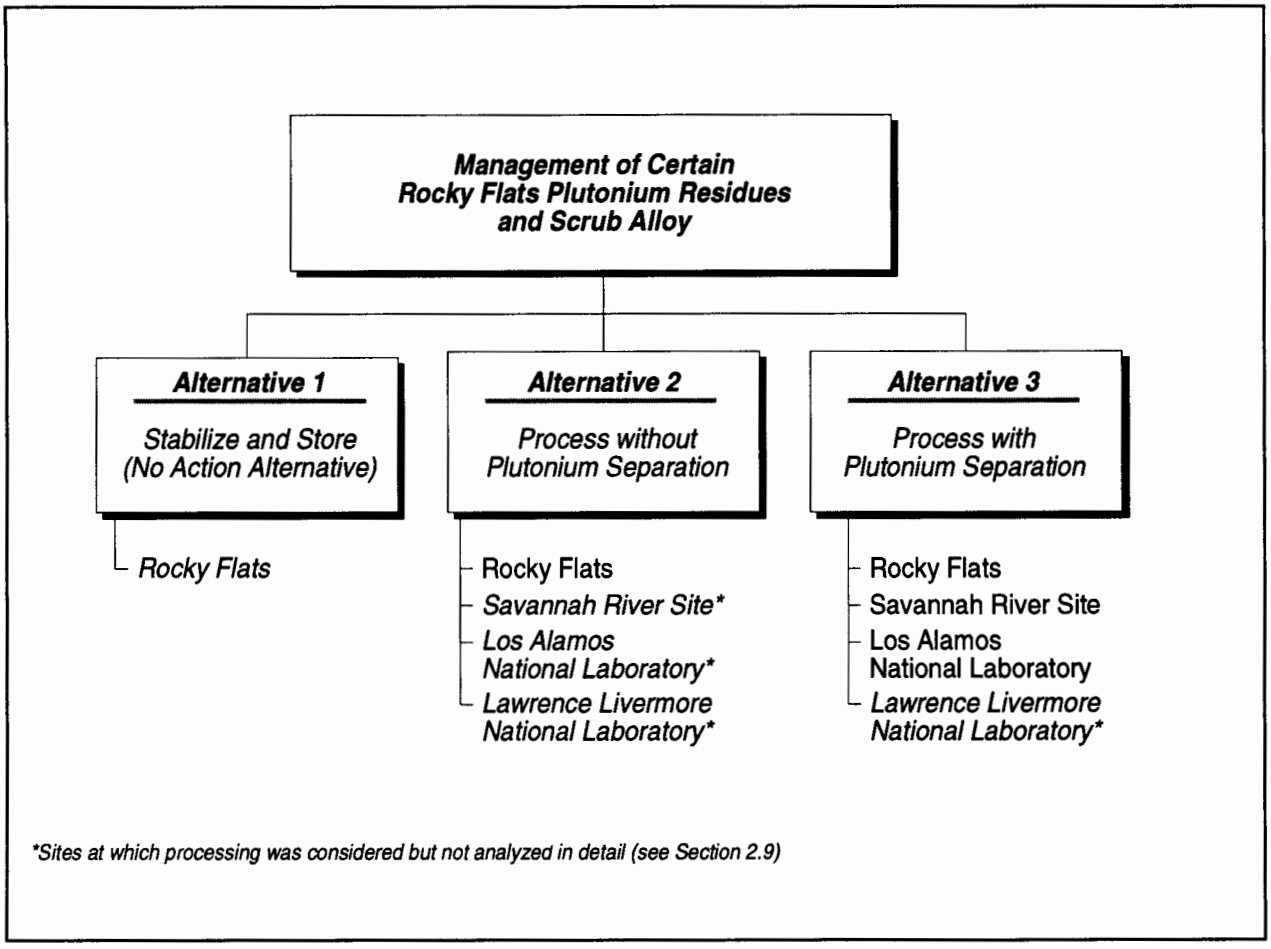

Figure 2–1 Plutonium Residue and Scrub Alloy Alternatives

frequency than the Final Safety Analysis Report assumed would damage the facility and result in radiological consequences to workers and the public). The issue is being resolved by the Unreviewed Safety Question process, which will identify operational restrictions, compensatory measures, or determine if the risk is acceptable per DOE guidelines. This issue is expected to be resolved by the end of January 1998.

Several processes that involve separating plutonium (i.e., Alternative 3) are analyzed for the Savannah River Site and Los Alamos National Laboratory. These sites have unique facilities and/or processing expertise for separating plutonium from certain categories of plutonium residues and scrub alloy that are not available at Rocky Flats. It is important to be aware that these separation alternatives are proposed primarily due to health and safety concerns related to the increased worker radiation doses associated with the non-separation alternatives. The Savannah River Site facilities for the separation of plutonium include the H-Canyon, HB-Line, F-Canyon, and the FB-Line. Use of these facilities, some of which are designed for remote operation, would result in lower worker radiation exposure than use of the glovebox facilities at Rocky Flats. For example, plutonium fluorides have an extremely high worker radiation dose due to the alpha-n reactions between the alpha particles in plutonium and the fluorine molecules. The plutonium separation process the at Savannah River Site (Purex) is performed in a remote-handling facility, which reduces worker dose substantially. Sand, slag, and crucible has significant amounts of americium, which has a much higher worker radiation dose than plutonium does. The plutonium separation process for sand, slag, and crucible (Purex) is also performed in a remote-handling facility at Savannah River Site. Many of the pyrochemical salts also contain significant amounts of americium. Although the separation technologies for salts to be processed at Los Alamos National Laboratory (distillation, water leach) are not remote-handled, they consist of much

shorter time exposures to the salts than the non-separation technology (blend-down) does, thereby reducing worker exposure substantially. Furthermore, the separation technologies result in a smaller quantity of processed material requiring handling at the processing sites than those processes that stabilize the residues and scrub alloy through immobilization or blend down of those materials through the addition of inert or low plutonium content materials. This further reduces worker exposure and generates less transuranic waste requiring disposal at WIPP. The reduced handling of this material at WIPP would decrease radiation exposure to the operational staff.

Los Alamos National Laboratory is considered as a candidate site for two separation process technologies for materials considered in this EIS. Scientists at Los Alamos National Laboratory developed the salt distillation technology being considered for separation of plutonium oxide from certain pyrochemical salts. The site has the experience needed to apply this technology and, therefore, is included in this EIS for salt distillation. Los Alamos National Laboratory is also being considered for water leach of direct oxide reduction salts. Any processing activities at Los Alamos National Laboratory would be done in Building PF-4, at TA-55, the Los Alamos National Laboratory Plutonium Facility.

Many of the plutonium residues at Rocky Flats have been managed as hazardous waste under the Resource Conservation and Recovery Act, although some of this material may not fit the Resource Conservation and Recovery Act definition of hazardous waste. This may be an influencing factor on whether DOE sends this material to other sites for further processing. The Savannah River Site and Los Alamos National Laboratory facilities that would be used for these processes are not presently permitted under the Resource Conservation and Recovery Act. These sites may need to seek Resource Conservation and Recovery Act permits for the facilities or waivers to process residues. Rocky Flats also plans to further characterize these materials to determine whether they are hazardous wastes.

In Sections 2.4 and 2.5.2, DOE has identified preferred processing options for most of the Rocky Flats plutonium residue and scrub alloy material categories and subcategories. These preferences are based on a combination of factors including process technical maturity, cost, and schedule. Preferred management options for other material categories have not yet been identified.

2.2 Quantity and Characteristics of Plutonium Residues and Scrub Alloy at Rocky Flats

Rocky Flats currently has in storage approximately 106,600 kilograms (kg) (235,000 pounds [lb]) of plutonium residues and 700 kg (1,540 lb) of scrub alloy containing approximately 2,600 kg and 200 kg (6,200 lb and 440 lb) of plutonium, respectively. DOE has determined that approximately 40 percent of the residues and 100 percent of the scrub alloy have plutonium concentrations above the safeguards termination limits.

The safeguards termination limits (see Table B-1, page B-5) specify the maximum concentrations of plutonium that may exist in plutonium-bearing materials below which the materials are not subject to the strict material control and accountability requirements applied under "safeguards" requirements. The concentration limits are determined by the difficulty in recovering plutonium from the material and are higher for plutonium embedded in solids such as glass or cement than for easily recoverable materials. The plutonium residues and scrub alloy that exceed the safeguards termination limits may require further processing beyond that described in the Solid Residue Environmental Assessment to meet criteria for disposal or other disposition and are the principal subject of this EIS.

The plutonium residue and scrub alloy materials subject to this EIS were described in the Notice of Intent (DOE 1996b). They have been grouped into material categories that would undergo the same set of processing technologies. DOE recognizes that materials within these categories do not have a uniform content and that some of the processing technologies assumed for a broad material category may not be appropriate for all of the materials included in that category.

DOE also recognizes that when storage containers are opened, the quantities and characteristics of the plutonium residues and scrub alloy may vary somewhat from those assumed in this analysis. The analyses in this EIS are based on the best knowledge of the amounts and characteristics of the plutonium residues and scrub alloy available at the time the EIS was prepared. The analysis methodologies and assumptions used in this EIS are conservative and would accommodate uncertainties in the quantities of materials to be processed. The plutonium residues and scrub alloy are briefly discussed in Chapter 1 and described in detail in Appendix B of this EIS. The five Notice of Intent categories are as follows:

- **Ash Residues**—The ash residue category consists of approximately 27,900 kg (61,500 lb) of material containing approximately 1,250 kg (2,760 lb) of plutonium in three basic groups: incinerator ash, firebrick heels and fines, and soot; sand, slag, and crucible; and graphite fines. Approximately 72 percent of the ash residue inventory (approximately 20,100 kg or 44,300 lb) would require additional processing to meet the requirements for disposal in WIPP or other disposition.

- **Salt Residues**—The salt residue category consists of about 16,000 kg (35,300 lb) of material containing approximately 1,000 kg (2,200 lb) of plutonium and can be further subdivided into three groups: electrorefining salts, molten salt extraction salts, and direct oxide reduction salts. These salts contain sodium chloride, potassium chloride, magnesium chloride, calcium chloride, zinc chloride, and cesium chloride. Approximately 93 percent of the salt residue inventory (approximately 14,900 kg or 32,800 lb) would require additional processing to meet the requirements for disposal in WIPP or other disposition.

- **Wet Residues**—The wet residues consist of approximately 16,500 kg (36,400 lb) of material containing approximately 340 kg (750 lb) of plutonium and are composed of a disparate assembly of materials, such as wet (aqueous- and organic-contaminated) combustibles, plutonium fluorides, high-efficiency particulate air filter media, sludges, greases/oil, and Raschig (glass) rings. Approximately 26 percent of the wet residue inventory (approximately 4,300 kg or 9,500 lb) would require additional processing to meet the requirements for disposal in WIPP or other disposition.

- **Direct Repackage Residues**—The direct repackage residue category consists of about 39,300 kg (86,600 lb) of material, containing about 340 kg (750 lb) of plutonium, and comprises those plutonium residues that are considered to be stable and do not require processing. The residues consist of such materials as paper, rags, cloth, plastic, personal protective equipment, and gaskets. Approximately 7.8 percent of the direct repackage residue (approximately 2,900 kg or 6,400 lb) would require additional processing to meet the requirements for disposal in WIPP or other disposition.

- **Scrub Alloy**—Scrub alloy is predominantly a magnesium/aluminum/americium/plutonium metal alloy that was created as an interim product in plutonium recovery. Scrub alloy is not considered a plutonium residue. The entire scrub alloy inventory of approximately 700 kg (1,540 lb), containing approximately 200 kg (440 lb) of plutonium, will require processing to put it in a form that would meet the requirements for disposition.

For the purpose of calculating the environmental impacts, DOE has regrouped the plutonium residues and scrub alloy into new categories that require similar processing technologies. These management alternatives for each category are described in Section 2.4. The 10 material categories used in this EIS are as follows:

1. Ash Residues
2. Pyrochemical Salt Residues
3. Combustible Residues
4. Plutonium Fluoride Residues
5. Filter Media Residues
6. Sludge Residues
7. Glass Residues
8. Graphite Residues
9. Inorganic (Metal and Others) Residues
10. Scrub Alloy

Table 2–1 shows how the 10 categories used in this EIS correspond to the 5 previously described residue and scrub alloy material categories from the Notice of Intent (DOE 1996b).

Table 2–1 Comparison of Plutonium Residue and Scrub Alloy Material Categories

Notice of Intent Categories	*EIS Categories*
Ash Residues - Incinerator Ash, Firebrick Heels and Fines, and Soot - Sand, Slag, and Crucible - Graphite Fines	**(#1) Ash Residues (20,060 kg [44,200lb])** -Incinerator Ash and Ash Heels, and Firebrick Fines -Sand, Slag, and Crucible -Graphite Fines - Inorganic Ash
Salt Residues - Electrorefining Salts - Molten Salt Extraction Salts - Direct Oxide Reduction Salts	**(#2) Pyrochemical Salt Residues (14,900 kg [32,800 lb])** -Electrorefining Salts -Molten Salt Extraction Salts -Direct Oxide Reduction Salts[a]
Wet Residues - Wet Combustibles (partial)	**(#3) Combustible Residues (partial)[b]** -Aqueous/Organic-Contaminated Combustibles
- Plutonium Fluoride	**(#4) Plutonium Fluoride Residues (2,630 kb [5,800 lb])**
- Wet Combustibles (partial)	**(#5) Filter Media Residues (315 kg [690 lb])**
- Sludge - Greases/Oily Sludge	**(#6) Sludge Residues (620 kg [1,370 lb])** -Sludge -Greases/Oily Sludge
- Raschig Rings	**(#7) Glass Residues (partial)[b]** -Raschig Rings
Direct Repackage - Glass	**(#7) Glass Residues (partial)[b]** -Other Glass
- Dry Combustibles	**(#3) Combustible Residues (partial)[b]** -Dry Combustibles
- Graphite, Firebrick	**(#8) Graphite Residues[b] (1,880 kg [4,150lb])** -Graphite, Firebrick
- Miscellaneous	**(#9) Inorganic Residues (Metal and Others)[b] (460 kg [1,000 lb])** -Miscellaneous
Scrub Alloy	**(#10) Scrub Alloy (700 kg [154 lb])**

[a] Safeguards termination limit variances may be applied to a portion of this salt category, which would allow disposal at WIPP without further processing beyond current stabilization and repackaging activities.

[b] Safeguards termination limit variances may be applied to these categories, which would allow disposal at WIPP without further processing beyond current stabilization and repackaging activities.

2.3 PROCESSING TECHNOLOGIES ASSESSED IN THIS EIS

The plutonium residues and scrub alloy processing technologies evaluated in this EIS were identified through a process that included review of technical reports and evaluation by technical experts from DOE Headquarters, Rocky Flats, the Savannah River Site, and Los Alamos National Laboratory. These experts also evaluated the feasibility of implementing the technologies at the DOE sites under consideration. This process is described in more detail in Section 2.9 and in Appendix C. The following documents were among those reviewed:

- *Environmental Assessment, Finding of No Significant Impact, and Response to Comments — Solid Residue Treatment, Repackaging, and Storage* (DOE 1996j).

- *Rocky Flats Environmental Technology Site: Direct Disposal Trade Study for Plutonium-Bearing Residues* (DOE 1995a).

- ❒ A series of trade studies on specific material categories by the DOE Nuclear Material Stabilization Task Group:

  - *Plutonium Combustibles Trade Study* (DOE 1996a)
  - *Plutonium Salts Trade Study* (DOE 1996l)
  - *Plutonium Sand, Slag, and Crucible Trade Study* (DOE 1997d)
  - *Ash Residues End-State Trade Study* (DOE 1996d)
  - *Plutonium Scrub Alloy Trade Study* (DOE 1996k).

- ❒ *Residue Program Rebaselining: Phase I Recommendation for Rebaselining Salts, SS&C, and Graphite Fines* (Ferrera 1996) (the Rocky Flats Rebaselining Study).

- ❒ *Residue Program Rebaselining: Phase II Recommendation for Rebaselining Ash, Combustibles, Fluorides, Sludges, Glass, and Firebrick and Inorganics* (Gilmartin 1997).

Based on information in these documents, a set of potential processing technologies was identified for each material category.

Each material category considered in this EIS was evaluated using the processes included in the No Action Alternative (i.e., stabilization and repackaging of residues that were considered in the Solid Residue Environmental Assessment), one or more processes that do not include separation of plutonium from the material, and one or more processes that include separation of plutonium from the material. Because of the significant differences in the chemical and physical characteristics of the materials in various categories, and in the process required for processing them, DOE proposes to make processing decisions on each subcategory rather than on the material categories. The technologies that apply to each of the categories are based on the best knowledge of the specifics of the processing options available at the time the EIS was prepared. These technologies are listed in **Figure 2–2** and are defined in the following sections; they are described in greater detail in Sections 2.4.1 through 2.4.10 and in Appendix C.

2.3.1 Processes Included in the No Action Alternative (Alternative 1)

The stabilization technologies evaluated for the No Action Alternative are those that were analyzed in the Solid Residue Environmental Assessment (DOE 1996j). Scrub alloy was not addressed in that Environmental Assessment. In this EIS, the No Action Alternative for scrub alloy is defined as continued storage at Rocky Flats with repackaging, as necessary. A material may be subjected to more than one technology conducted in series. For example, the No Action Alternative for incinerator ash is calcination followed by cementation. Some subgroups may be subject to several different processes.

2.3.2 Process without Plutonium Separation (Alternative 2)

The technologies evaluated in this EIS for processing without plutonium separation include those identified in the Plutonium Residues Trade Studies or the Rocky Flats Rebaselining Study (Ferrera 1996) that were considered mature enough for near-term implementation. Each material category in the EIS is evaluated using one or more technologies that do not involve separating plutonium from the material. All such processing would take place at Rocky Flats.

2.3.3 Process with Plutonium Separation (Alternative 3)

The technologies evaluated in this EIS for processing with plutonium separation are those that were identified in the Plutonium Residues Trade Studies or the Rocky Flats Rebaselining Study (Ferrera 1996) that were considered mature enough for implementation within the next several years. Each material category in the EIS

	Processing Technologies																			
	No Action (All Stabilizations Would Occur at Rocky Flats)								Without Plutonium Separation* (All Processing Would Occur at Rocky Flats)						With Plutonium Separation*					
Material Categories	Calcination	Cementation	Pyro-Oxidation	Neutralization/Dry	Thermal Desorption/Steam Passivation	Repackaging	Acid Dissolution/Plutonium Oxide Recovery	Filtration/Dry	Cementation	Calcination/Vitrification	Blend Down	Catalytic Chemical Oxidation	Fluidized Bed Incineration	Sonic Wash	Acid Dissolution/Plutonium Oxide Recovery at Rocky Flats	Purex Process/Plutonium Metal or Oxide Recovery (the process would only occur at the Savannah River Site)	Mediated Electrochemical Oxidation (could occur at Rocky Flats or the Savannah River Site)	Salt Distillation (the process could occur at Rocky Flats or Los Alamos National Laboratory)	Salt Scrub (the process at Rocky Flats requires subsequent processing at the Savannah River Site)	Water Leach (the process would occur at Rocky Flats or Los Alamos National Laboratory)
Ash Residues																				
Incinerator Ash Residues	●	●								■	●					●	●			
Sand, Slag, and Crucible Residues	●	●								●	●					■				
Graphite Fines Residues		●								■	●						●			
Inorganic Ash Residues	●	●								■	●									
Pyrochemical Salt Residues																				
Molten Salt Extraction/Electrorefining			●								●							■	●	●
Direct Oxide Reduction			●								●								●	■
Combustible Residues																				
Aqueous-Contaminated				■							●	●	NR	●			●			
Organic-Contaminated					■						●	●	NR	●			●			
Dry						■					●	●	NR	●			●			
Plutonium Fluoride Residues							●				●				●	■				
Filter Media Residues				●						●	●		NR	●			●			
Sludge Residues								●		●	●				●					
Glass Residues				■						●	●			●			●			
Graphite Residues						■			●	●	●						●			
Inorganic (Metal and Other) Residues						■				●	●						●			
Scrub Alloy						●				N						■				

* *May also require stabilization processes included under No Action*
■ = Preferred processing option (refer to Section 2.6 of the Summary). Preferred processing options have not yet been identified for filter media or sludge residues.
● = Other technical options
N = Nonpreferred Approach
NR = Not reasonable. DOE considers that this option is not a reasonable alternative.

Figure 2–2 Processing Technologies Assessed for Each Plutonium Residue and Scrub Alloy Category

is evaluated using one or more technologies that involve separating plutonium from the material. In addition, DOE will discuss the applicability of the technology at each of the three candidate sites—Rocky Flats, the Savannah River Site, and Los Alamos National Laboratory.

2.4 MANAGEMENT ALTERNATIVES FOR EACH MATERIAL CATEGORY

The following sections cover the processing technologies and sites considered for each material category of the Rocky Flats plutonium residues and scrub alloy. Sections 2.4.1 through 2.4.10 contain brief descriptions of the material categories to be discussed, and descriptions of the technologies analyzed for Alternative 1 (the No Action Alternative), Alternative 2 (Process without Plutonium Separation), and Alternative 3 (Process with Plutonium Separation). More detailed descriptions of the material categories and processing technologies may be found in Appendices B and C, respectively. The impacts are discussed in Chapter 4 and Appendix D. Figures 2-3 through 2-12 contain flow diagrams of the processing options for each material type. The preferred processing options(s) are presented in bold.

2.4.1 Management of Ash Residues

Ash residues at Rocky Flats include materials in four subcategories: (1) incinerator ash and ash heels, and firebrick fines; (2) sand, slag, and crucible (3) graphite fines; and (4) inorganic ash. The last category includes

chloride-contaminated magnesium oxide crucible and oxide from ventilation ducts. The total quantity of ash residues at Rocky Flats subject to processing is approximately 20,060 kg (44,220 lb) and includes approximately 1,160 kg (2,560 lb) of plutonium. The technology/site options analyzed for ash residues are shown in **Figure 2–3**. The impacts associated with the management of ash residues are presented in Tables 2-8 through 2-11 and in Section 4.5.

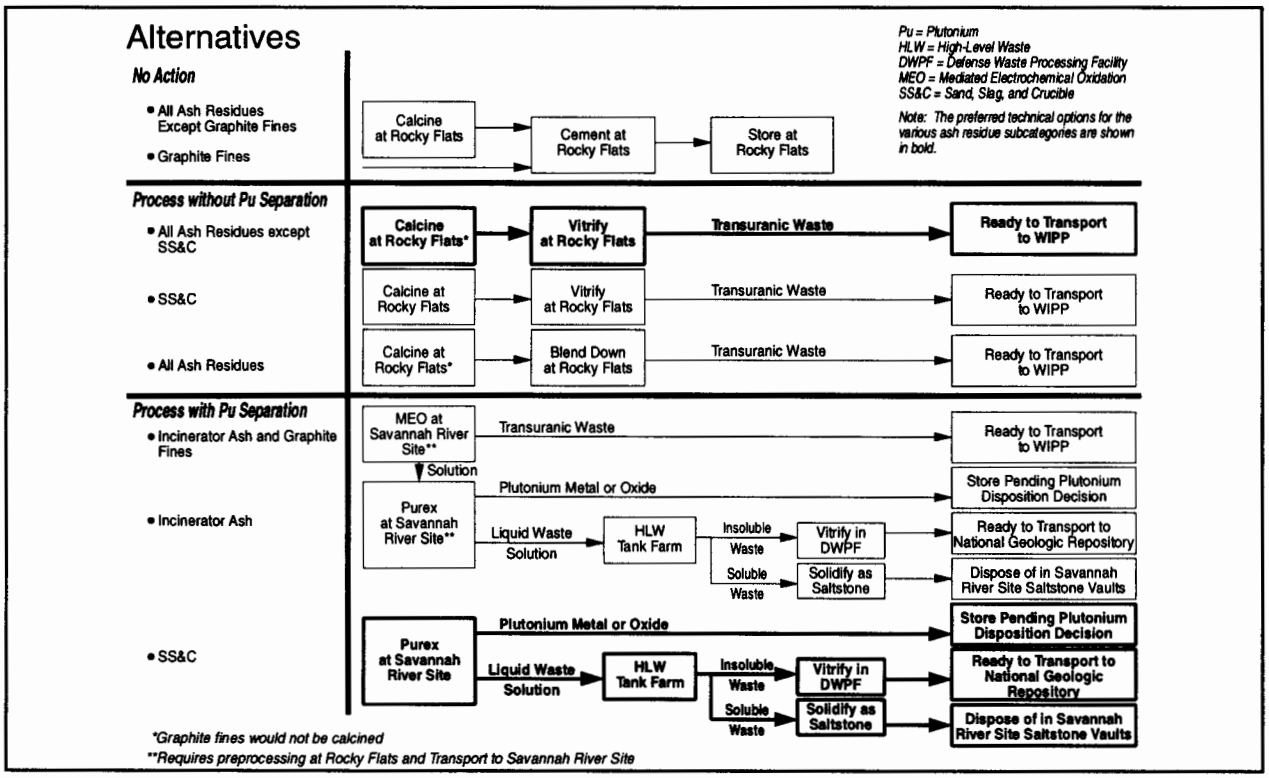

Figure 2–3 Processing Options for Ash Residues

DOE has identified vitrification as the preferred processing option for incinerator ash, graphite fines, and inorganic ash residues. Vitrification is a nonaqueous process and as such is favored because of the limited aqueous processing capability at Rocky Flats. Furthermore, the addition of glass frit to form a glass matrix will yield a product meeting the 5 percent plutonium by weight safeguards termination limit for special nuclear material microencapsulated in refractory compounds or in solid dilution. If necessary, more frit could be added to achieve the 2 percent safeguards termination limit required for plutonium bound in a matrix of solid sintered or agglomerated refractory materials. The number of drums required for the 2 percent plutonium concentration would not significantly increase from the number of drums required at the 5 percent limit because the containers are plutonium content limited and the additional glass frit could be added without filling the drums.

The Purex process at the Savannah River Site has been identified as the preferred processing option for sand, slag, and crucible residues. These residues are readily processed in either the F- or H-Canyons, existing operational systems. Because the sand, slag, and crucible residue has not been previously heated to high temperatures, it does not have to be preprocessed using the sodium peroxide fusion process to improve the solubility of plutonium. Accordingly, it would only have to be prepackaged at Rocky Flats prior to shipment to the Savannah River Site for processing.

2.4.1.1 Alternative 1—No Action

- **Calcination/Cementation**—The methodologies for stabilizing plutonium residues to meet Rocky Flats' interim safe storage criteria[1] are described in detail in the Solid Residue Environmental Assessment (DOE 1996j). The ash residues would be size reduced by crushing and calcining and then cementing or repackaging to immobilize respirable fines. The containers of cemented and/or repackaged residues would then be placed inside 210-liter (L) (55-gal) drums in a configuration that meets the interim safe storage criteria. These drums would be stored at Rocky Flats until a final disposition decision is made by DOE. All stabilization activities would take place in Building 707 or Building 371. Calcination of powdered or granular materials in muffle furnaces[2] is considered to be a proven technology. Cementation of materials to immobilize fines and to form an acceptable solid is also considered to be a proven technology, although optimization studies are routinely performed to improve specific characteristics.

2.4.1.2 Alternative 2—Process without Plutonium Separation

DOE analyzed two processing technologies for ash residues that do not involve plutonium separation: vitrification and blend down with inert or low plutonium content materials to meet the safeguards termination limits. Quantitative analyses of these technologies were conducted for processing at Rocky Flats.

- **Vitrification**—Vitrification (encapsulation in a glass matrix) was used as the technology for immobilization in conducting the impact analysis of ash residues. Vitrification (also discussed in Appendix C) is being considered at Rocky Flats for stabilization of some materials in its waste backlog and is considered to be a proven technology for most residue types to which it may be applied. A technical development program is underway for vitrification of ash residues. Vitrification is being evaluated for the plutonium residues that do not meet the safeguards termination limits in their current form. Activities are underway to optimize the process and reduce the steps necessary to achieve an acceptable waste form. In the Rocky Flats process, ash residues would be placed in Module E, Building 707. There the ash would be unpacked, sorted, size reduced (as necessary), and measured into 8.2-L (2.2-gal) cans. The amount of ash added to the cans would be limited to 83.5 grams (g) (0.18 lb) plutonium per can. Ash residues (except graphite fines) would be calcined before being vitrified to prevent off-gases from combusting during vitrification. Glass frit would be added until the resulting material would be below the safeguards termination limits for vitrified material. The mixture would then be melted at 700 to 1,300 degrees Celsius (°C) (1,290 to 2,370 degrees Fahrenheit (°F) to be encapsulated in glass. After cooling, the vitrified ash would be packaged according to the WIPP waste acceptance criteria and placed in interim storage pending disposal at WIPP.

- **Blend Down**—Some material may have a plutonium concentration only slightly greater than the safeguards termination limits or may consist of only a small quantity of material that is above the safeguards termination limits. In these circumstances, the plutonium may be blended down by adding material with a plutonium concentration below the safeguards termination limit so that the material may be disposed of at WIPP without further processing. The residue would be moved to Module B, Building 707, and bagged into the glovebox. There residues would be unpacked, size reduced as necessary, measured into batches (except for graphite fines), and calcined at 900°C (1,650°F). The calcination would oxidize any carbon or organic compounds present to carbon dioxide and would also eliminate water. The residue could also be blended with an inert material such as uranium oxide, salt, or magnesium oxide to form a mixture that

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[1]*The interim safe storage criteria were developed in response to the Defense Nuclear Facilities Safety Board's Recommendation 94-1 (DNFSB 1994).*

[2]*Muffle furnaces are small (approximately 1 cubic foot), oven-like, electrically heated units; they are lined with refractory material and they can be used to heat material placed onto trays inserted into the unit.*

meets plutonium safeguards termination limits. Calcination and blending are considered to be proven technologies.

Incinerator ash, firebrick fines, and graphite fines would be measured into batches with 83.5 g (0.18 lb) or less of plutonium, allowing for maximum packaging flexibility during the final packaging step. The sand, slag, and crucible residues, chloride-contaminated magnesium oxide crucible, and oxide from ventilation ducts would be measured into batches with about 18 g (0.04 lb) of plutonium because of the high ratio of diluent to residue matrix required. After processing, the batches would be packaged according to the WIPP waste acceptance criteria and placed in interim storage pending disposal at WIPP.

2.4.1.3 Alternative 3—Process with Plutonium Separation

DOE analyzed two processes for separation of plutonium from the ash residue: the Purex process and mediated electrochemical oxidation. Quantitative analyses of these technologies were conducted for the Savannah River Site. Both of these technologies involve acid dissolution of the ash followed by conversion to plutonium metal. In the Purex process, all of the plutonium in the ash residues (except graphite and firebrick fines, magnesium oxide crucible, and oxides from ducts) would be converted to plutonium metal or oxide. In the mediated electrochemical oxidation process, all the ash residues (except sand, slag, and crucible; magnesium oxide crucible; and oxide from ducts) would be converted to plutonium metal or oxide. Sand, slag, and crucible would be processed using the Purex process. Neither the Purex nor mediated electrochemical oxidation processes can separate plutonium from the magnesium oxide crucible or oxide from ducts.

Ash stabilization activities for incinerator ash and graphite fines would be conducted in Module E, Building 707, at Rocky Flats before shipment to the Savannah River Site. The residues requiring calcination before shipment would be unpacked in the glovebox, size-reduced as necessary, measured into batches, and calcined at 900°C (1,650°F) for 2 hours. The calcination would oxidize carbon and organics to carbon dioxide and would eliminate water to provide a material that would meet shipping criteria.

The existing equipment used in the Purex process at the Savannah River Site cannot process incinerator ash in its present form because the ash is not readily soluble in nitric acid. If mediated electrochemical oxidation is not used to dissolve plutonium, the incinerator ash would first be fused with an oxidant, such as sodium peroxide to convert it to a more soluble form before shipment to the Savannah River Site. The fusion process would be in addition to the calcination step in the preprocessing of incinerator ash.

- **Mediated Electrochemical Oxidation at the Savannah River Site**—At the Savannah River Site, the ash residues (except sand, slag, and crucible; chloride-contaminated magnesium oxide crucible; and oxide from ventilation ducts) would be received at the Plutonium Storage Facility for interim storage. The ash residues would then be transferred to the New Special Recovery facility and dissolved using newly installed dissolvers that use the silver(II) ion to dissolve the normally intractable plutonium in the ash. These dissolvers were developed by Pacific Northwest National Laboratory, the Lawrence Livermore National Laboratory, and the Savannah River Site for this purpose and are used in France to recover plutonium. The New Special Recovery facility would have to be modified for silver(II) electrochemical dissolvers. The process would also require minimal operation of the F-Canyon. An equivalent option would be to install the silver dissolver in the HB-Line and use the H-Canyon/HB-Line facilities. The mediated electrochemical oxidation process is considered to be a well demonstrated technology, although it has not yet been used in production operations in DOE facilities.

  Once the plutonium is in solution, any undissolved material would be filtered out, packaged according to the WIPP waste acceptance criteria and placed in interim storage pending disposal at WIPP. The remaining plutonium-bearing solution would be transferred to the F-Canyon (or H-Canyon) where it would be processed through the existing Purex system to separate plutonium from waste materials in the solution.

The waste fraction would be transferred to the high-level waste system, where it would be added to the materials in the high-level waste tanks. The insoluble solids would be vitrified with high-level waste in the Defense Waste Processing Facility and the residual liquids would be solidified as saltstone. The plutonium-bearing fraction would be transferred to the FB-Line (HB-Line), where it would be precipitated as plutonium trifluoride and reduced with calcium metal to plutonium metal. (If the material is processed through the HB-Line, the final product would be plutonium oxide.) The plutonium would be thermally stabilized and packaged to meet DOE-STD-3013-96 (DOE 1996e), and placed in interim storage in the Actinide Packaging and Storage Facility pending disposition in accordance with decisions reached under the Surplus Plutonium Disposition Environmental Impact Statement (DOE 1997b).

- **Purex Process**—At the Savannah River Site, ash residues (except firebrick fines, graphite fines, chloride-contaminated magnesium oxide crucible, and oxide from ventilation ducts) would be received at the 235-F facility for storage. The residues would then be transferred to a Canyon facility, where they would be dissolved in nitric acid. The solution would then be separated into two fractions, a waste solution and a plutonium-bearing solution. The waste fraction would be transferred to the high-level waste system, where it would be added to the materials in the high-level waste tanks. The solids would be vitrified with high-level waste in the Defense Waste Processing Facility, and the residual liquids would be solidified as saltstone. The plutonium-bearing fraction would be transferred to a finishing line (FB/HB), where it would be precipitated and converted to a stable oxide or metal. The plutonium would be thermally stabilized, packaged to meet DOE-STD-3013-96 (DOE 1996e), and placed in interim storage in the Actinide Packaging and Storage Facility pending disposition in accordance with decisions reached under the Surplus Plutonium Disposition EIS (DOE 1997b). The Purex process at the Savannah River Site is considered to be a proven technology.

2.4.2 Management of Pyrochemical Salt Residues

The primary subcategories of pyrochemical salt residues at Rocky Flats are electrorefining salt residues, molten salt extraction salt residues, and direct oxide reduction salt residues. The first two categories consist primarily of a sodium chloride/potassium chloride matrix and are contaminated with plutonium chloride, americium chloride, other metal chlorides, and significant quantities of plutonium, americium, and other metals. The direct oxide reduction salts consist primarily of a calcium chloride matrix. They are contaminated with plutonium chloride, americium chloride, calcium oxide, calcium metal, plutonium oxide, plutonium fluoride, and other materials. A major difference in the possible processing of these residues is that the sodium chloride/potassium chloride matrix may be distilled from the contaminants, whereas the calcium chloride matrix is not readily distilled. The pyrochemical salt residues category also includes numerous materials that were associated with salt processing (e.g., crucibles) or that were generated during research activities. Because of technical considerations, a combination of the described processing technologies may be required to process all of the pyrochemical salt residues. The total quantity of pyrochemical salts at Rocky Flats subject to processing is approximately 14,900 kg (32,830 lb) and includes approximately 1,000 kg (2,200 lb) of plutonium. The technology/site options analyzed for processing salt residues are shown in **Figure 2–4**. The impacts associated with the management of salt residues are presented in Tables 2-11 and 2-12 and in Section 4.6.

DOE has identified salt distillation at Rocky Flats as the preferred processing option for molten salt extraction/electrorefining salt residues because it is a nonaqueous process and has a high rate of throughput. DOE has identified the water leach process at Los Alamos National Laboratory as the preferred processing option for direct oxide reduction salt residues. These residues have a calcium chloride matrix, which cannot be readily distilled away from the plutonium oxide/americium oxide present in the material. Los Alamos National Laboratory is favored over Rocky Flats as the processing site because of the limited waste water processing capability at Rocky Flats. Subsequent to the notice of intent to prepare this EIS (DOE 1996b), DOE granted a variance from safeguards termination limits for most of the direct oxide reduction salt residues subject to this

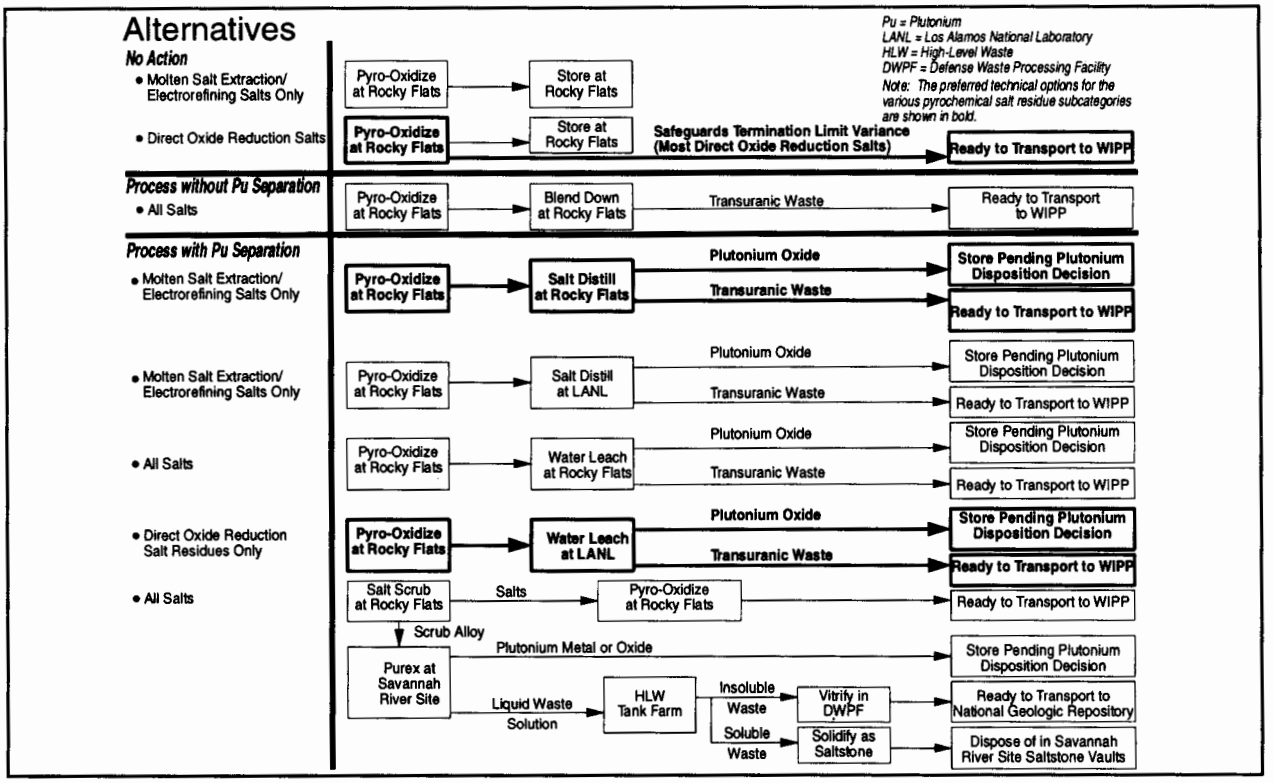

Figure 2–4 Processing Options for Pyrochemical Salt Residues

EIS. This would allow those salts to be pyro-oxidized as described in the No Action Alternative and then sent to WIPP for disposal as transuranic waste without additional processing.

2.4.2.1 Alternative 1—No Action

The methodologies for stabilizing plutonium residues to meet the Rocky Flats interim safe storage criteria are described in detail in the Solid Residue Environmental Assessment (DOE 1996j).

- **Pyro-Oxidation**—The salt residues under this alternative would be transferred to a glovebox in Module A of Building 707. An oxidant such as sodium carbonate would be added to the salt residue and the mixture loaded into a stainless-steel can, which would be placed in a furnace and heated to about 800°C (1,470°F) in an inert atmosphere and stirred for approximately 2 hours. As the molten salt cools, it solidifies into a solid monolith. After cooling, the pyro-oxidized salt would be packaged and removed from the glovebox. Pyro-oxidation of salts in stationary furnaces is considered to be a proven technology.

  The repackaged, stabilized salt would be assayed to determine its plutonium content, placed in secondary packaging, and transferred to the designated onsite interim storage facility until a final disposition decision is made by DOE. The purpose of this oxidation is to ensure conversion of reactive metals to nonreactive oxides.

2.4.2.2 Alternative 2—Process without Plutonium Separation

DOE analyzed pyro-oxidation followed by blending down with inert materials to the safeguards termination limit as the technology that does not involve plutonium separation. A quantitative analysis of this technology was conducted for the Rocky Flats Site.

- **Pyro-Oxidation/Blend Down**—The salt residues would first be pyro-oxidized in a metal or ceramic crucible. After cooling, the salt matrix and plutonium oxide would be removed from the crucible. The crucible would be discarded and managed as transuranic waste or sand, slag, and crucible as described in Section 2.4.1. The salt and plutonium oxide would be crushed to achieve a uniform size and then blended with an inert material (such as pure salt or uranium oxide) to form a mixture that meets the plutonium safeguards termination limits. The salt would then be packaged according to the WIPP waste acceptance criteria and placed in interim storage pending disposal at WIPP.

2.4.2.3 Alternative 3—Process with Plutonium Separation

DOE analyzed three processing technologies for separation of plutonium from the pyrochemical salt residues: (1) salt distillation (molten salt extraction/electrorefining salt residues only), (2) water leach, and (3) salt scrub. Quantitative analyses of all three technologies were conducted for implementation at Rocky Flats and for salt distillation of molten salt extraction/electrorefining salt residues and water leach of direct oxide reduction salt residues for implementation at Los Alamos National Laboratory. Pyro-oxidation of the salts at Rocky Flats would be required before any shipment of salt residues to Los Alamos National Laboratory.

- **Salt Distillation**—This process would separate transuranic materials from a salt matrix by distilling the salt away from any plutonium/americium oxide present in the salt. For this EIS, DOE considered salt distillation only for molten salt extraction/electrorefining salt residues. Distillation of direct oxide reduction salt residues requires further development because higher temperatures are required for calcium chloride distillation and because it does not yield a good separation of the salt from plutonium/americium oxide; these higher temperatures are beyond the capability of available equipment. The salt would be pyro-oxidized and then loaded into the salt distillation furnace and heated under vacuum to approximately 950°C (1,740°F) for approximately 6 hours. Under these conditions, the salts would distill away from the plutonium/americium oxides in the mixture. No hazardous chemicals would be released during this process. After the separation, the furnace would be cooled and opened. The separated salts and plutonium/americium oxide/residual salts would then be assayed, packaged, and handled by two separate paths. The separated salts would be packaged according to the WIPP waste acceptance criteria and placed in interim storage pending disposal at WIPP. The plutonium/americium oxides would then be packaged according to DOE-STD-3013-96 (DOE 1996e) and placed in safe interim storage pending disposition in accordance with decisions reached under the Surplus Plutonium Disposition EIS (DOE 1997b).

  Pyro-oxidation of salts is considered to be a proven technology, although specific process variables are being evaluated in an attempt to make the pyro-oxidation process more compatible with a pyro-distillation follow-on processing step. Salt distillation of the sodium chloride/potassium chloride matrix from molten salt extraction/electrorefining salts has been well demonstrated on a pilot scale with actual residue materials, although optimization studies are ongoing and final designs of the production equipment will be required. An additional uncertainty involved in the salt distillation process is the disposition of the transuranic oxide materials resulting from distillation of salts from molten salt extraction salts. These materials contain elevated concentrations of americium by comparison to other plutonium oxide materials, resulting in elevated gamma radiation levels and may require extra shielding and special handling procedures.

- **Water Leach**—The dissolution process being considered for recovery of plutonium/americium oxides from pyrochemical salts is water leach of the salt. In this process, the salt would first be pyro-oxidized, as previously described in Section 2.4.2.1. The salt would then be placed in the leaching vessel and water would be added. Because the pyro-oxidation process produces an excess of sodium oxide, hydrochloric acid must be added to prevent the resulting solution from becoming excessively alkaline. After approximately 1 hour, the slurry would be vacuum filtered. The solid filter cake would consist primarily of damp plutonium/americium oxide, which would be placed in a furnace and dried at 400°C (750°F) for

4 hours. After drying, the plutonium/americium oxide would be calcined at 1,000°C (1,830°C) for 4 hours. No hazardous chemicals would be released during this process. It would then be packaged according to DOE-STD-3013-96 (DOE 1996e) and placed in interim storage pending disposition in accordance with decisions reached under the Surplus Plutonium Disposition EIS (DOE 1997b). The filtrate would be evaporated, leaving a lean salt that would be packaged according to the WIPP waste acceptance criteria and placed in interim storage pending disposition at WIPP.

The water leach process is considered to be a proven technology. However, if it is used to process molten salt extraction salts, an uncertainty exists involving the disposal of the transuranic oxide materials remaining from the water leach of molten salt extraction salts. This is the same problem discussed above for salt distillation of these salts. The residual materials contain elevated concentrations of americium by comparison to other plutonium oxide materials, resulting in elevated gamma radiation levels that must be addressed in handling. Estimates of radiation levels from these oxides packaged in containers meeting DOE-STD-3013-96 (DOE 1996e) indicate that the materials may not be suitable for storage at the new vault being constructed at the Savannah River Site, although special shielding approaches are being evaluated. In the event that shielding is an unacceptable alternative, these materials may have to be processed in another manner or stored separately prior to final disposition.

- **Salt Scrub**—Salt scrub is the technology historically used to recover plutonium from molten salt extraction/electrorefining salt residues. This technology can also be used for direct oxide reduction salt residues. The salt residue would be placed in a crucible with a mixture of aluminum and magnesium (or, in newer processes, gallium and calcium) and heated in a glovebox furnace to approximately 800°C (1,470°F) for approximately 2 hours. Any plutonium and americium chlorides present in the residue would be reduced by magnesium (or calcium) to plutonium and americium metals, which would then be extracted by the aluminum (or gallium). The alloy would then separate from the salts and form a metallic button (called scrub alloy) at the bottom of the crucible.

  After cooling, the salts and scrub alloy button would be removed from the crucible and separated from one another. The residual salts would be analyzed to determine if they meet safeguards termination limits for disposal at WIPP. Salts that meet the limits would be pyro-oxidized (as described previously in Section 2.4.2.1) to oxidize any reactive metals, packaged according to the WIPP waste acceptance criteria, and placed in interim storage pending disposal at WIPP. Salts that do not meet the safeguards termination limits would be scrubbed again. The scrub alloy would be sent to the Savannah River Site to be processed in the Canyons using the Purex process (Section 2.4.10).

  The salt scrub process is considered to be a proven process for clean, recently packaged salt residues. However, technical uncertainties exist for this process as applied to less pure salts and/or salts that have absorbed moisture during storage. Development work would be required prior to or in parallel with the operations to address these uncertainties, with the result possibly being a population of salts not amenable to this technique. Since the scrub alloy process could be performed in the stationary furnaces that have been installed at Rocky Flats as part of the No Action Alternative, currently installed capability exists to support this process. The salts scrubbed by this process, however, may not meet all the safeguards termination limits for disposal at WIPP and may need some subsequent processing prior to disposition.

2.4.3 Management of Combustible Residues

The combustible plutonium residues are divided into three subcategories: aqueous-contaminated combustibles, organic-contaminated combustibles, and dry combustibles. These residues are solid materials contaminated with plutonium; they include gloves, clothes, and other combustible materials. The total quantity of Rocky Flats combustible residues subject to processing is approximately 1,140 kg (2,510 lb) and includes approximately 21 kg (46 lb) of plutonium. The technology/site options analyzed for processing these residues

are shown in **Figure 2–5**. The impacts of processing combustible residues are presented in Table 2-13 and Section 4.7.

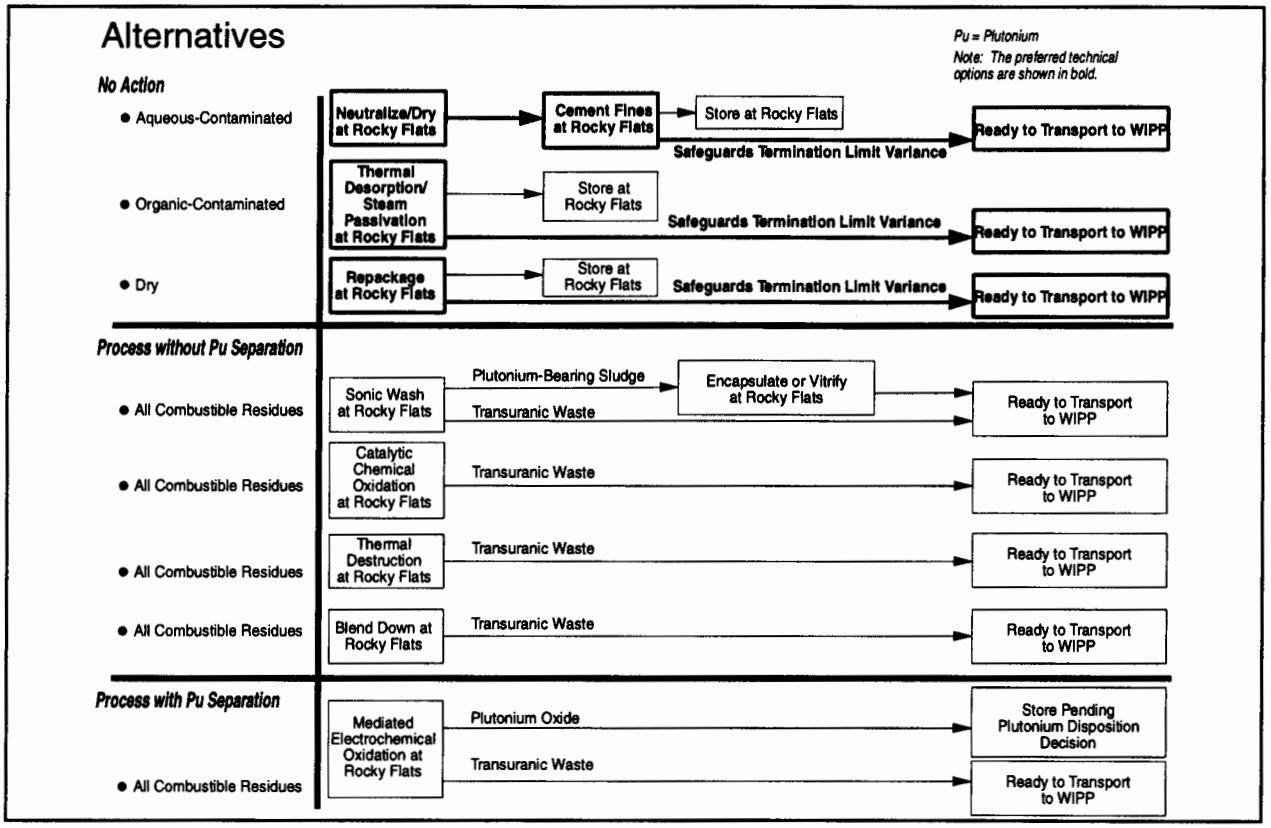

Figure 2–5 Processing Options for Combustible Residues

DOE's preferred processing option for aqueous-contaminated combustible residues is neutralization followed by drying with any fines stabilized by cementation or repackaging. The preferred processing option for organic-contaminated combustible residues is a combination of washing, low temperature thermal desorption to remove volatile organic materials, stabilization of plutonium fines, mixing with an absorbent material, and cementation. The preferred processing option for dry combustible residues is just to repackage the materials for disposal because they are already in a chemical or physical form that does not require stabilization. These are the technologies that are described in the Rocky Flats Solid Residue Environmental Assessment (DOE 1996j). Subsequent to the Notice of Intent to prepare this EIS (DOE 1996b), DOE granted a variance from the safeguards termination limits for all of the combustible residues subject to this EIS. This would allow all of the combustible residues to be sent to WIPP for disposal as transuranic waste without further processing.

2.4.3.1 Alternative 1—No Action

All processing activities for combustibles under the No Action Alternative would be conducted in existing glovebox lines in Building 371 at Rocky Flats. Specific stabilization methods for the aqueous-contaminated and organic-contaminated combustibles, as well as for dry combustibles, are described in the following paragraphs.

❒ **Neutralize/Dry**—Aqueous-contaminated combustibles are combustible materials that contain or have been exposed to discernible quantities of water-based solutions (typically acids or bases). Larger items would be size reduced to facilitate washing. The materials would be washed with a neutralizing solution, excess

liquid would be removed by filtration, and the remaining residues would be dried either by mixing with an absorbent material or by drying at low temperatures. Any fines resulting from this process would be immobilized by cementation or packaging. The remaining residue would be repackaged for interim storage until a final disposition decision is made by DOE. The washing solution would be periodically withdrawn, assayed for plutonium content, and sent to the liquid waste treatment facility. This process is currently in use at Rocky Flats.

- **Thermal Desorption/Steam Passivation**—The organic-contaminated combustibles would be stabilized by washing, low temperature (approximately 80°C [176°F]) thermal desorption to remove volatile organic materials, stabilization of plutonium fines, mixing with an absorbent material, and cementation. Steam would be added to the low temperature thermal desorption to stabilize plutonium fines. The stabilized residue would be repackaged for interim storage until a final disposal decision is made by DOE. This process is considered to be a proven technology; however, final process parameters are currently under investigation (for more details see Appendix C).

- **Repackage**—Dry combustible residues are in a chemical or physical form that does not require stabilization to meet interim safe storage criteria. The present packaging configuration, however, does not meet those criteria. Accordingly, these residues would be directly repackaged, without stabilization, into metal containers meeting interim safe storage criteria. After repackaging, the residue containers would be sent to an appropriate storage area until a final disposition decision is made by DOE. Repackaging is considered to be an acceptable management approach.

2.4.3.2 Alternative 2—Process without Plutonium Separation

DOE analyzed four technologies that do not involve plutonium separation for processing combustible residues: sonic wash, catalytic chemical oxidation, fluidized bed incineration, and blend down with inert materials to the safeguards termination limits. Quantitative analyses of these technologies were conducted for processing at Rocky Flats.

- **Sonic Wash**—The sonic wash technology is applicable to all three subcategories of combustible residues. In this process, plutonium is physically removed from solid hydrogenous and other insoluble matrices by washing in a weak caustic solution with agitation induced by sound waves in the sonic range. The process mechanically improves contact of the neutralizing solution with the irregular matrix surfaces and improves the removal of solid transuranic oxides from the surface of the feed matrices. The feed material would be shredded, placed in a basket, and lowered into a sonic wash unit that contained a weak caustic solution. The charge would be agitated by sonic waves and a portion of the oxides, along with other higher density materials, would wash off the matrix and settle to the bottom. The matrix material would be rinsed, dried, and repackaged for shipment to WIPP for disposal. The settled heavy materials or sludges containing the higher fraction of transuranic oxides would be filtered from the wash solution, dried, and stored until a batch large enough to vitrify is gathered. The material first would be blended with a low-melting temperature glass then heated to 700 to 1,300°C (1,290 to 2,370°F) to melt the glass and encapsulate or vitrify the waste. The stabilized material would be packaged according to the WIPP waste acceptance criteria and placed in interim storage pending disposal at WIPP. The effluent streams from the filtration and rinsing steps would be evaporated and recycled back to the sonic wash unit.

  The sonic wash technology has been demonstrated with residue-type materials on a bench scale. Because of the significant effort required to demonstrate a consistent process and develop the procedures and analysis necessary for routine operation, DOE estimates that this process would be available 2 years after the issuance of the Record of Decision for this EIS.

- **Catalytic Chemical Oxidation (Digestion)**—The process used to represent digestion of organic materials in combustible residues is catalytic chemical oxidation process. This process uses catalysts dissolved in acid to oxidize organic materials and to dissolve metals associated with the residues at elevated temperatures and pressures. Any metals present, including plutonium, would be converted to metal oxides by boiling down the solution. The residual metal oxides would be packaged according to the WIPP waste acceptance criteria and placed in interim storage pending disposal at WIPP.

  Catalytic chemical destruction of combustibles at elevated temperatures and pressures has been demonstrated in a commercial environment, but is unproven as a production process in the size and service required and for residue material applications. Because of the significant effort required to demonstrate a consistent process and to develop the procedures and analysis necessary for routine operations, the estimated time to deploy this technology would be 4 years after the issuance of the Record of Decision for this EIS.

- **Thermal Destruction (Fluidized Bed Incineration)**—Fluidized bed incineration is used as the representative technology for thermal destruction. Fluidized bed incineration is a two-stage flameless combustion process that relies on the heat transfer characteristics of a fluidized bed to destroy combustible matrices while ensuring that the final chemical state of the transuranic constituents are stable oxides. The fluidized bed vessel contains a powdered matrix that would be kept in motion by a fluidizing medium of nitrogen and oxygen introduced at the bottom of the vessel. The incineration system has two fluidized beds. The materials to be destroyed would be shredded to provide a reasonably uniform-sized feed. The primary fluid bed matrix, which is composed of a catalyst and a sorbent, would be heated to approximately 500°C (930°F) and then the combustible material would be added. At the temperature of the reaction vessel, the catalyst helps the organic materials to pyrolyze. The sorbent, typically sodium carbonate, would absorb and neutralize any acidic off-gases. Other gases would pass to a secondary fluidized bed, which also contains a catalyst and is operated at approximately 650°C (1,200°F). At this temperature, the catalyst would convert the gases from the first chamber to carbon dioxide and water. The gases would then pass over a catalytic converter and through high-efficiency particulate air filters before being exhausted.

  A cyclone separator would be placed between the two fluid bed chambers, removing small particles carried out of the primary fluid by the fluidizing medium. The only solid products of the fluidized bed incinerator would be a stable dry powder from the cyclone separator and any solids collected on the filter system. These solids would be packaged according to the WIPP waste acceptance criteria and placed in interim storage pending disposal at WIPP. The fluidized beds would be changed occasionally as the sorbent and catalysts become ineffective.

  Although this technology was demonstrated in previous Rocky Flats operations and at other sites, it has not been demonstrated under current Clean Air Act permitting standards. In addition, location of the facility in Building 776 has significant programmatic risk because of the condition of the facility and its schedule for decommissioning. Other locations for a new incinerator at Rocky Flats have yet to be identified. Because of the significant effort required to develop the analysis necessary for routine operation and the uncertainty of the permitting process for a new or restarted facility, the estimated time to deploy this operation would be 4 years after the issuance of the Record of Decision for this EIS. As a result, DOE considers that thermal destruction at Rocky Flats is not a reasonable alternative. However, to provide the public with a better understanding of the process, the results of the impact assessments are included in this EIS. There is no way that DOE will consider this process as acceptable for implementation.

- **Blend Down**—Some materials that have plutonium concentrations only slightly above the safeguards termination limits may be shredded for efficient packing and blended with low-plutonium concentration materials (e.g., residues containing plutonium below the safeguards termination limits) or other appropriate materials. These materials would be introduced into a glovebox, shredded, diluted with other materials as

required, and repackaged. The new packages would then be packaged according to the WIPP waste acceptance criteria and placed in interim storage pending disposal at WIPP.

2.4.3.3 Alternative 3—Process with Plutonium Separation

DOE analyzed mediated electrochemical oxidation for all three kinds of combustible residues. A quantitative analysis of this technology was conducted for processing at Rocky Flats.

- **Mediated Electrochemical Oxidation**—This process uses silver ions generated in an electrochemical cell to catalyze the dissolution of unreactive plutonium materials from residues and, depending on the substrate material, to convert some "combustible" materials into carbon dioxide and water. To ensure that a large surface area was exposed to the solution, the material would be shredded. Then the materials would be placed in a corrosion-resistant wire basket to allow solid-solution contact while maintaining the ability to remove the undissolved solids easily.

  In the mediated electrochemical oxidation dissolution process, a solution of silver nitrate in nitric acid would be pumped into an electrochemical cell, where the silver(I) ion is oxidized to the silver(II) ion. The solution would be pumped immediately into the reaction tank, where it would dissolve plutonium oxide contained in the matrix, most organic and carbonaceous materials, and many other contaminants. Any solid material remaining after the reaction would be filtered, washed, dried, packaged according to the WIPP waste acceptance criteria, and placed in interim storage pending disposal at WIPP.

  Plutonium dissolved in the process would be mixed with a solution of oxalic acid, causing the plutonium to precipitate as plutonium oxalate. The slurry would be filtered through a stainless steel filter boat and washed with dilute nitric acid. The filtrate would be evaporated to recycle much of the water and acid, and the evaporator bottoms would be neutralized, cemented, and packaged for shipment to WIPP for disposal. The plutonium oxalate filter cake on the stainless steel filter boat would be placed in a calcining furnace and heated to 400°C (750°F) for 4 hours to decompose the oxalate and entrained water into the glovebox atmosphere, leaving a dry plutonium oxide cake. After cooling, the plutonium oxide would be removed from the filter boat, sampled, weighed, and packaged for temporary storage. Later, the plutonium oxide would be thermally stabilized, packaged according to DOE-STD-3013-96 (DOE 1996e), and placed in interim storage pending disposition in accordance with decisions reached under the Surplus Plutonium Disposition EIS (DOE 1997b). The remediated electrochemical oxidation process is considered to be a well demonstrated technology, although it has not yet been used in production operations in DOE facilities.

2.4.4 Management of Plutonium Fluoride Residues

The plutonium fluoride residues at Rocky Flats, which were generated in the hydrofluorination and reduction operations, are solid materials that have a high plutonium content. The alpha-neutron reaction, which occurs between plutonium and fluorine, results in a high neutron emission rate from these residues and may cause a high neutron exposure to workers. The total quantity of Rocky Flats plutonium fluorides needing processing is approximately 315 kg (690 lb) and includes approximately 140 kg (310 lb) of plutonium. The technology/site options analyzed for plutonium fluoride residues are shown in **Figure 2–6**. The impacts associated with the management of plutonium fluorides are presented in Table 2-14 and Section 4.8.

DOE has identified the Purex process at the Savannah River Site as the preferred option for processing plutonium fluoride residues. The Savannah River Site has existing operations (i.e., the F- and H-Canyons) that can process the material.

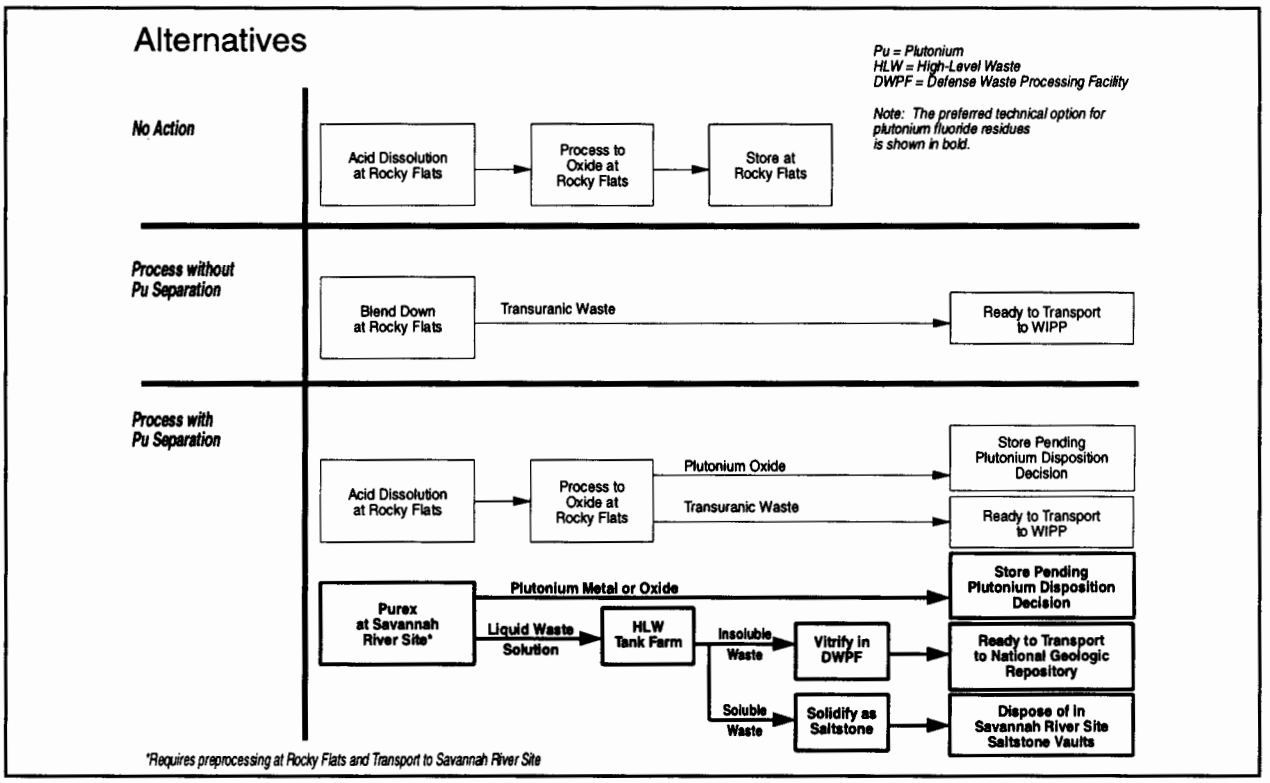

Figure 2–6 Processing Options for Plutonium Fluoride Residues

2.4.4.1 Alternative 1—No Action

- **Acid Dissolution/Plutonium Oxide Recovery**—Plutonium would be recovered from plutonium fluoride by dissolving the material in nitric acid. The resulting solution would be mixed with a solution of oxalic acid, causing the plutonium to precipitate as plutonium oxalate. The slurry would be filtered through a stainless steel filter boat and washed with dilute nitric acid. Magnesium hydroxide would be added to the precipitation filtrate to precipitate any remaining plutonium. This material would be filtered, calcined at 450°C (840°F), and repackaged for interim storage until a final disposition decision is made. The plutonium oxalate filter cake on the stainless steel filter boat would be placed in a calcining furnace and heated to 450°C (840°F) for 4 hours, decomposing the oxalate and evaporating entrained water into the glovebox atmosphere and leaving a dry plutonium oxide cake. After cooling, the plutonium oxide would be removed from the filter boat, sampled, weighed, and packaged for temporary storage. The plutonium oxide would then be thermally stabilized, packaged according to DOE-STD-3013-96 (DOE 1996e), and placed in interim storage. This process is considered to be a proven technology.

2.4.4.2 Alternative 2—Process without Plutonium Separation

DOE analyzed blending the fluoride with inert materials to the safeguards termination limits as the processing technology without plutonium separation. A quantitative analysis of this technology was conducted for processing at Rocky Flats.

- **Blend Down**—The only technology applicable for this residue category is to blend the plutonium fluoride with an inert material such as uranium oxide, magnesium oxide, or salt. Although this material has a large concentration of plutonium (approaching 50 percent plutonium, by weight), the small quantity of this

residue may make blending down reasonable. The processed material would be packaged according to the WIPP waste acceptance criteria and placed in interim storage pending disposal at WIPP.

2.4.4.3 Alternative 3—Process with Plutonium Separation

DOE analyzed two technologies for separation of plutonium from plutonium fluoride residues: acid dissolution followed by plutonium oxide recovery and the Purex process. Quantitative analyses of these technologies were conducted for the acid dissolution process at Rocky Flats and for the Purex process at the Savannah River Site.

- **Acid Dissolution/Plutonium Oxide Recovery**—This is the same technology that would be used in the No Action Alternative, except that the plutonium oxide recovered would be packaged according to DOE-STD-3013-96 (DOE 1996e) and placed in interim storage pending disposition in accordance with decisions reached under the Surplus Plutonium Disposition EIS (DOE 1997b).

- **Purex Process**—This is the same technology previously described (in Section 2.4.1.3) for ash residues. The plutonium fluoride residues would be packaged for shipment to the Savannah River Site. At the Savannah River Site, the material would be dissolved in nitric acid in a Canyon facility and then recovered as metal or oxide in the Canyon finishing line.

2.4.5 Management of Filter Media Residues

Two types of solid filter media residues exist at Rocky Flats—high-efficiency particulate air filters and Ful Flo filters. The high-efficiency particulate air filters are made of fiberglass and may be treated like other glasses; the Ful Flo filters are made from organic polymers. The total quantity of filter media needing processing is approximately 2,630 kg (5,800 lb) and includes approximately 110 kg (240 lb) of plutonium. The processing technology/site options analyzed for filter media residues are shown in **Figure 2–7**. The impacts associated with the management of filter media residues are presented in Tables 2-15 and 2-16 and in Section 4.9.

DOE has not yet identified a preferred processing technology option for filter media residues.

2.4.5.1 Alternative 1—No Action

- **Neutralize/Dry**—These filter media would be neutralized and dried as described in Section 2.4.3.1. The product would be placed in interim storage until a final disposition decision is made by DOE.

2.4.5.2 Alternative 2—Process without Plutonium Separation

DOE analyzed four processing technologies for filter media residues that do not involve plutonium separation: vitrification (high-efficiency particulate air filter media only), blend down with inert materials to the safeguards termination limits, fluidized bed incineration, and sonic wash. Quantitative analyses of these technologies were conducted for processing at Rocky Flats.

- **Vitrification (High-Efficiency Particulate Air Filter Media Only)**—High-efficiency particulate air filter media are composed of fiberglass material; thus, they can be stabilized by mixing with glass frit and then heating until a vitrified melt is formed. The technology analyzed for high-efficiency particulate air filter media is the same as described in Section 2.4.1.2 for ash residues.

- **Blend Down**—Filter media may be shredded and blended with inert materials to meet the safeguards termination limits. Rocky Flats would use the same methodology previously described for combustible materials in Section 2.4.3.2.

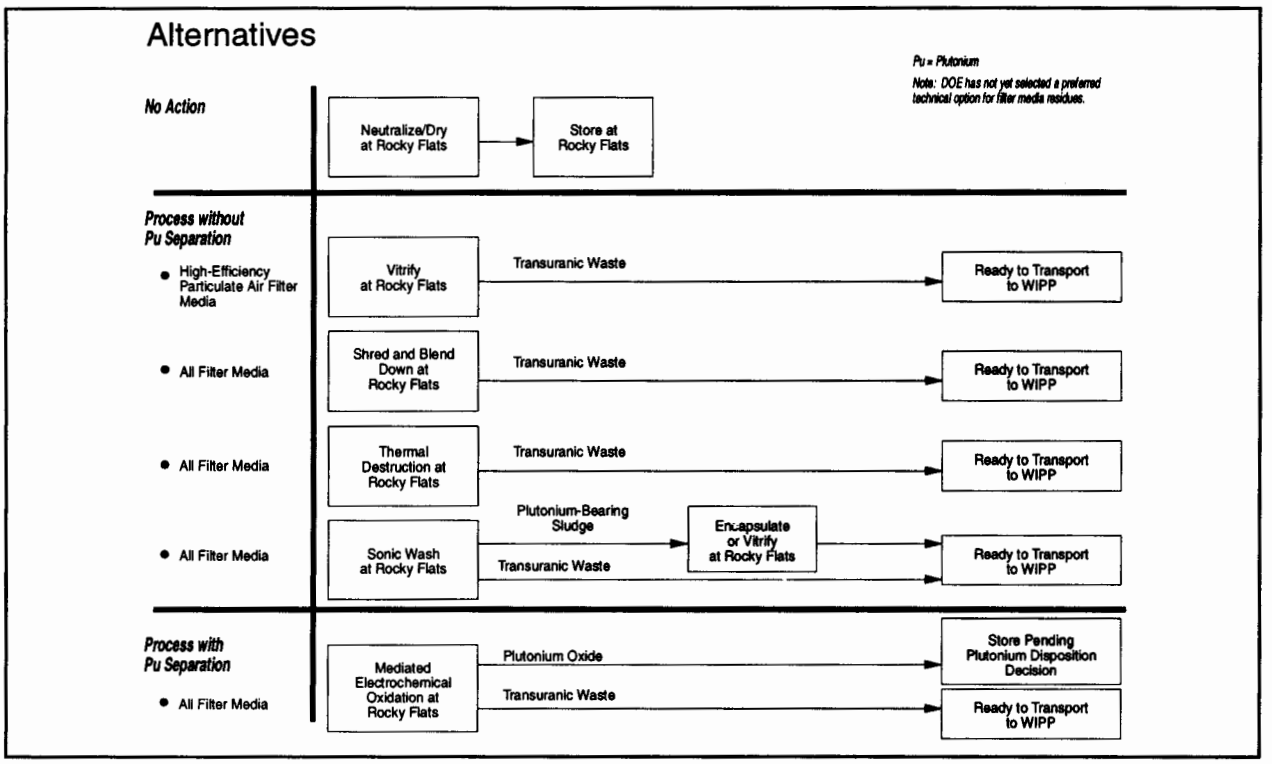

Figure 2–7 Processing Options for Filter Media Residues

- **Thermal Destruction (Fluidized Bed Incineration)**—Fluidized bed incineration is the representative technology used to estimate the impacts from combustion of plutonium-contaminated combustible materials located at Rocky Flats. High-efficiency particulate air filter media would be melted in the process and would be removed as incinerator ash. Most of the Ful Flo filter material would be completely destroyed in the process. Any plutonium contamination would appear in the incinerator ash. Rocky Flats would use the same process previously described for combustible materials in Section 2.4.3.2.

  However, to provide the public with a better understanding of the process, the results of the impact assessments are included in this EIS. There is no way that DOE will consider this process as acceptable for implementation.

- **Sonic Wash**—The sonic wash process uses sound waves to dislodge particles of plutonium oxide and other contaminants from the filter media. Then the media would be disposed of as transuranic waste, and the residual plutonium-bearing sludge would be stabilized by vitrification and also disposed of as transuranic waste. Rocky Flats would use the same process previously described for combustible materials in Section 2.4.3.2.

2.4.5.3 Alternative 3—Process with Plutonium Separation

DOE analyzed mediated electrochemical oxidation for processing of filter media residues with plutonium separation. A quantitative analysis of the impacts of implementing this technology at Rocky Flats was conducted.

- **Mediated Electrochemical Oxidation**—This technology was described previously in Section 2.4.3.3. Plutonium dissolved in the process would be precipitated as an oxalate and then calcined to plutonium oxide. The oxide would then be thermally stabilized, packaged according to DOE-STD-3013-96 (DOE 1996e), and placed in interim storage pending disposition in accordance with decisions reached

under the Surplus Plutonium Disposition EIS (DOE 1997b). Other solid material would be dried, stabilized, packaged according to the WIPP waste acceptance criteria, and placed in interim storage pending disposal at WIPP.

2.4.6 Management of Sludge Residues

Sludges were generated by a variety of processes at Rocky Flats. The total quantity of sludges needing processing is approximately 620 kg (1,370 lb) and includes approximately 27 kg (60 lb) of plutonium. The technology/site options analyzed for sludge residues are shown in **Figure 2–8**. The impacts associated with the management of sludge residues are presented in Table 2-17 and Section 4.10.

DOE has not yet identified a preferred processing option for sludge residues.

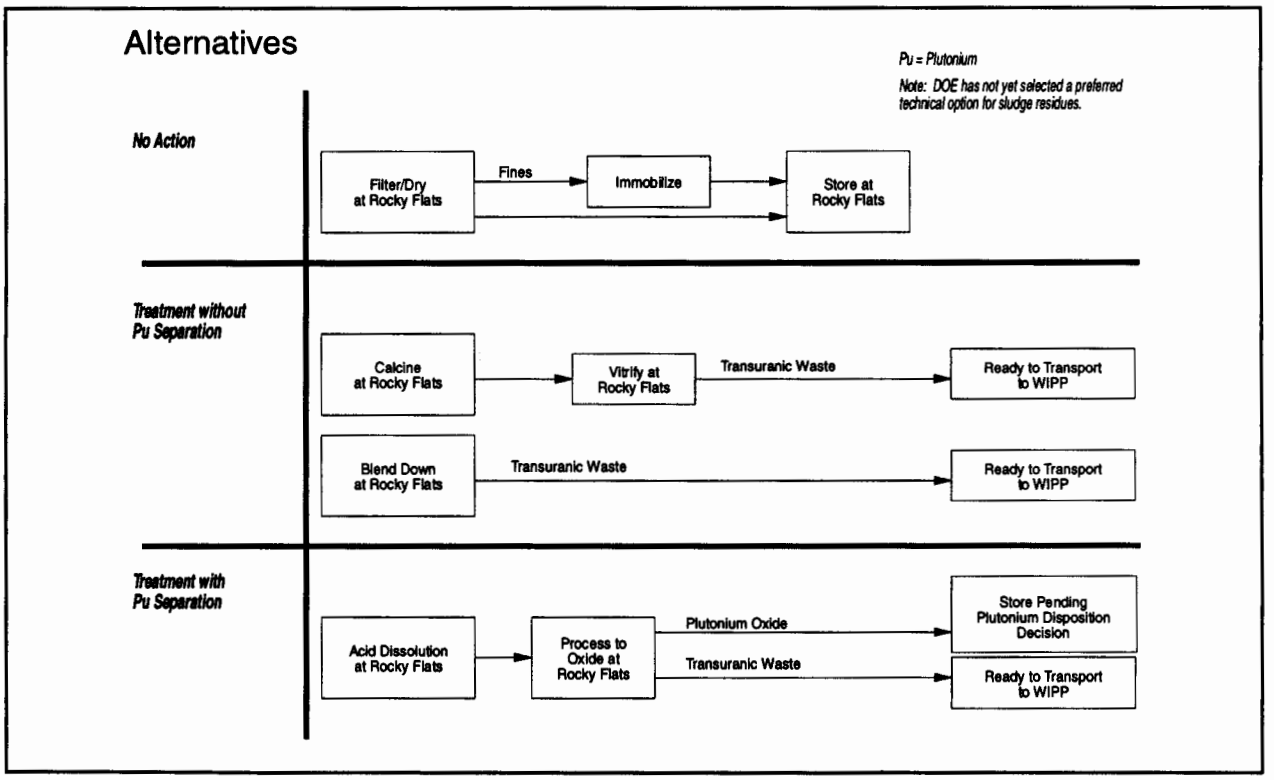

Figure 2–8 Processing Options for Sludge Residues

2.4.6.1 Alternative 1—No Action

- **Filter/Dry**—The stabilization process assumed in the No Action Alternative is to process miscellaneous sludges by filtering off any excess liquid and drying the remaining material by mixing with an absorbent. The resulting dried material would be tested to determine if respirable fines are present. Any fines present would be immobilized using a process such as cementation. The final step would be to repackage the residue for interim storage until a final disposition decision is made by DOE. The small quantity of liquid would be sent to the Rocky Flats liquid waste treatment facility. This process is considered to be a proven technology.

2.4.6.2 Alternative 2—Process without Plutonium Separation

DOE analyzed two technologies for processing sludge residues, including greases and oily sludge residues, that do not involve plutonium separation: vitrification and blend down with inert materials to the safeguards termination limits. Quantitative analyses of these technologies were conducted for processing at Rocky Flats.

- **Vitrification**—Vitrification of sludges at Rocky Flats would be done in a furnace placed inside a glovebox. The procedure used would be the same as the procedure for ash residues described in Section 2.4.1.2.

- **Blend Down**—Sludge residues would be blended with an inert material, such as uranium oxide or magnesium oxide, to form a mixture that meets plutonium safeguards termination limits. The residues would be analyzed for plutonium content, moved to Module B, Building 707, and bagged into the glovebox. The residues would then be unpacked, size-reduced as necessary, diluted by mixing with an inert material (including an absorbent to dry any free liquids), packaged according to the WIPP waste acceptance criteria, and placed in interim storage pending disposal at WIPP.

2.4.6.3 Alternative 3—Process with Plutonium Separation

DOE analyzed one technology for processing sludge residues that involves plutonium separation: acid dissolution followed by plutonium oxide recovery. A quantitative analysis of the impacts of implementing this technology was conducted for Rocky Flats.

- **Acid Dissolution/Plutonium Oxide Recovery**—Recovery of plutonium from sludges by acid dissolution would consist of dissolving the material in nitric acid followed by precipitation of the plutonium with oxalic acid. The feed material would first be size reduced to a powder or granular material, which would be introduced into the dissolver using a screw feeder. The dissolver would be charged with 7.5 molar nitric acid, which would recirculate within the dissolver column. The dissolver would be sparged (agitated) with air to prevent settling of solids and to provide intimate contact of solid and acid.

  The plutonium dissolved in the process would be mixed with a solution of oxalic acid, causing the plutonium to precipitate as plutonium oxalate. The slurry would be filtered through a stainless steel filter boat and washed with dilute nitric acid. Magnesium hydroxide would be added to the precipitation filtrate to precipitate any remaining plutonium. This material would then be filtered, calcined at 450 °C (840°F), packaged according to the WIPP waste acceptance criteria, and placed in interim storage pending disposal at WIPP. The plutonium oxalate filter cake on the stainless steel filter boat would be placed in a calcining furnace and heated to 450°C (840°F) for 4 hours, decomposing the oxalate, evaporating entrained water into the glovebox atmosphere, and leaving a dry plutonium oxide cake. After cooling, the plutonium oxide would be removed from the filter boat, sampled, weighed, and packaged for temporary storage. The plutonium oxide would then be thermally stabilized, packaged according to DOE-STD-3013-96 (DOE 1996e), and placed in interim storage pending disposition in accordance with decisions reached under the Surplus Plutonium Disposition EIS (DOE 1997b). This process is considered to be a proven technology.

2.4.7 Management of Glass Residues

This category is composed of Raschig rings and other miscellaneous glass residues. Raschig rings are hollow borosilicate glass cylinders that are 3.8 cm (1.5 in) long by 3.8 cm (1.5 in) diameter and 0.48 cm (0.19 in) thick. They were used to absorb neutrons and thus prevent criticality in large process tanks. Over time, the rings become coated with insoluble plutonium compounds. The total quantity of glass residues at Rocky Flats needing processing is approximately 135 kg (300 lb) and includes approximately 5 kg (11 lb) of plutonium.

The technology/site options analyzed for processing these materials are shown in **Figure 2–9**. The impacts associated with the management of glass residues are presented in Table 2-18 and Section 4.11.

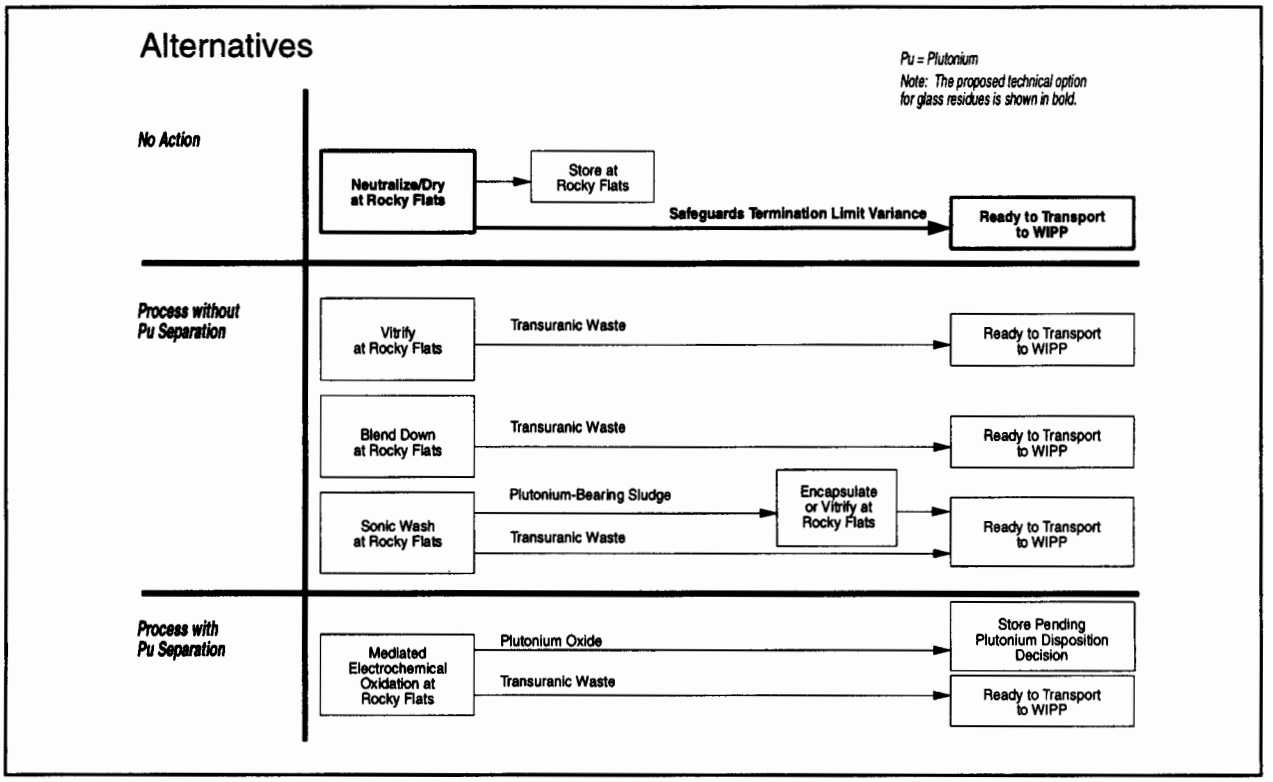

Figure 2–9 Processing Options for Glass Residues

DOE's preferred processing option for glass residues is neutralization followed by drying. Large items would be size reduced to facilitate washing, and any fines would be stabilized by cementation or repackaging. This is the technology described for glass residues in the Rocky Flats Solid Residue Environmental Assessment (DOE 1996j). Subsequent to the Notice of Intent to prepare this EIS (DOE 1996b), DOE granted a variance from the safeguards termination limits for the glass residues subject to this EIS. This would allow all of the glass residues to be processed in the same manner and to be sent to WIPP for disposal as transuranic waste.

2.4.7.1 Alternative 1—No Action

- **Neutralize/Dry**—The process assumed for stabilizing glass residues in the No Action Alternative is the same as the Neutralize/Dry process described in Section 2.4.3.1 for aqueous-contaminated combustible residues. Larger items would be size reduced to facilitate washing. The materials would be washed with a neutralizing solution, excess liquid would be filtered off, and the remaining residues would be dried either by mixing with an absorbent material or by heating at low temperatures and then repackaged for interim storage pending disposal at WIPP. The washing solution would be periodically withdrawn, assayed for plutonium content, and sent to the liquid waste treatment facility in Building 374.

2.4.7.2 Alternative 2—Process without Plutonium Separation

DOE analyzed three technologies for processing glass residues that do not involve plutonium separation: vitrification, blend down with inert materials to the safeguards termination limits, and sonic wash. Quantitative analyses of implementing these technologies at Rocky Flats were conducted.

- **Vitrification**—Because these residues are composed of various forms of glass, they are readily vitrified. The technology that would be used at Rocky Flats is vitrification in a furnace as described for ash residues in Section 2.4.1.2.

- **Blend Down**—The residues would be moved to Module B, Building 707, at Rocky Flats, and bagged into the glovebox. Then the residues would be unpacked, size reduced as necessary, diluted by mixing with inert materials (including an absorbent to dry any free liquids), packaged according to the WIPP waste acceptance criteria, and placed in interim storage pending disposal at WIPP.

- **Sonic Wash**—The sonic wash process for glass residues is the same as the process described for combustibles in Section 2.4.3.2.

2.4.7.3 Alternative 3—Process with Plutonium Separation

DOE analyzed mediated electrochemical oxidation for processing of glass residues with plutonium separation at Rocky Flats. A quantiative analysis of the impacts of implementing this technology was conducted for Rocky Flats.

- **Mediated Electrochemical Oxidation**—This technology was described previously in Section 2.4.3.3. Plutonium dissolved in the process would be precipitated as an oxalate and then calcined to plutonium oxide. The oxides would be thermally stabilized, packaged according to DOE-STD-3013-96 (DOE 1996e), and placed in interim storage pending disposition in accordance with decisions reached under the Surplus Plutonium Disposition EIS (DOE 1997b). Any other solid residues would be dried, stabilized, packaged according to the WIPP waste acceptance criteria, and placed in interim storage pending disposal at WIPP.

2.4.8 Management of Graphite Residues

The graphite residues generated during foundry operations at Rocky Flats are solid pieces of graphite from broken and intact molds. The total quantity of graphite needing processing is approximately 1,880 kg (4,140 lb) and includes approximately 100 kg (220 lb) of plutonium. The technology/site options analyzed for processing graphite residues are shown in **Figure 2–10**. The impacts associated with the management of graphite residues are presented in Table 2-19 and Section 4.12.

DOE's preferred processing option for graphite residues is repackaging without further processing. This is the processing described for graphite residues in the Rocky Flats Solid Residue Environmental Assessment (DOE 1996j). Subsequent to the Notice of Intent to prepare this EIS (DOE 1996b), DOE granted a variance from the safeguards termination limits for the graphite residues subject to this EIS. This would allow all of the graphite residues to be processed in the same manner and to be sent to WIPP for disposal as transuranic waste.

2.4.8.1 Alternative 1—No Action

- **Repackage**—Graphite residues would be directly repackaged, without further processing, into metal containers meeting interim safe storage criteria. After repackaging, the residue containers would be sent to an appropriate storage area pending disposal at WIPP.

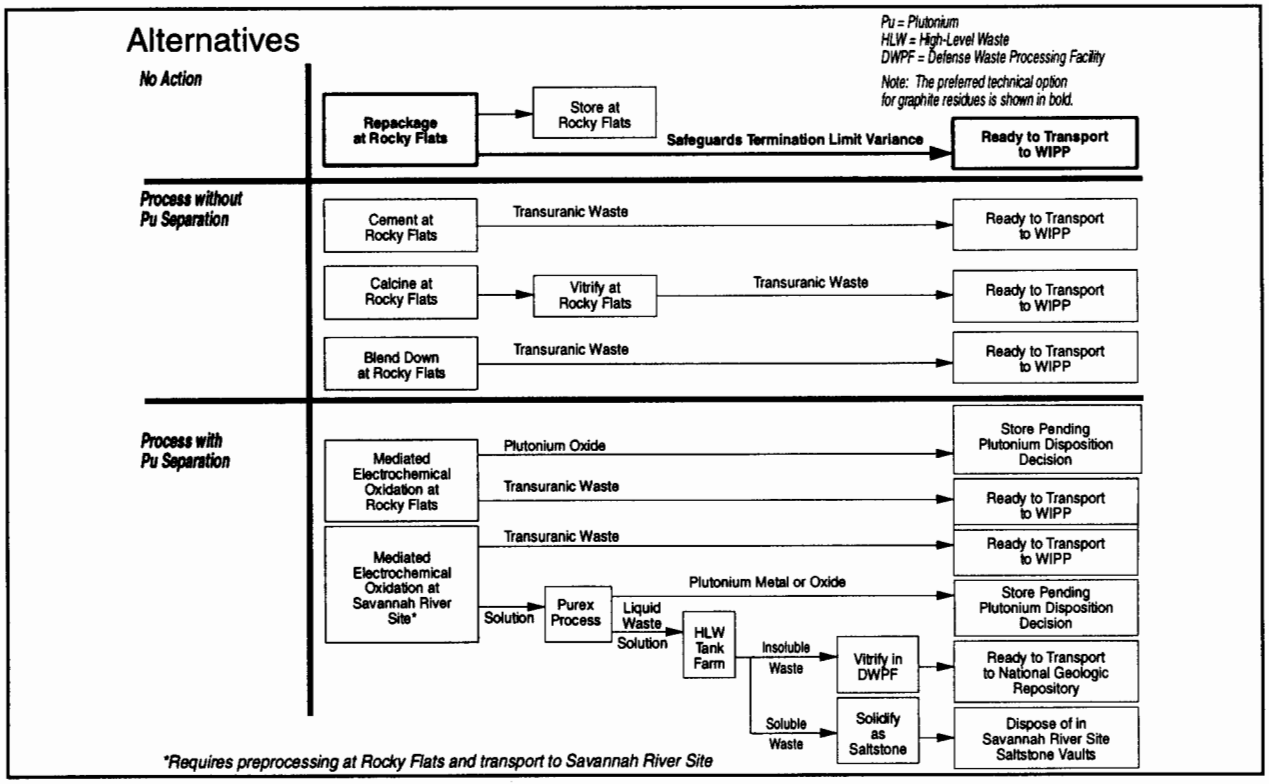

Figure 2–10 Processing Options for Graphite Residues

2.4.8.2 Alternative 2—Process without Plutonium Separation

DOE analyzed three technologies for processing graphite residues that do not involve plutonium separation: cementation, vitrification, and blend down with inert materials to the safeguards termination limits. Quantitative analyses of implementing these technologies at Rocky Flats were conducted.

- **Immobilization (Cementation)**—The graphite residues would be size reduced, cemented, packaged according to the WIPP waste acceptance criteria, and placed in interim storage pending disposal at WIPP. The process is considered to be a proven technology.

- **Immobilization (Vitrification)**—In the Rocky Flats furnace vitrification process, the graphite residues would be placed in Module E, Building 707. The residues would be unpacked, sorted, size reduced (as necessary), and measured into 2-L (0.5-gal) cans. The amount of material added to the cans would be limited to 83.5 g (0.18 lb) plutonium per can, the maximum permissible for 2 cans per shipment to WIPP. The residues would be calcined before vitrification to prevent off-gases from combusting during vitrification. Glass frit would be added until the resulting material would be below the safeguards termination limits for vitrified material. The mixture would then be melted to form a glass. After cooling, the cans of vitrified material would be packaged according to the WIPP waste acceptance criteria and placed in interim storage pending disposal at WIPP. This process is considered to be proven technology. Activities are underway to optimize the process and reduce steps necessary to achieve an acceptable waste form.

- **Blend Down**—The plutonium concentration in graphite residues would be decreased by blending with an inert material for disposal at WIPP without further processing. The residues first would be moved to Module B, Building 707, and bagged into the glovebox. The residues would be unpacked, size reduced

as necessary, diluted by mixing with an inert material, packaged according to the WIPP waste acceptance criteria, and placed in interim storage pending disposal at WIPP.

2.4.8.3 Alternative 3—Process with Plutonium Separation

DOE analyzed mediated electrochemical oxidation for processing graphite residues with plutonium separation. Quantitative analysis of the impacts of implementing this technology were conducted for Rocky Flats and the Savannah River Site.

- **Mediated Electrochemical Oxidation**—At both Rocky Flats and the Savannah River Site, plutonium would be dissolved using the silver(II) ion to oxidize the plutonium. Any insoluble material remaining would be removed by filtration dried and packaged according to the WIPP waste acceptance criteria, and placed in interim storage pending disposal at WIPP. The plutonium-bearing solution, however, would be treated differently at the two sites. At Rocky Flats, the plutonium would be precipitated as plutonium oxalate then calcined to plutonium oxide. At the Savannah River Site, the plutonium-bearing solution would be further treated using the Purex process to produce plutonium metal or oxide. These processes were previously described in Section 2.4.3.3 and Section 2.4.1.3 for Rocky Flats and the Savannah River Site, respectively. In both cases, the plutonium metal or plutonium oxide would be thermally stabilized, packaged according to DOE-STD-3013-96 (DOE 1996e), and placed in interim storage pending disposition in accordance with decisions reached under the Surplus Plutonium Disposition EIS (DOE 1997b).

2.4.9 Management of Inorganic (Metal and Others) Residues

Inorganic residues are solids (e.g., metals, ceramics, and oxides) used during production operations that do not have any combustible components. The total quantity of inorganic residues needing processing is approximately 465 kg (1,030 lb) and includes approximately 18 kg (40 lb) of plutonium. The technology/site options analyzed for processing inorganic residues are shown in **Figure 2–11**. The impacts associated with the management of inorganic residues are given in Table 2-20 and Section 4.13.

DOE's preferred processing option for inorganic (metal and others) residues is repackaging without further processing. This is the processing described for inorganic residues in the Rocky Flats Solid Residue Environment Assessment (DOE 1996j). Subsequent to the Notice of Intent to prepare this EIS (DOE 1996b), DOE granted a variance from the safeguards termination limits for the inorganic residues subject to this EIS. This would allow all of the inorganic residues to be processed in the same manner and to be sent to WIPP for disposal as transuranic waste.

2.4.9.1 Alternative 1—No Action

- **Repackage**—These residues would be repackaged, directly without further processing, into metal containers meeting interim safe storage criteria. After repackaging, the residue containers would be sent to an appropriate storage area pending disposal at WIPP.

2.4.9.2 Alternative 2—Process without Plutonium Separation

DOE analyzed two technologies that do not involve plutonium separation for processing inorganic residues: vitrification and blend down with inert materials to the safeguards termination limits. Quantitative analyses of these technologies at Rocky Flats were conducted.

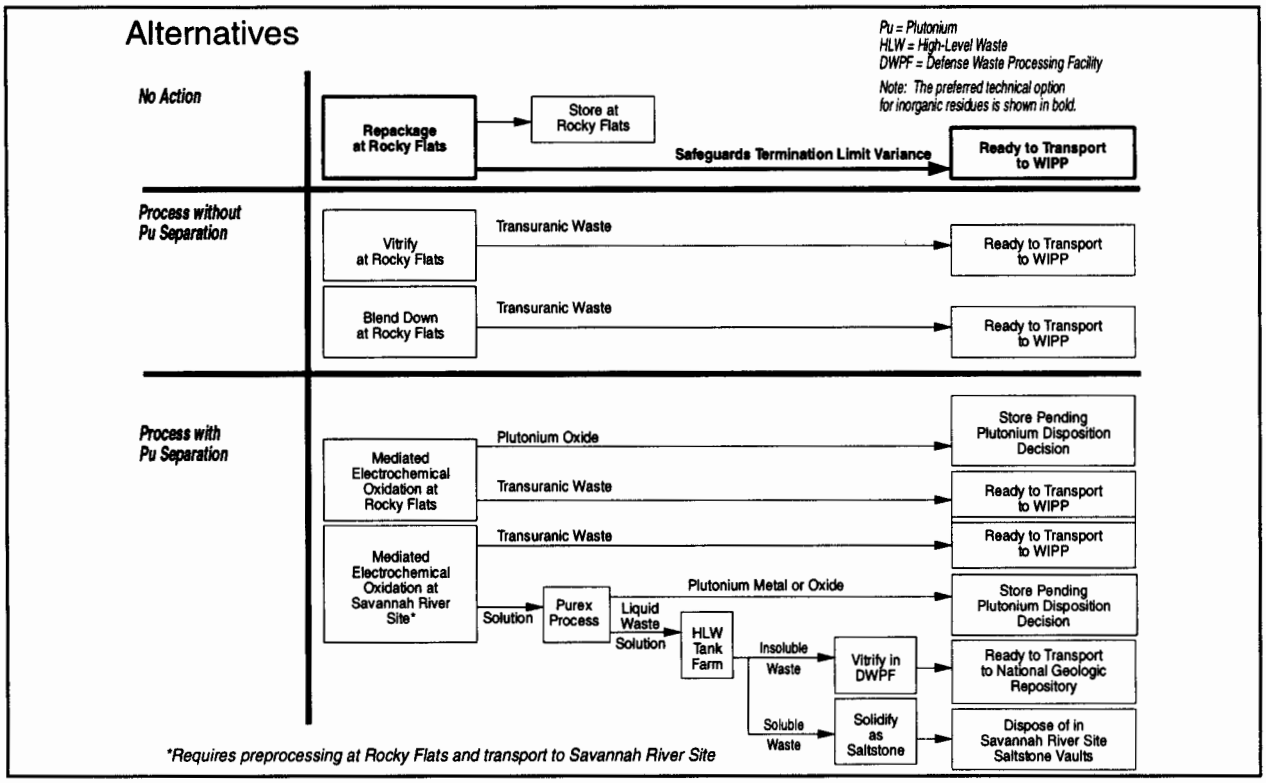

Figure 2–11 Processing Options for Inorganic Residues

- **Immobilization (Vitrification)**—In the vitrification process, the residues would be placed in Module E, Building 707, unpacked, sorted, size reduced (as necessary), and weighed into 8.2-L (2.2-gal) cans. The amount of material added to the cans would be limited to 83.5 g (0.18 lb) of plutonium per can, the maximum permissible for shipment to WIPP. Glass frit would be added to the cans until the resulting material reaches the safeguards termination limit for vitrified material. The mixture would then be melted and encapsulated in glass. After cooling, the vitrified ash would be packaged according to the WIPP waste acceptance criteria and placed in interim storage pending disposal at WIPP. The process is considered to be a proven technology. Activities are underway to optimize the process and reduce the steps necessary to achieve an acceptable waste form.

- **Blend Down**—The plutonium concentration of the residues would be decreased by blending with an inert material for disposal at WIPP without further processing. The residues would be moved to Module B, Building 707, and bagged into the glovebox. Then the residues would be unpacked, size-reduced as necessary, diluted by mixing with an inert material (including an absorbent to dry any free liquids), packaged according to the WIPP waste acceptance criteria, and placed in interim storage pending disposal at WIPP.

2.4.9.3 Alternative 3—Process with Plutonium Separation

DOE analyzed mediated electrochemical oxidation for processing inorganic residues with plutonium separation. Quantitative analyses of the impacts of implementing this technology at Rocky Flats and the Savannah River Site were conducted.

- **Mediated Electrochemical Oxidation**—This process was described previously in Section 2.4.3.3 and Section 2.4.1.3 for Rocky Flats and the Savannah River Site, respectively.

2.4.10 Management of Scrub Alloy

Scrub alloy is a solid metal mixture of magnesium, aluminum, americium, and plutonium that was generated during the salt scrub process of molten salt extraction salts and the anode alloy processing of electrorefining anode heels. Some of the scrub alloy is from developmental programs and contains calcium/gallium or calcium/cerium. The total quantity of scrub alloy at Rocky Flats needing processing is approximately 700kg (1,540 lb) and includes approximately 200 kg (440 lb) of plutonium. The processing technology/site options analyzed for scrub alloy are shown in **Figure 2–12**. The impacts associated with the management of scrub alloy are presented in Table 2-21 and Section 4.14.

DOE has identified the Purex process at the Savannah River Site as the preferred processing option for scrub alloy. The Purex process is the traditional methodology for processing scrub alloy from Rocky Flats.

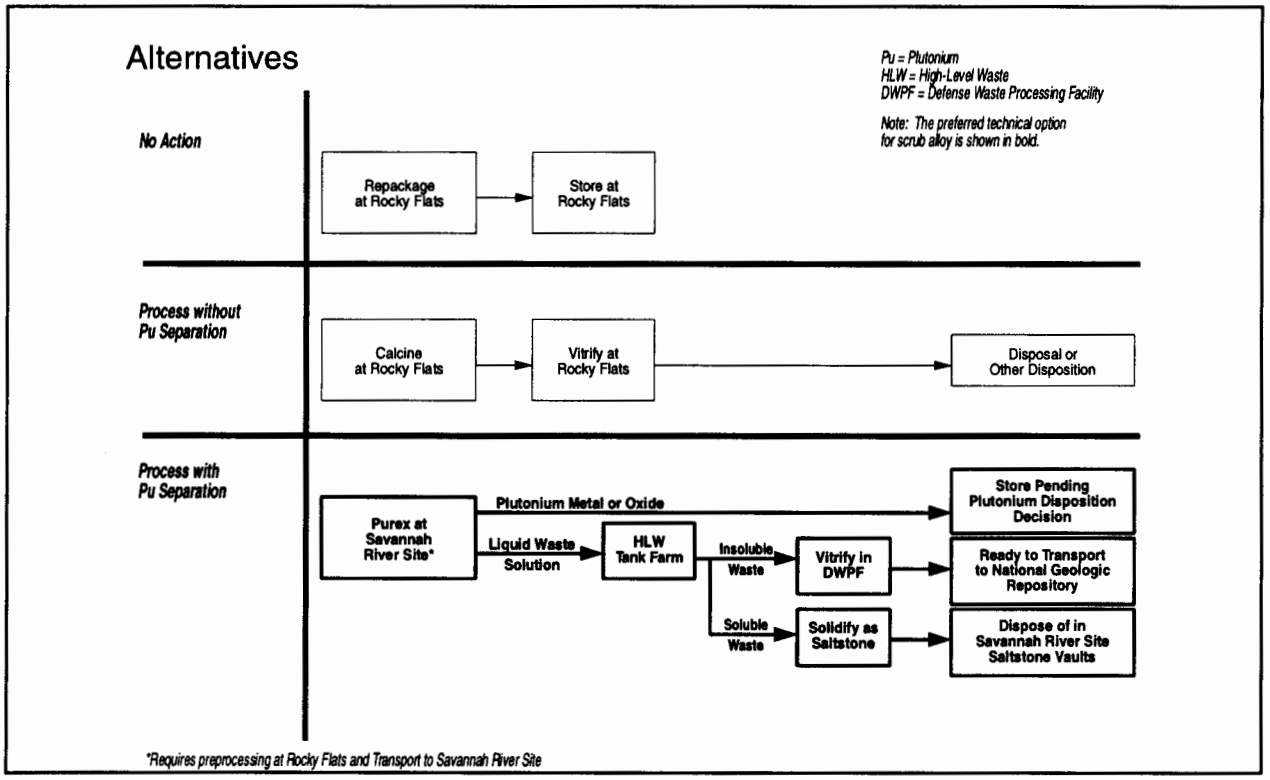

Figure 2–12 Processing Options for Scrub Alloy

2.4.10.1 Alternative 1—No Action

- **Continued Storage (Repack as Necessary)**—In the No Action Alternative, scrub alloy would continue to be stored in vaults at Rocky Flats until a suitable disposition is determined. The material would be monitored for leaks and deterioration of the packaging. As repackaging becomes necessary, the drums would be unpacked and the packages entered into a glovebox, where the scrub alloy buttons would be placed in new cans. The cans would be removed from the glovebox and placed in new drums for safe and secure storage until a final disposition decision is made by DOE.

2.4.10.2 Alternative 2—Process without Plutonium Separation

DOE analyzed calcination of scrub alloy followed by vitrification for processing of scrub alloy without plutonium separation. Quantitative analysis of the impacts of implementing this technology was conducted at Rocky Flats.

- **Calcination/Vitrification**—The vitrification process proposed by Rocky Flats for scrub alloy requires two steps. First, the scrub alloy would be converted to an oxide by burning and calcining at 600°C (1,110°F) and 1,000°C (1,830°F), respectively. Then the calcined material would be blended with sufficient glass frit to make a product that would satisfy the safeguards termination limits then heated in a furnace to a temperature of 700 to 1,300°C (1,290 to 2,370°F). The end product would consist of a vitrified monolith containing less than 5 percent plutonium. The material would then be packaged and placed in interim storage pending disposal or other disposition.

  Because calcination of powdered or granular materials in muffle furnaces is considered to be a proven technology and plutonium metals and other alloys have been routinely burned in the past, calcination of scrub alloy is considered to be a low-risk technology, although it has not been specifically proven in this context. The vitrification process of fusing the metal oxide with glass frit in a muffle furnace to form a non-uniform, amorphous, encapsulated product should be identical to the vitrification process described for other materials in this EIS.

  This disposition of scrub alloy through a calcination and vitrification process was not envisioned as a disposal approach at the time of the WIPP Supplemental EIS (DOE 1997a) and therefore was not included in the WIPP Baseline Inventory Report. Further NEPA review will be needed for disposal of the transuranic waste generated from processing the scrub alloy. In the event that this technology were to be implemented, the resulting transuranic waste (although of satisfactory composition and form) might be subject to disposal delays because of the necessity to revise regulatory documentation. Because this material has historically been considered to be "War Reserve" material, its final disposition to WIPP has not been programmatically evaluated.

2.4.10.3 Alternative 3—Process with Plutonium Separation

DOE analyzed the Purex process for processing of scrub alloy with plutonium separation. A quantitative analysis of the impacts of implementing this technology at the Savannah River Site was conducted.

- **Purex Process**—Scrub alloy would be packaged for shipment at Rocky Flats and shipped to the Savannah River Site. At the Savannah River Site, the scrub alloy would be received at the 235-F Storage Facility and then transferred to a Canyon facility where it would be dissolved in nitric acid. The solution would be processed through a finishing line as with other stabilization processes. The product would be plutonium metal or oxide that would be thermally stabilized, packaged according to DOE-STD-3013-96 (DOE 1996e), and placed in interim storage in the Actinide Packaging and Storage Facility pending disposition in accordance with decisions reached under the Surplus Plutonium Disposition EIS (DOE 1997b). The Purex process is considered to be a proven technology at the Savannah River Site.

2.5 Strategic Management Approaches

Alternatives for processing the Rocky Flats plutonium residues and scrub alloy have been constructed by selecting a particular processing technology and management site for each of the material categories of plutonium residues and scrub alloy. The environmental impacts from selecting any particular scenario are equal to the sum of the impacts from each material category/technology/site combination used to construct the

particular alternative. However, DOE will need to consider each material category or subcategory separately in deciding how to proceed with the processing of these materials for disposal at WIPP or other disposition.

Strategic management approaches based on a general theme are described in this section. The approaches are material/technology/site combinations for the No Action Alternative, DOE preferred management approach, and a set of six additional management approaches. The six additional management approaches assist in the decision making process by providing the reader a wide range of potential processing scenarios and associated impacts. The environmental impacts for each of the eight alternatives are presented in Table 2-22 and Section 4.22. The technologies and sites considered for each material category are described in detail in Sections 2.4.1 through 2.4.10.

2.5.1 No Action Alternative

The stabilization technologies that represent the No Action Alternative are those analyzed in the Solid Residue Environmental Assessment (DOE 1996j). The stabilization of scrub alloy was not addressed in the Solid Residue Environmental Assessment. The No Action Alternative for scrub alloy is continued storage at Rocky Flats with repackaging, as necessary. Some of the materials may be subjected to more than one processing technology conducted in series (e.g., some of the incinerator ash will be calcined and then cemented or repackaged). The material categories and the stabilization technologies used for the No Action Alternative are listed in **Table 2–2** and are also discussed in the sections for each material category, Sections 2.4.1 through 2.4.10. All of the stabilization activities would occur at Rocky Flats.

Table 2–2 Stabilization Technology Used in the No Action Alternative for Each Material Category

Material	*No Action Alternative*
Incinerator ash residues	Calcination followed by cementation or repackaging
Sand, slag, and crucible residues	Calcination followed by cementation or repackaging
Graphite fines residues	Calcination followed by cementation or repackaging
Inorganic ash residues	Calcination followed by cementation or repackaging
Molten salt extraction/electrorefining salt residues	Pyro-oxidation
Direct oxide reduction salt residues	Pyro-oxidation
Aqueous-contaminated combustible residues	Neutralize/dry
Organic-contaminated combustible residues	Wash/thermal desorption/steam passivation
Dry combustible residues	Repackage
Plutonium fluoride residues	Acid dissolution/process to plutonium oxide
High-efficiency particulate air filter media residues	Neutralize/dry
Ful Flo filter media residues	Neutralize/dry
Sludge residues	Filter/dry
Glass residues	Neutralize/dry
Graphite residues	Repackage
Inorganic (metal and others) residues	Repackage
Scrub alloy	Repackage

2.5.2 Preferred Management Approach

In this Draft EIS, DOE has identified a preferred technology for processing some of the Rocky Flats plutonium residues and scrub alloy, but has not identified a preferred technology for all of the material categories. A preferred method will be specified for all of the material categories in the Final EIS. The material categories

and DOE's preferred processing methods are listed in **Table 2–3** and are also discussed in the sections for each material category, in Section 2.4.

Table 2–3 Preferred Processing Technology and Site for Each Material Category

Material	*Preferred Process Option*
Ash residues (incinerator ash)	Vitrification at Rocky Flats (See Section 2.4.1)
Ash residues (sand, slag, and crucible)	Purex process at the Savannah River Site (Section 2.4.1)
Ash residues (graphite fines)	Vitrification at Rocky Flats (Section 2.4.1)
Ash residues (inorganic)	Vitrification at Rocky Flats (Section 2.4.1)
Molten salt extraction/electrorefining salt residues (sodium chloride/potassium chloride salts)	Salt distillation at Rocky Flats (Section 2.4.2)
Direct oxide reduction salt residues (calcium chloride salts)	Pyro-oxidation at Rocky Flats and water leach at Los Alamos National Laboratory (Section 2.4.2) (No Action for some)
Combustible residues (aqueous-contaminated)	Neutralize/Dry at Rocky Flats* (Section 2.4.3) (No Action)
Combustible residues (organic-contaminated)	Wash/thermal desorption/steam passivation at Rocky Flats* (Section 2.4.3) (No Action)
Combustible residues (dry)	Repackage at Rocky Flats* (Section 2.4.3) (No Action)
Plutonium fluoride residues	Purex process at the Savannah River Site (Section 2.4.4)
Filter media residues	TBD
Sludge residues	TBD
Glass residues	Neutralize/dry at Rocky Flats* (Section 2.4.7) (No Action)
Graphite residues	Repackage at Rocky Flats* (Section 2.4.8) (No Action)
Inorganic (metal and others) residues	Repackage at Rocky Flats* (Section 2.4.9) (No Action)
Scrub Alloy	Purex process at the Savannah River Site (Section 2.4.10)

TBD = To be determined, DOE has not yet selected a preferred processing options.
*DOE granted safeguards termination limit variances for these categories. This allows these materials to be sent to WIPP for disposal as transuranic waste without additional processing. Only part of the direct oxide reduction salts were granted a safeguards termination limits variance.

2.5.3 Other Management Approaches

In addition to the No Action and the Preferred Management Approaches, DOE constructed six other illustrative combinations of selected technologies and sites for each residue and scrub alloy material category as examples of unique management approaches. While these combinations represent a range of reasonable strategic management approaches, it is important to recognize that these are only six of a myriad of unique alternatives that could have been constructed for the materials subject to this EIS. These approaches were constructed to illustrate for the public and DOE decision makers the range of approaches that could be available and the impacts of those selected approaches. The combinations of technologies and sites were chosen to illustrate management approaches that emphasize the following:

- minimize total process duration at Rocky Flats,
- minimize cost,
- conduct all processing at Rocky Flats,
- conduct fewest actions at Rocky Flats,
- select processes yielding the greatest amount of plutonium separation, and
- select processes without plutonium separation.

The processing technologies and sites for each material category used to construct each management approach are shown in **Table 2–4**.

Table 2–4 Selected Management Approaches for Processing Rocky Flats Plutonium Residues and Scrub Alloy

Material Category	*Minimize Total Process Duration at Rocky Flats*[a]	*Minimize Cost*	*Conduct All Processes at Rocky Flats*	*Conduct Fewest Actions at Rocky Flats*	*Process with Maximum Plutonium Separation*	*Process without Plutonium Separation*
Incinerator Ash Residues	Preprocess at Rocky Flats and MEO at SRS	Vitrify at Rocky Flats	Vitrify at Rocky Flats	Preprocess at Rocky Flats and MEO at SRS	Preprocess at Rocky Flats and MEO at SRS	Vitrify at Rocky Flats
Graphite Fines Ash Residues	Preprocess at Rocky Flats and MEO at SRS	Vitrify at Rocky Flats	Vitrify at Rocky Flats	Preprocess at Rocky Flats and MEO at SRS	Preprocess at Rocky Flats and MEO at SRS	Vitrify at Rocky Flats
Sand, Slag, and Crucible Ash Residues	Preprocess at Rocky Flats and Purex at SRS	Vitrify at Rocky Flats	Vitrify at Rocky Flats	Preprocess at Rocky Flats and Purex at SRS	Preprocess at Rocky Flats and Purex at SRS	Vitrify at Rocky Flats
Inorganic Ash Residues	Vitrify at Rocky Flats	Vitrify at Rocky Flats	Vitrify at Rocky Flats	Vitrify at Rocky Flats	Vitrify at Rocky Flats[b]	Vitrify at Rocky Flats
Molten Salt Extraction/ Electrorefining Salt Residues	Salt Scrub at Rocky Flats and Purex at SRS	Salt Scrub at Rocky Flats and Purex at SRS	Salt Distillation at Rocky Flats	Preprocess at Rocky Flats and Salt Distillation at LANL	Salt Distillation at Rocky Flats	Blend Down at Rocky Flats
Direct Oxide Reduction Salt Residues	Salt Scrub at Rocky Flats and Purex at SRS	Salt Scrub at Rocky Flats and Purex at SRS	Water Leach at Rocky Flats	Preprocess at Rocky Flats and Water Leach at LANL	Preprocess at Rocky Flats and Water Leach at LANL	Blend Down at Rocky Flats
Aqueous-Contaminated Combustible Residues	Blend Down at Rocky Flats	Blend Down at Rocky Flats	Neutralize/Dry at Rocky Flats	Neutralize/Dry at Rocky Flats	MEO at Rocky Flats	Neutralize/Dry at Rocky Flats
Organic-Contaminated Combustible Residues	Blend Down at Rocky Flats	Blend Down at Rocky Flats	Thermal Desorption/ Steam Passivation at Rocky Flats	Thermal Desorption/Steam Passivation at Rocky Flats	MEO at Rocky Flats	Thermal Desorption/ Steam Passivation at Rocky Flats
Dry Combustible Residues	Blend Down at Rocky Flats	Blend Down at Rocky Flats	Repackage at Rocky Flats	Repackage at Rocky Flats	MEO at Rocky Flats	Repackage at Rocky Flats
Plutonium Fluoride Residues	Preprocess at Rocky Flats and Purex at SRS	Preprocss at Rocky Flats and Purex at SRS	Acid Dissolution/ Plutonium Oxidation at Rocky Flats	Preprocess at Rocky Flats and Purex at SRS	Preprocess at Rocky Flats and Purex at SRS	Blend Down at Rocky Flats
HEPA Filter Media Residues	Blend Down at Rocky Flats	Blend Down at Rocky Flats	Vitrify at Rocky Flats	Vitrify at Rocky Flats	MEO at Rocky Flats	Vitrify at Rocky Flats
Ful Flo Filter Media Residues	Blend Down at Rocky Flats	Blend Down at Rocky Flats	Sonic Wash at Rocky Flats	Sonic Wash at Rocky Flats	MEO at Rocky Flats	Sonic Wash at Rocky Flats
Sludge Residues	Vitrify at Rocky Flats	Blend Down at Rocky Flats	Vitrify at Rocky Flats	Vitrify at Rocky Flats	Acid Dissolution/ Plutonium Oxidation at Rocky Flats	Vitrify at Rocky Flats
Glass Residues	Vitrify at Rocky Flats	Blend Down at Rocky Flats	Neutralize and Dry at Rocky Flats	Neutralize and Dry at Rocky Flats	MEO at Rocky Flats	Neutralize and Dry at Rocky Flats

Material Category	Minimize Total Process Duration at Rocky Flats[a]	Minimize Cost	Conduct All Processes at Rocky Flats	Conduct Fewest Actions at Rocky Flats	Process with Maximum Plutonium Separation	Process without Plutonium Separation
Graphite Residues	Preprocess at Rocky Flat and MEO at SRS	Repackage at Rocky Flats	Repackage at Rocky Flats	Repackage at Rocky Flats	Preprocess at Rocky Flats and MEO at SRS	Repackage at Rocky Flats
Inorganic Residues	Preprocess at Rocky Flats and MEO at SRS	Repackage at Rocky Flats	Repackage at Rocky Flats	Repackage at Rocky Flats	Preprocess at Rocky Flats and MEO at SRS	Repackage at Rocky Flats
Scrub Alloy	Preprocess at Rocky Flats and Purex at SRS	Preprocess at Rocky Flats and Purex at SRS	Calcine and Vitrify at Rocky Flats[c]	Preprocess at Rocky Flats and Purex at SRS	Preprocess at Rocky Flats and Purex at SRS	Calcine and Vitrify at Rocky Flats[d]

[a] Minimum time to process residues and scrub alloy at Rocky Flats for shipment to the Savannah River Site, Los Alamos National Laboratory, or WIPP. All residue and scrub alloy processing in Rocky Flats Building 707 would be on the minimum process time critical path.
[b] No process with plutonium separation is available.
[c] Calcination/vitrification is the only proposed action process for scrub alloy analyzed at Rocky Flats.
[d] Calcination/vitrification is the only process without plutonium separation analyzed for scrub alloy.

HEPA = High-efficiency particulate air
SRS = Savannah River Site
MEO = Mediated electrochemical oxidation
LANL = Los Alamos National Laboratory

2.6 STORAGE METHODS AND ISSUES

In this EIS, storage was considered for two categories of materials: (1) Plutonium residues and scrub alloy and (2) plutonium metal and oxides. Rocky Flats transuranic waste storage capacity is not explicitly addressed in this EIS; however, it may become an issue if WIPP does not open on time.

2.6.1 Storage of Plutonium Residues and Scrub Alloy

DOE has provided guidance on the interim safe storage of plutonium-bearing solid materials (i.e., storage for 20 years or less) in *Criteria for Interim Safe Storage of Plutonium-Bearing Solid Materials* (DOE 1995b). These criteria were promulgated to provide a DOE-wide consistent approach to assuring safe interim storage of these plutonium-bearing materials while effecting the DOE Implementation Plan for the Defense Nuclear Facilities Safety Board's Recommendation 94-1, dated February 28, 1995.

Alternatives 2 and 3 (the proposed processing without and with plutonium separation, respectively) would produce transuranic wastes that may be packaged using the pipe component. The pipe component is the baseline storage container for plutonium residues that meet requirements for disposal at WIPP. This container may also be used for transuranic waste (DOE 1996f). This container may be used for storing plutonium residues and for transuranic waste. This container is a flanged stainless-steel pipe measuring 15.2 or 30.5 cm (6 or 12 inches [in]) in diameter. A lid bolted to the flange allows the residue material to be sealed within the pipe, which is placed inside a 210-L (55-gal) storage drum (**Figure 2–13**). The container may be fitted with a high-efficiency particular air filter vent to release any hydrogen gas produced by radiolysis of water or organic materials. The pipe component would be used for packaging of fissile gram equivalent–limited materials to achieve maximum loading of TRUPACT II shipping containers in a manner that would prevent intermixing and criticality concerns in the event of a transportation accident. The WIPP Final Supplemental EIS-II (DOE 1997a) includes a discussion of the pipe component and incorporates loading TRUPACT IIs to 2,800 fissile gram equivalents. Accordingly, the WIPP waste acceptance criteria are being revised to include the pipe component and this subsequent loading limit. The pipe component would also block radiation emitted by high americium content materials at Rocky Flats, allowing them to be classified as contact-handled transuranic waste.

Before placement in a pipe component, processed plutonium residues would be packaged in containers (e.g., "bagout bags" and "produce cans") that provide additional barriers to control inadvertent release or dispersion of the materials. Produce cans are small sealed cans in which the material would be placed while in the glovebox. Bagout bags are the plastic bags used in removing containers from a glovebox.

Residues and scrub alloy awaiting transfer to another onsite facility or an offsite facility (Savannah River Site or Los Alamos National Laboratory) for further processing would be stored temporarily in one of a number of double-containment, intrasite packages. Prior to shipment offsite, the double-contained packages would be placed into Type B containers authorized by the U.S. Department of Transportation and DOE for shipment (Section 2.8.1).

2.6.2 Storage of Plutonium Metal and Oxides

Processing the residues and scrub alloy under Alternative 3 would result in stabilized plutonium metal or oxides, which would be placed into safe and secure storage pending disposition in accordance with decisions reached under the Surplus Plutonium Disposition EIS (DOE 1997b).

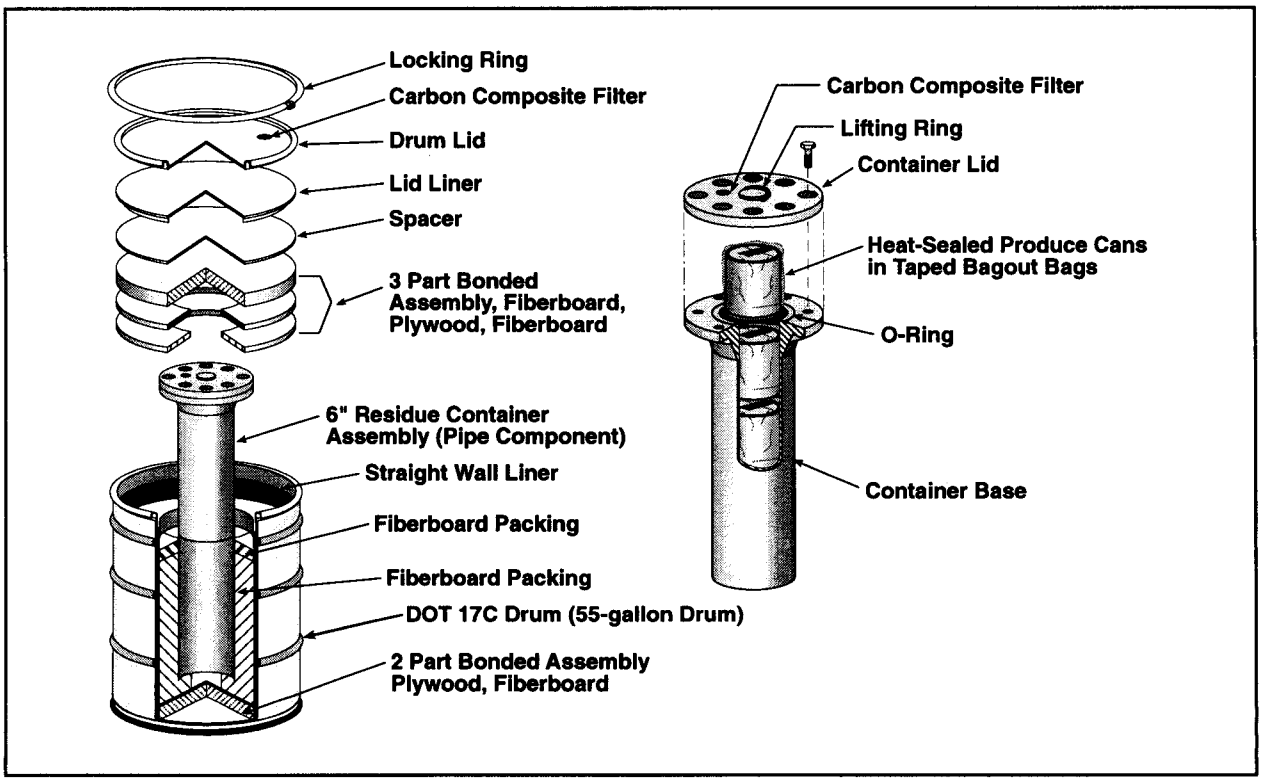

Figure 2–13 Pipe Component

To ensure safe interim storage conditions, DOE has issued guidance that plutonium should not be stored in the form of plutonium solutions, metal turnings, or particles with a specific surface area greater than 1 square centimeter per gram (DOE 1996e). Plutonium metal items should be free of hazardous or pyrophoric materials or corrosion products. Plutonium oxides should be stabilized at 1,000°C (1,830°F) for 1 hour. In packaging, no plastic should contact plutonium metal or oxide, and metal should be packaged in as dry and inert an atmosphere as possible. Existing metal packages should be inspected for significant external corrosion, and packages containing more than 0.5 kg (1.1 lb) plutonium metal should be weighed annually (DOE 1996e). These storage methods would be used under Alternative 1 (the No Action Alternative).

Safe, long-term storage of plutonium is addressed by DOE-STD-3013-96, *DOE Standard: Criteria for Preparing and Packaging Plutonium Metals and Oxides for Long-Term Storage* (DOE 1996e). This Standard establishes safety criteria for packaging plutonium metals and stabilized plutonium oxides to ensure safe storage for at least 50 years. The Standard applies to packaging for safe storage of plutonium metals, alloys, and oxides that contain at least 50 percent plutonium by mass. To meet the Standard, materials containing plutonium must be in stable forms and must be packaged in containers designed to maintain their integrity both under normal storage conditions and during anticipated handling accidents. The processes in Alternative 3 would produce plutonium metals and oxides that satisfy this Standard.

2.7 Disposal or Other Disposition

Under the No Action Alternative, plutonium residues would be stabilized in preparation for disposal at WIPP and DOE would apply the safeguard termination limits variances, as discussed in more detail in Section 2.1, Alternative 1, above. Scrub alloy would be packaged for interim storage pending disposal decisions to be made under the Surplus Plutonium Disposition EIS (DOE 1997b). Under the Proposed Action, however,

materials that are the subject of this EIS would be either processed and packaged in accordance with the WIPP waste acceptance criteria for disposal at WIPP or, in the case of plutonium metal or oxide, would be packaged according to DOE-STD-3013-96 (DOE 1996e) and placed in interim storage at the processing site pending disposition in accordance with decisions as noted above. During processing, some waste streams might be produced with the characteristics of low-level waste or low-level mixed waste. These waste streams would be managed according to the waste management practices for these waste types at the processing site.

2.7.1 Disposal of Transuranic Waste at WIPP

Transuranic waste generated from processing residues would be processed to meet the waste acceptance criteria for transuranic wastes required by WIPP (DOE 1996i). A summary of the nuclear and chemical properties of materials to meet these criteria are shown in **Table 2–5**. The environmental impacts of shipping transuranic wastes to WIPP and the impacts of disposal at that site are covered in the *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement* (DOE 1997a).

For the purposes of this EIS, it is assumed that the TRUPACT II shipping containers would be loaded with up to 2,800 fissile gram equivalents of plutonium-239 (up to 200 fissile gram equivalents of plutonium-239 per drum for each of 14 drums). As shown in Table 2-5, the WIPP waste acceptance criteria currently permit only 325 fissile gram equivalents of plutonium-239 to enter WIPP in a TRUPACT II. The Nuclear Regulatory Commission (NRC 1997) certified the 2,800 fissile gram equivalents loading for the TRUPACT II in February 1997. The WIPP Supplemental EIS (DOE 1997a) analyzed the impacts of transporting the Rocky Flats waste utilizing the higher TRUPACT II loading. It is anticipated that the WIPP waste acceptance criteira will be revised to reflect the higher TRUPACT II loading approved by the Nuclear Regulatory Commission.

Table 2–5 Summary of Selected WIPP Waste Acceptance Criteria

Criterion	Requirements
Nuclear Criticality (plutonium-239 fissile gram equivalents)	Less than 200 fissile gram equivalents of plutonium-239 per drum Less than 325 fissile gram equivalents of plutonium-239 per TRUPACT II
Plutonium-239 Equivalent Activity	Less than or equal to 1,800 curies plutonium-239 equivalent activity for solidified/vitrified waste
Contact Dose Rate	Less than or equal to 200 millirem per hour
Thermal Power	Less than 40 watts per TRUPACT II
Transuranic Alpha Activity	Greater than 100 nanocuries per gram of waste matrix
Pyrophoric Materials	Less than 1% radionuclide pyrophorics and no nonradionuclide pyrophorics
Explosives, Corrosives, and Compressed Gases	No compressed gases or ignitable, reactive, or corrosive wastes
Flammable Volatile Organic Chemicals	Less than or equal to 500 parts per million in container headspace

2.7.2 Disposition of Plutonium Oxide and Metal

Plutonium that is separated as either plutonium metal or plutonium oxide under Alternative 3 would be packaged according to DOE-STD-3013-96 (DOE 1996e) and placed in safe and secure storage pending disposition by immobilization or conversion to mixed oxide fuel in accordance with decisions reached under the Surplus Plutonium Disposition EIS. DOE issued a "Notice of Intent to Prepare an Environmental Impact Statement on Surplus Plutonium Disposition" in the *Federal Register* on May 22, 1997 (DOE 1997b).

2.8 TRANSPORTATION

Transportation of plutonium residues or scrub alloy would not occur under Alternative 1 (No Action) or Alternative 2 (processing without plutonium separation) because all processing would occur at Rocky Flats. Under Alternative 3 (processing with plutonium separation), however, some plutonium residues and scrub alloy would be transported to other DOE sites for processing that involves plutonium separation. The transportation of other plutonium-bearing materials (e.g., plutonium metal, plutonium oxide, and transuranic waste) is analyzed in other DOE EISs (Sections 1.6.4 and 1.6.6).

The number of shipments that could potentially be sent to the Savannah River Site or Los Alamos National Laboratory under Alternative 3 for each processing technology is shown in **Table 2–6**. These shipments cannot be added to obtain the total shipments because that would lead to double counting of some shipments. Incinerator ash and firebrick fines may be processed using either the Purex process or the mediated electrochemical oxidation process at the Savannah River Site. Accordingly, shipments of these materials are counted for both processes. In addition, some uncertainty exists concerning whether some pyrochemical salt materials will be processed with the molten salt extraction/electrorefining salt residues or with the direct oxide reduction salt residues. To be conservative, these materials were analyzed with both salt categories. Accordingly, these materials were included in the shipments for both salts to Los Alamos National Laboratory.

Table 2–6 Shipments of Plutonium Residues and Scrub Alloy for Processing with Plutonium Separation

Material Category	Process/Site	Shipments
Incinerator Ash and Firebrick Fines[a] Residues	Purex at Savannah River Site Mediated Electrochemical Oxidation at Savannah River Site	116 86
Sand, Slag, and Crucible Residues	Purex at Savannah River Site	26
Graphite Fines Residues	Mediated electrochemical oxidation at Savannah River Site	7
Molten Salt Extraction/ Electrorefining Salt Residues	Water Leach at Los Alamos National Laboratory Purex at Savannah River Site (following salt scrub at Rocky Flats)	52 24
Direct Oxide Reduction Salt Residues	Salt Distillation at Los Alamos National Laboratory Purex at Savannah River Site (following salt scrub at Rocky Flats)	13 4
Plutonium Fluoride Residues	Purex at Savannah River Site	7
Graphite Residues	Mediated Electrochemical Oxidation at Savannah River Site	16
Inorganic (metal and others) Residues	Mediated Electrochemical Oxidation at Savannah River Site	4
Scrub Alloy	Purex at Savannah River Site	6

[a] Firebrick fines would not be processed by the Purex process.

DOE's goal is to provide a level of safety and health for DOE transportation operations that is equivalent to, or greater than that provided by compliance to applicable Federal, State, Tribal, and local regulations. In addition to meeting applicable shipping containment and confinement requirements in 10 Code of Federal Regulations (CFR) Part 71 and 49 CFR, packaging for transport of this material must be certified separately by DOE (DOE 1994b).

Four aspects of ground transportation are discussed in the following sections: (1) the ground transportation system, (2) the ground transportation route selection process, (3) emergency planning, and (4) security considerations.

2.8.1 Ground Transportation System Descriptions

Currently, DOE anticipates that any transportation of the scrub alloy and those plutonium residues with the highest plutonium concentrations would definitely be required to be made through use of the Transportation Safeguards System and shipped using the Safe Secure Trailer System, which is a secure system, some details of which are classified. Nevertheless, DOE is evaluating whether it would be possible to use commercial carriers for shipments of plutonium residues containing low concentrations of plutonium and whether there would be any advantage to such shipments. In both cases, plutonium residues and scrub alloy would be shipped from Rocky Flats to other DOE sites in Type B containers. The containers used by DOE for these shipments are authorized by the Department of Transportation and DOE. The single-containment 6M container may be used to transport plutonium residues containing less than 20 curies and scrub alloy.

In general, plutonium-bearing residues that are in a granular or powder form would be shipped in other Type B packaging, such as the double-containment 9968 or 9975 containers. However, small amounts of granular or powder materials can be shipped in 6M. This approach could be used where cost efficient. The 6M and 9975 containers are shown in **Figure 2–14**. Some of the plutonium residues could also be transported in the TRUPACT II, a reusable certified Type B shipping packaging for plutonium-bearing wastes. A cutaway view of the TRUPACT II is shown in **Figure 2–15**. The TRUPACT II containers were specifically designed to transport transuranic waste to WIPP.

2.8.1.1 The Safe Secure Trailer System

The Safe Secure Trailer System is an integral part of the Transportation Safeguards System operated by the DOE Transportation Safeguards Division for the DOE Office of Defense Programs. The Transportation Safeguards System normally is used to transport nuclear weapons, nuclear weapons components, and special nuclear materials. The Safe Secure Trailer System is a specially designed 18-wheel tractor-trailer, shown in **Figure 2–16**, which incorporates various deterrents to prevent unauthorized removal of cargo. All Safe Secure Trailer System components undergo periodic preventive maintenance inspections and extensive maintenance checks before every trip. Additionally, DOE conducts periodic audits and surveys to ensure DOE transportation system compliance with Department of Transportation regulations.

2.8.1.2 The Commercial Transport System

The use of commercial transportation would be based on DOE's determination that the special protection and safety requirements mandated by the Nuclear Materials Safeguards Category (DOE 1994a) are not needed because the amount of plutonium present does not require strict material control and accountability. The vehicles that would be used in this transportation system would meet maintenance and safety standards established by DOE Order 460.1A (DOE 1996c) and the Department of Transportation 49 CFR Part 396.

2.8.2 Ground Transportation Route Selection Process

DOE would develop the ground transportation routes for any residue or scrub alloy commercial shipments conducted using a transportation planning process that would involve consultation with State and local officials. This EIS describes how nominal routes were chosen, based on Department of Transportation regulations incorporated in DOE Order 460.1A (DOE 1996c) and DOE Order 5610.12 (DOE 1994b). The actual route to be used for any shipment would be chosen based on a detailed and updated transportation planning process performed shortly before the shipment would occur.

Commercial highway routing of nuclear material is systematically determined according to Department of Transportation regulations 49 CFR Parts 171-179 and 49 CFR Part 397. The Department of Transportation

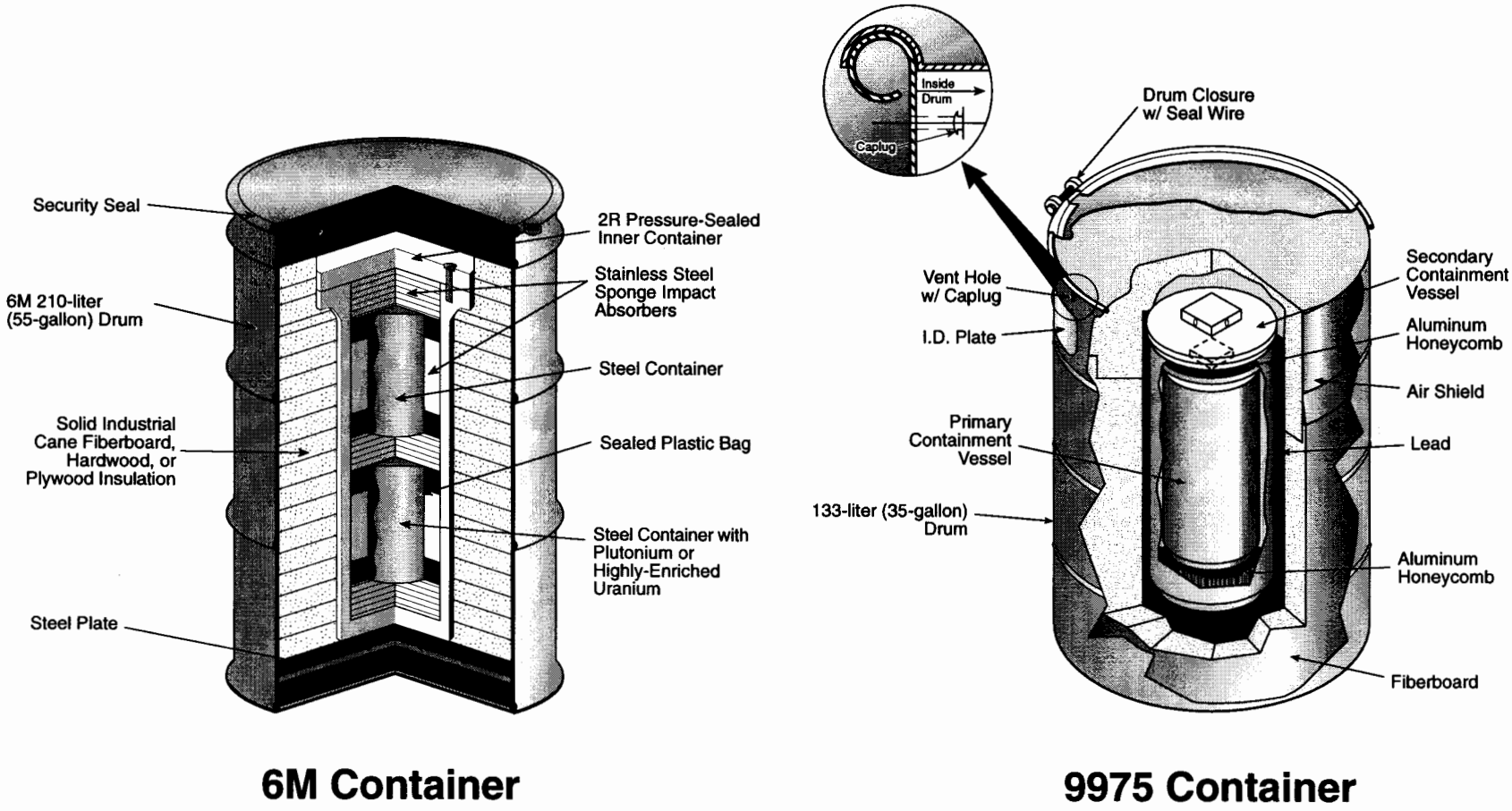

Figure 2–14 Type 6M and 9975 Transport Containers

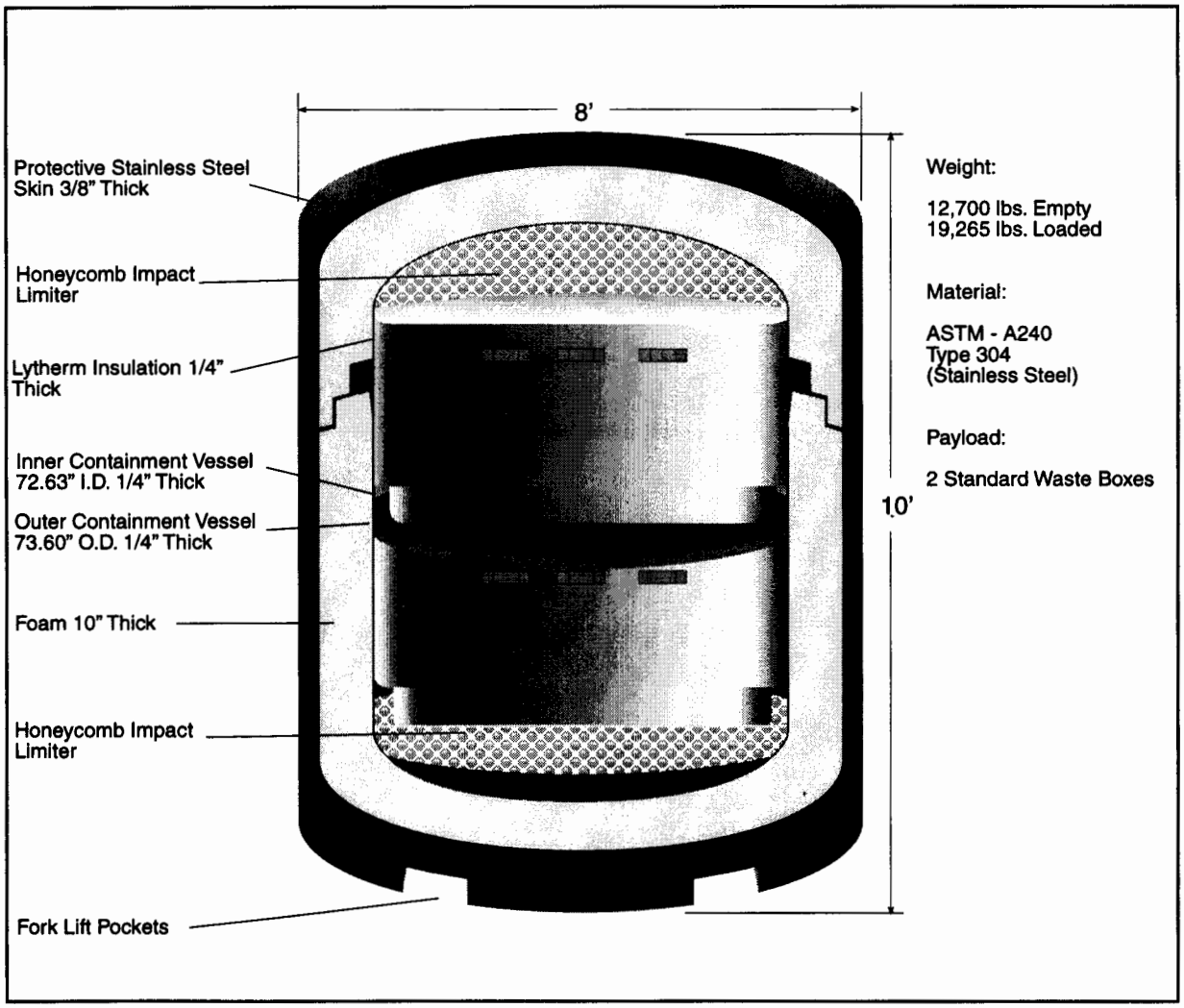

Figure 2–15 TRUPACT II

routing regulations require that shipment of a "highway route controlled quantity" of radioactive material be transported over a preferred highway network, including interstate highways (with preference toward interstate system bypasses and beltways around cities) and State-designated preferred routes. A State or Tribe may designate a preferred route to replace or supplement the interstate system according to Department of Transportation procedures (DOT 1992). Transportation Safeguards Division shipment routes are classified and are not publicly disclosed in order to protect national security interests.

Carriers of highway route controlled quantities are required to use the preferred network except near the beginning or end of the trip when moving from origin to the nearest interstate or from the interstate exit nearest the destination, when making necessary repair or rest stops, or when emergency conditions render the interstate unsafe or impassible. Travel times would be a primary criterion for selecting the preferred route for a shipment, and would be the primary criterion for commercial shipments.

The HIGHWAY computer code may be used for selecting highway routes in the United States. The HIGHWAY database is a computerized road atlas that currently describes approximately 386,400 kilometers (240,000 miles) of roads, including the interstate system and all U.S.-designated highways. In addition, most of the principal State highways and many local and community roads are identified. The code is updated periodically to reflect current road conditions and has been benchmarked against reported mileages and

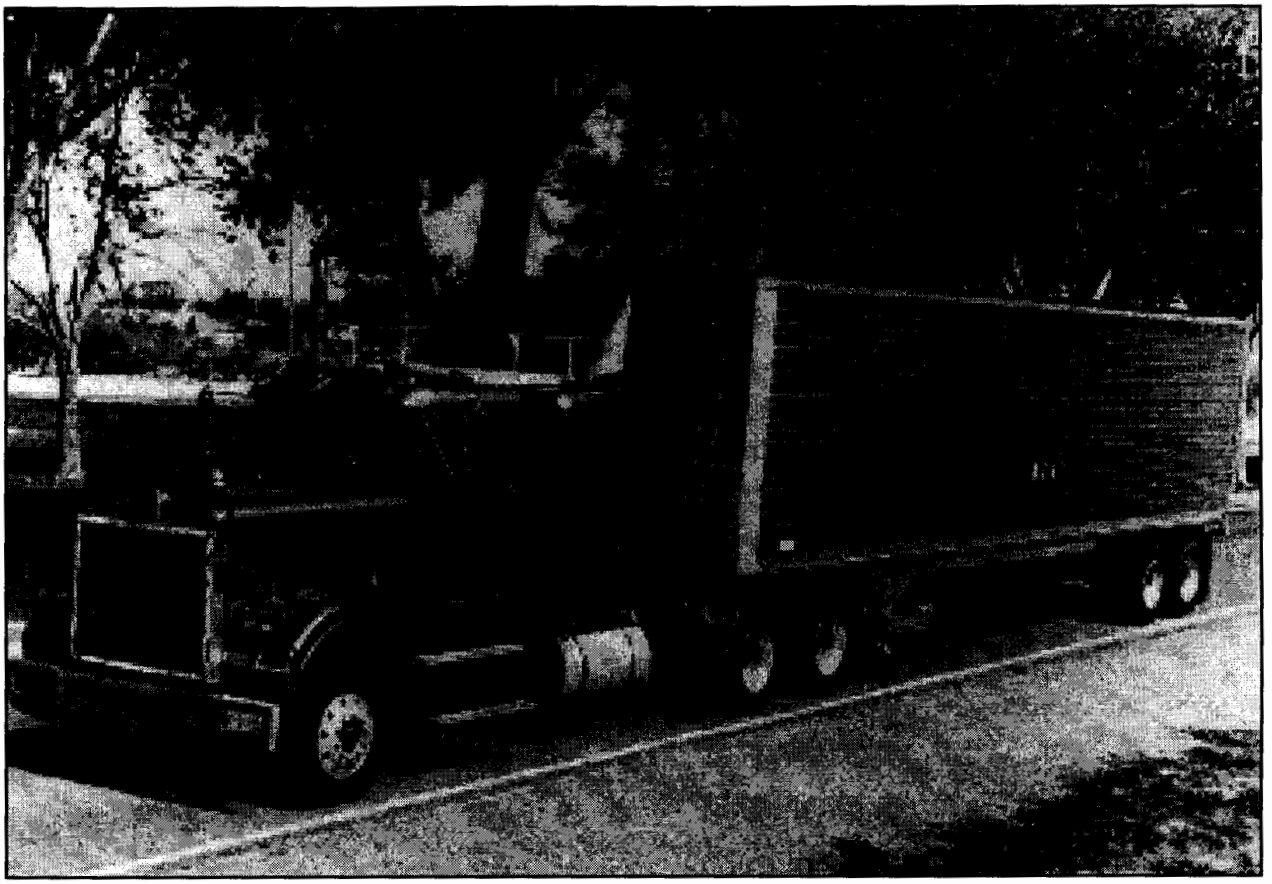

Figure 2–16 Safe Secure Trailer System

observations of commercial truck firms. Features in the HIGHWAY code allow users to select routes conforming to Department of Transportation regulations. Additionally, the HIGHWAY code contains data on population densities along the routes. The distances and populations from the HIGHWAY code are part of the information used for the transportation impact analysis (Appendix E).

Routes that may be used for the shipment of plutonium residues and scrub alloy have been selected using the HIGHWAY code. These routes were selected for risk assessment purposes and do not necessarily represent the actual routes that would be used to transport nuclear materials in the future. Specific routes cannot be identified in advance in part because they would be classified to protect national security interests. In addition, the selection of the actual route to be used would be accomplished near the time of shipment to allow the selection to consider environmental and other conditions that exist, or are predicted to exist, at the time of shipment. Such conditions might include adverse weather conditions, road conditions, bridge closures, and local traffic problems. For security reasons, details about a route would not be publicized before the shipment.

2.8.3 Emergency Management Considerations

Emergency management planning involves Federal, State, Tribal, and local governments and the general public. State, local, and Tribal agencies have responsibilities in responding to an incident involving a DOE shipment within their jurisdiction. Emergency response plans outline the organizations and their responsibilities; emergency response procedures describe how the plan will be implemented.

For ground shipments of nonweapon-related nuclear materials (including the materials addressed in this EIS), State, Tribal, and local jurisdictions along the transportation corridor review DOE's plans and procedures for

response to promote their consistency with State and local actions. DOE offers a variety of emergency response resources and information to supplement the existing response system. The States and DOE have conducted evaluations to determine the current radiological response capabilities and training necessary to maintain and improve existing capabilities to allow personnel to respond effectively to a possible shipment incident.

The DOE Transportation Safeguards Division regularly conducts drills and exercises as part of their training program. DOE developed an exercise program that provides an opportunity to evaluate local and State capabilities. Exercises can enhance learning, test systems, increase awareness, and provide information to evaluate the effectiveness of training. Exercises range from table-top to full-scale exercises. Transportation exercises are held on a rotational basis among the States as needed. Transportation accident exercises are held to test DOE response capabilities and local and State systems.

DOE monitors the status and location of the shipments, while maintaining 24-hour, real-time communication with every convoy. In the event of an emergency, convoy escorts would immediately contact the DOE Emergency Operations Center, which would then alert the State or local authorities who have been designated by the States as points of contact for such emergencies. The Emergency Operations Center would also contact DOE emergency response teams, as appropriate. Law enforcement agencies in each State have been provided information on how to response to a shipment emergency.

As part of the process of preparing this EIS, DOE met with State and local officials from affected States in Kansas City, Missouri, on April 15 and 16, 1997, and in Nashville, Tennessee, on May 7 and 8, 1997, to discuss the potential shipments of Rocky Flats plutonium residues and scrub alloy to other DOE sites for processing. Although the timing and exact routes of these shipments would be classified because of the quantities of plutonium they contain, DOE reviewed its emergency response procedures and solicited participant responses on improvements to its shipping program. DOE is fully committed to working with the State and local communities along the transportation routes to promote the safe passage of these potential shipments.

2.8.4 Security Considerations

The objective of a security system is to analyze security risks and protect against them. In most cases, a security system enhances emergency management capabilities. It is designed to detect, communicate, and respond to an incident or adversarial act directed at the shipment of nuclear material, and it may include equipped, armed (e.g., for nuclear weapons and related components), and trained escorts accompanying the shipment.

A physical security system is implemented by DOE to address health and safety considerations, to facilitate rapid response to incidents, minimize the possibilities for theft or radiological sabotage of nuclear material, and facilitate the location and recovery of shipments that may have come under control of unauthorized persons. Following an incident or detection of a threat directed against the shipment, measures typically are taken to communicate the incident or threat information to an emergency operations center, to initiate predetermined response actions, and to continuously track the shipment. The measures may address neutralizing a malevolent act, recovering material, or mitigating the consequences of an incident. The security measures employed by DOE during operations with either the Commercial Transport System or the Safe Secure Trailer System would assure that health, safety, and environmental considerations during the transport of plutonium residues and scrub alloy would be addressed properly.

2.9 Sites, Technologies, and Issues Not Analyzed

In developing the scope of this EIS, DOE considered many technologies at four candidate sites, including those identified during the initial screening and evaluation process and the public scoping process. The initial screening process DOE used in selecting technologies for detailed analysis in this EIS is described briefly in the following section. DOE's rationale for not analyzing certain technologies and DOE sites in detail is discussed in Section 2.9.2. Issues identified during the public scoping process that are not analyzed or are out of scope are discussed in Sections 2.9.3 and 2.9.4, respectively.

2.9.1 Initial Screening and Evaluation Process

The impacts of stabilizing the Rocky Flats plutonium residues to meet DOE interim safe storage criteria are described in the Solid Residues Environmental Assessment (DOE 1996j). However, the analysis did not address stabilization of scrub alloy. The technologies analyzed in the Environmental Assessment represent the minimum actions that DOE would need to conduct to safely store the plutonium residues at Rocky Flats. The minimum actions that DOE would need to conduct to continue storage of scrub alloy would be to repackage the material whenever it became evident that the current packaging was deteriorating. Accordingly, DOE determined that those processes should represent the No Action Alternative in this EIS.

DOE used a screening process to identify a reasonable set of alternative technologies for detailed analysis in this EIS. The screening process assessed a wide range of potential processing technologies identified in several DOE studies. Additional information on these studies may be found in Section 2.3 and Appendix C.

After identifying a preliminary set of technologies from these studies, DOE screened the technologies further using a set of criteria that included the following:

- direct applicability of the technology to the particular material type,
- maturity and timing of the technology so that processing could be accomplished in the 2002 to 2006 timeframe or earlier to meet site closure targets within reasonable cost,
- experience of the DOE site in employing the technology and availability of the facilities and equipment,
- minimization of worker exposures, and
- amount of secondary wastes generated and existence of appropriate secondary waste disposition methods.

Next, several working sessions were held between DOE Headquarters and site technical and management representatives to better understand the suitability of the technologies to be applied to each material type, the experience of the sites with the technologies, and the capability of the sites to implement the technologies within the desired timeframe. Based on these discussions, DOE identified reasonable technologies to include in this EIS.

The steps in the screening process described above are illustrated in **Figure 2–17.**

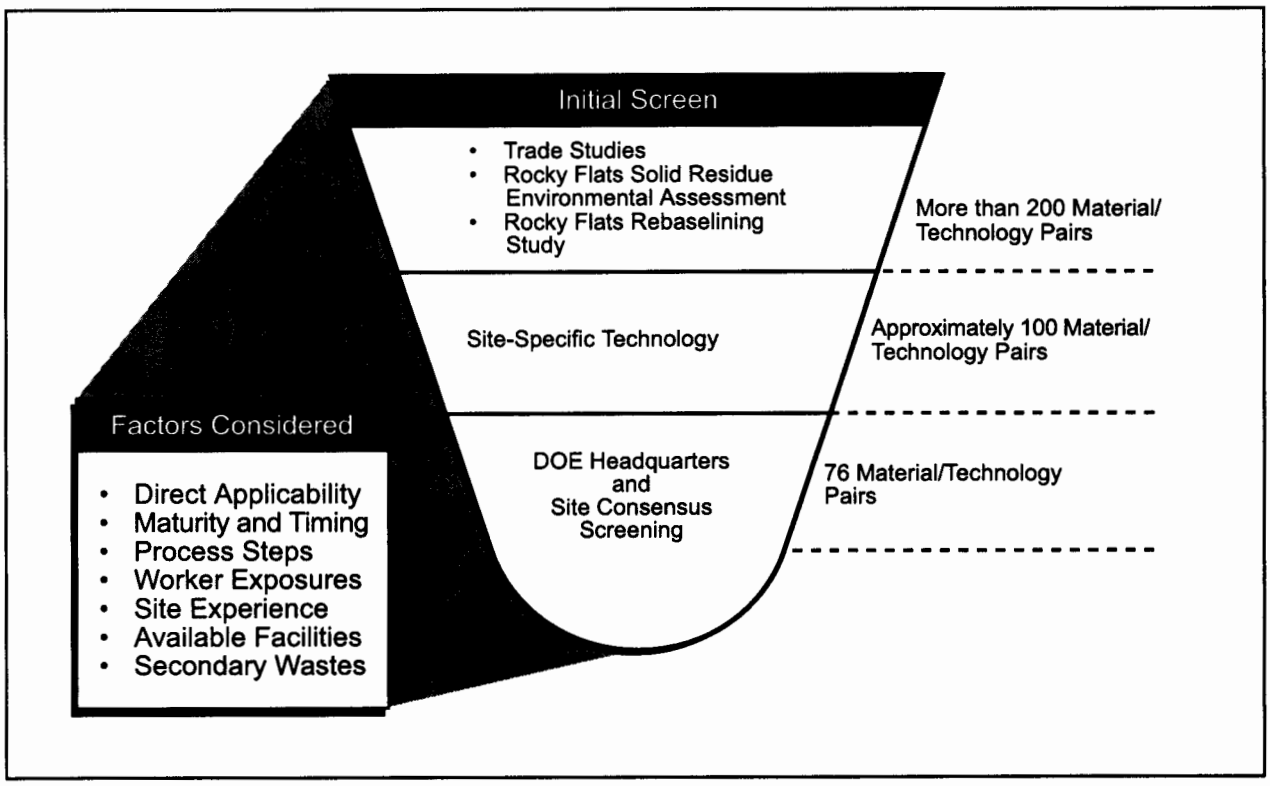

Figure 2–17 Material/Technology/Site Screening Process

2.9.2 Sites and Technologies Not Analyzed

This section discusses DOE's rationale for not further analyzing specific sites and technologies.

For Alternative 2 (Processing without Plutonium Separation), DOE is considering processing only at the Rocky Flats Site. Material transported to another site under this alternative would need to be stabilized, repackaged, or otherwise preprocessed before shipment. Because the material would be handled again at the processing site, this preprocessing would be an additional handling step that would increase costs and exposures, particularly to workers. Transportation from Rocky Flats to the processing site would increase the total materials transportation prior to disposition, thus increasing costs and increasing total exposures to the general population and to transportation workers. DOE concluded that the preprocessing and transportation necessary to conduct processing without plutonium separation at another DOE site would increase risks and costs without providing any tangible benefits. For these reasons, DOE has determined that offsite processing without plutonium separation is unreasonable.

Lawrence Livermore and Los Alamos National Laboratories were initially considered for Alternative 3 (Processing with Plutonium Separation) because both sites have the capability to implement many of the technologies considered in this EIS. However, much of this capability is limited to laboratory bench scale operations suitable for initial development of the technology, but not for production operations. In addition, much of this limited processing capability is committed to other programs, including processing backlogs of residues from previous national laboratory operations.

Because of limitations discussed above, DOE concluded that it is unreasonable to consider the Los Alamos National Laboratory for processing most of the residue and scrub alloy at Rocky Flats and the EIS analyses processing only small amounts of certain Rocky Flats plutonium residues (for which Los Alamos National

Laboratories has capabilities not found elsewhere) to preclude disrupting other ongoing Los Alamos National Laboratory activities.

The Lawrence Livermore National Laboratory has an administrative limit on the amount of plutonium that may be present there at any time, established as a result of an agreement with the State of California. The existing plutonium inventory at Lawrence Livermore must be actively managed to remain under this administrative limit. This limitation would require that most or all of any residues processed at Lawrence Livermore National Laboratory be shipped an extra time, probably back to Rocky Flats, for storage. As a result of the limited capabilities and the administrative controls at the site, DOE has determined that it is unreasonable to consider Lawrence Livermore National Laboratory as a site for processing any of the Rocky Flats plutonium residues or scrub alloy.

DOE also determined that even though certain technologies for plutonium separation (Alternative 3) are feasible at some sites, the technologies are not reasonable options and are not analyzed in this EIS (see **Table 2–7**). The principal reasons for this determination were that: (1) the site has other important missions that compete for the site's limited processing capability (as discussed above), and (2) the potential processing site has limited storage capability for the plutonium residues and scrub alloy or for plutonium metal or oxides that result from processing. In particular, Los Alamos National Laboratory has a Defense Programs mission as the only plutonium component manufacturing site, and this mission would compete with plutonium residue processing for the TA-55 facility processing capacity. In addition, Los Alamos National Laboratory has limited storage capacity for plutonium-bearing materials.

Table 2–7 Processing with Plutonium Separation: Technology/Site Combinations Not Analyzed[a]

Material Category	Specific Technology	Site(s) Dismissed
Incinerator Ash and Graphite Fines Residues	Mediated Electrochemical Oxidation	Rocky Flats
Molten Salt Extraction/Electrorefining Salts (Sodium Chloride/Potassium Chloride Salts)	Salt Distillation Salt Scrub	SRS SRS, LANL
Direct Oxide Reduction Salts (Calcium Chloride Salts)	Water Leach Salt Scrub	SRS SRS, LANL
Combustible Residues	Mediated Electrochemical Oxidation	SRS, LANL
Plutonium Fluoride Residues	Acid Dissolution	LANL
High-Efficiency Particulate Air Filter Media Residues	Immobilization (Vitrification)	SRS
Graphite Residues	Mediated Electrochemical Oxidation	LANL
Inorganic Residues	Mediated Electrochemical Oxidation	LANL

[a] Refer to the text for the reasons that these technology/site combinations were not analyzed.
SRS = Savannah River Site
LANL = Los Alamos National Laboratory

Based on the above considerations, processing at Los Alamos National Laboratory is not considered a reasonable option for any material except salt residues.

The Savannah River Site was not considered further for salt residues because its facilities are not designed to process material containing large quantities of chlorides. Combustible residues and wet residues such as high-efficiency particulate air filter media residues were not further considered for any site other than Rocky Flats because potential radiolysis of these materials with resulting hydrogen gas generation limits the ability of DOE to transport these materials. Mediated electrochemical oxidation is not considered for removing plutonium from incinerator ash and graphite fines at Rocky Flats even though it was considered for several other plutonium residue material categories at Rocky Flats. The justification for this distinction is that Rocky Flats

only has the capability to process small amounts of aqueous wastes in its liquid wastewater treatment system. The site could process the small quantity of liquid effluent that would result from processing combustible residues, filter media residues, glass residues, graphite residues, and inorganic residues, but processing the large quantity of incinerator ash and graphite fines [approximately 15,000 kg (33,000 lb)] would produce more liquid effluent than the site could handle. Accordingly, mediated electrochemical oxidation of ash residues was dismissed as a technology at Rocky Flats.

2.9.3 Issues Raised During the Public Scoping Process That Are Not Analyzed

This section considers some alternatives, technologies, and other issues raised during scoping and briefly explains why they were eliminated from further analysis or not otherwise included in this EIS.

- **Processing Residues Using the Glass Material Oxidation Dissolution System**—DOE eliminated the Glass Material Oxidation Dissolution System process from consideration because of timeliness and technical immaturity. The time required to complete the necessary research and development on technical issues (e.g., the melting process and the volume and quality of the glass products) precludes the use of the Glass Material Oxidation Dissolution System process within the timeframe of analysis covered by this EIS.

- **Minimize Proliferation Risks through Vitrification and the "Spent Fuel Standard"**—The spent fuel standard is in reality not a standard, but is instead a general concept that calls for plutonium to be placed into a form that will withstand dissolution as effectively as spent fuel, and that has a radiation field, like spent fuel, that would also deter access to the plutonium. The underlying idea is that plutonium put into such a form would be less desirable as a source of plutonium than would the much larger supply of power reactor spent fuel that already exists in numerous locations around the world. This standard was put forth as a means to allow the safe disposal of fissile materials removed from nuclear weapons, or fissile materials that have been purified to the point where they are suitable for use in nuclear weapons.

  In the plutonium residues and scrub alloy covered by this EIS, the plutonium is a minority constituent of a mixture of materials that would preclude use of the plutonium in a nuclear weapon. The process that is used to determine when such materials can be disposed of is to determine when they are in a form that is suitable for termination of safeguards. All of the alternative technologies evaluated in this EIS would change the plutonium residues and scrub alloy into such forms, making it unnecessary to consider application of the spent fuel standard. Under alternative technologies evaluated in this EIS in which the plutonium is separated from the plutonium residues or scrub alloy, any plutonium that was separated would be dispositioned either into mixed oxide fuel, used in a nuclear reactor, thus becoming spent fuel after use, or imbedded in logs of vitrified high-level radioactive waste, thus taking a form recognized as meeting the spent fuel standard.

  DOE considers processes that convert the plutonium residues into a form that satisfies the spent fuel standard without first separating the plutonium from the residues to be unreasonable alternatives. To convert the plutonium residues directly to a form that satisfies the spent fuel standard at Rocky Flats, it would be necessary to transport high-level radioactive waste to Rocky Flats for use in "spiking" the waste form (i.e., adding a radiation source to the waste form to make it "self-protecting"). It would also be necessary to develop a new process and build new facilities, such as a vitrification plant, at the Rocky Flats site on an expedited basis, contrary to its current mission to clean up and shut down. Finally, it would also be necessary to determine whether any waste form that might be produced would be acceptable for disposal in a geologic repository. If the plutonium residues were to be converted directly into a form that meets the spent fuel standard at a site other than Rocky Flats, it would be necessary to develop and implement a new process and determine whether the final waste form that might be produced would be acceptable for disposal in a geologic repository.

DOE concludes that there is no need to process the plutonium residues directly to the spent fuel standard and that doing so would pose much greater difficulties than alternatives means of achieving the nuclear weapons nonproliferation and disposition objectives for these materials.

- **Process Scrub Alloy or Plutonium Residues Using Melt and Dilute Technology**—The melt and dilute technology is being considered by DOE as a step in the preparation of aluminum based research reactor spent nuclear fuel for disposal, as an alternative to chemical separation. Since one of the alternatives for processing scrub alloy and plutonium residues in this EIS is chemical separation, it has been suggested that DOE should also consider application of the melt and dilute technology to the scrub alloy and plutonium residues.

  The melt and dilute technology focuses on developing techniques and equipment to mix aluminum and the aluminum-based fuel elements to form a dilute metal form that meets safeguards termination requirements and is suitable for shipment and storage. The system will have to deal with the specific characteristics of spent fuel, remote handling, and high-radiation fields. It has the advantage of being a single-step process, although that step has complications inherent in high-temperature metallurgical processing of radioactive materials.

  In considering this suggestion, DOE notes that the composition of aluminum-based research reactor spent nuclear fuel is considerably different from scrub alloy or plutonium residues. By comparison to the scrub alloy, the spent fuel consists of aluminum structure/cladding, enriched uranium, fission products, and a small quantity of plutonium (typically less than 1%). Scrub alloy is an alloy of magnesium, aluminum, americium, and plutonium, with a plutonium content of about 30 percent. Some of the scrub alloy was produced by an experimental process and contains calcium/gallium or calcium/cerium, with no aluminum. The physical form of the spent fuel is relatively long, fabricated fuel elements, whereas the form of the scrub alloy is approximately 3-inch diameter, extremely contaminated "buttons," encased in several layers of protective containment. These wide differences in physical composition, properties, and forms argues that there is not simple basis for concluding that a technology that works for aluminum-based spent fuel would also work for scrub alloy.

  The differences between spent fuel and plutonium residues is even more significant. Whereas the spent fuel and scrub alloys are both metals, and might be expected to dissolve in aluminum (assuming no formation of intermetalics or precipitates) to form a uniform products, residues are almost never non-refractory metals. Residues consist of a number of chemical forms, including oxides, ceramics, hydrocarbons, combustibles, glasses, and salts. While pyrochemical processing is possible to make these materials compatible with the metallurgical processes employed in the melt and dilute technology, the resulting materials would contain slags, precipitates, and inclusions, and would never represent a uniform, diluted products. The equipment would need to handle a large number of feed configurations, and would require considerable amount of research and development. Thus, melt and dilute technology is inappropriate for processing residues.

  The development of the melt and dilute technology for aluminum-based spent fuel has progressed to the point where non-irradiated mock-up fuel elements have been melted and diluted in a prototype melter in laboratory studies. In these laboratory studies, the basic metallurgy and associated physical processes have been demonstrated to be feasible and workable. Nevertheless, even with this much development completed, the technology is not expected to be fully qualified for use until approximately 2004. No similar level of development exists with respect to scrub alloy. There has been no demonstration that the process will work for scrub alloy, much less any demonstration of the specific process technologies or equipment that would be required. Consequently, it is doubtful that the melt and dilute technology could be ready for implementation by the 2006 time frame scheduled for the shut down of Rocky Flats. In

consideration of these facts, DOE believes that melt and dilute technology is not appropriate of reconsideration as a technology for processing scrub alloy or plutonium residues.

However, DOE is considering another dilution technology for scrub alloy in this EIS that does not involve plutonium separation—the calcination/vitrification process. DOE believes that this is a better process than the melt and dilute technology for scrub alloy because the technology is more mature and could be implemented with minimal changes at Rocky Flats by 2006. Furthermore, it satisfies the same objectives as the melt and dilute process, i.e., to immobilize the material without separation of plutonium in such a manner as to meet the safeguards termination limits.

- **Construct a New Vitrification Facility at Rocky Flats**—DOE does not consider the construction of a large-scale vitrification facility at Rocky Flats to be economically or technically justifiable given the relatively small amounts of material requiring vitrification at the site. The "furnace vitrification" technology proposed for use at Rocky Flats produces a processed material that is encapsulated rather than incorporated in a glass matrix, but would meet the specifications of the safeguards termination limits.

- **Processing at Rocky Flats Followed by Shipment Offsite for Storage**—Shipment of processed Rocky Flats plutonium residues and scrub alloy offsite for interim storage pending disposition would involve additional shipping and result in additional impacts due to extra material handling. Shipment of processed plutonium residues and scrub alloy to another site for storage would involve the additional steps of loading the materials onto trucks at Rocky Flats, shipping to another site, unloading and placing the material into storage, and potentially having to move the material again to WIPP or another DOE site for disposition. In addition, DOE's decision on storage of plutonium, as stated in the *Record of Decision for the Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1997c), is to consolidate storage of weapons-usable plutonium by upgrading and expanding existing and planned facilities at the Pantex Plant in Texas and the Savannah River Site in South Carolina. For these reasons, processing at Rocky Flats and Shipment offsite for storage is not analyzed.

- **Construction of a New Long-Term Storage Facility at Rocky Flats**—DOE believes that long-term storage of the plutonium residues and scrub alloy at Rocky Flats is not a reasonable alternative that should be considered in this EIS for the following reasons. Long-term storage of plutonium residues and scrub alloy at Rocky Flats is not consistent with the site's cleanup and closure mission, and also does not satisfy the purpose and need for agency action described in this EIS. Specifically, DOE has committed to remove all plutonium from Rocky Flats based on: the *Final Rocky Flats Cleanup Agreement* among the State of Colorado, DOE, and the U.S. Environmental Protection Agency (EPA) for Rocky Flats (CDPHE 1996); the proximity of Rocky Flats to the Denver metropolitan area; and the fact that none of the Rocky Flats facilities are in suitable condition for long-term storage. Although DOE considered development of a new plutonium storage facility (see section 1.6), this is no longer reasonable because of DOE's decision to disposition these materials either through deep geologic disposal at WIPP or in accordance with disposition options for separated plutonium (see DOE's "Record of Decision on the Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement" [DOE 1997d]). In the event of significant delays in implementing these disposal or disposition methods, DOE would need to reevaluate its storage options.

- **Use of Decommissioned Minuteman Silos for Long-Term Storage of Plutonium Residues and Scrub Alloy**—DOE does not consider the use of one or more decommissioned Minuteman silos to store the plutonium residues or scrub alloy to be a reasonable alternative. The Strategic Arms Reduction Treaty, signed in July 1991, requires that the United States and the Union of Soviet Socialist Republics destroy the missile silos covered by the treaty to ensure that they have been taken out of service. DOE does not want to create new DOE nuclear sites while attempting to close existing sites. Furthermore, missile silos have neither the facilities required to support the operations involved in the long-term storage of processed

residues or scrub alloy nor the capabilities for emergency response following potential accidents. The costs and regulatory requirements associated with the provision of these capabilities could be very high.

2.9.4 Issues Raised During the Public Scoping Process that are Out-of-Scope

In this section, DOE briefly discusses five issues that were raised during the scoping process that it considers to be out of the scope of this EIS.

Issue 1: Reprocessing should be restarted for spent fuel from nuclear power plants. On-site basins are full and spent fuel should not be considered waste.

DOE Response: This EIS addresses only Rocky Flats' plutonium residues and scrub alloy and, thus, does not address spent fuel because this would encourage and add legitimacy to the dissemination of technology that could be easily abused in a clandestine nuclear weapons program, and would produce large stockpiles of plutonium that could be diverted to a weapons program.

Issue 2: DOE is over reliant on WIPP as a disposal option. Problems cited include the following:

- WIPP has not been demonstrated to be a safe disposal site and may never be proven safe;
- The opening of WIPP is uncertain (there have been delays in past, it may never open);
- Basing plans on WIPP could result in unsafe storage at Rocky Flats unless DOE plans contingencies;
- The residues and scrub alloy should be stored in a monitored, retrievable manner—not so with WIPP;
- Burial eliminates or strongly hinders the possible use of future cleanup technologies;
- WIPP is on native lands and DOE should not push this material onto other people who have been "marginalized;"
- WIPP has a pressurized brine reservoir, and there is a possibility of a breach into the environment;
- The salts at WIPP are not dry and are thus corrosive;
- Fault lines exist at WIPP which can create vertical passageways for pressurized leaking waste;
- WIPP must be shown to limit radionuclide transport for 10,000 years—plutonium has a "half-life of 24,000 years," which means it remains dangerous for several hundreds of thousands of years;
- Transportation to WIPP is a problem—increased risks from transportation, inappropriate emergency planning along the thousands of miles along the route to WIPP.

DOE Response: This EIS addresses only the preparation of the plutonium residues and scrub alloy prior to their disposal or other disposition in accordance with the Final Supplemental WIPP EIS (DOE 1997d) and with final decisions made for disposition of the nation's surplus weapons-usable plutonium stockpile (please see the "Record of Decision for the Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement," DOE 1997a). This EIS does not address issues associated with disposal at WIPP or other disposition of Rocky Flats plutonium residues and scrub alloy or their transportation to WIPP.

The long-term performance of WIPP in isolating radionuclides from the environment has been evaluated and determined by DOE to meet disposal and operational requirements of the EPA. The EPA will be the ultimate decisionmaker on WIPP's compliance with its disposal regulations in 40 CFR 191 and its compliance criteria in 40 CFR 194 as it completes its review and makes its findings on DOE's compliance certification application. The environmental impacts of opening WIPP or not opening WIPP are analyzed in the Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement (DOE 1997a). This

is the second supplemental EIS on WIPP. This document and its preceding documents address the impacts of operating WIPP and the impacts of transporting waste materials to WIPP, including transportation of wastes from Rocky Flats and the Savannah River Site to WIPP.

WIPP could open as early as May 1998, following EPA's certification of compliance. The opening of WIPP remains a high priority within DOE.

Issue 3: DOE should include in its proposed action the disposition of the enormous quantities of U-235 within the DOE complex because they pose the same level of proliferation risk as plutonium. Same controls over the materials and disposition should apply.

DOE Response: This EIS addresses only a specific amount of plutonium residues and scrub alloy at Rocky Flats that need to be further processed to meet safeguards termination limits (see Chapter 1 and Appendix B of this EIS. The management and disposition of highly enriched uranium is addressed in DOE's *Disposition of Surplus Highly Enriched Uranium Final Environmental Impact Statement* (DOE 1996h) and its Record of Decision (DOE 1996g).

Issue 4: Rocky Flats needs stricter cleanup standards and should expeditiously decontaminate and decommission its facilities. The surrounding communities have already been adversely impacted by Rocky Flats's past activities. DOE should address contamination from past accidents and fires at the site.

DOE Response: The EIS analyzes the impacts of managing certain Rocky Flats plutonium residues and scrub alloy (see Chapter 4). Impacts from other site activities and cleanup standards for decommissioning and decontaminating Rocky Flats facilities are not within the scope of this EIS for decisionmaking purposes. Section 4.20 of Chapter 4, however, does analyze cumulative impacts (impacts of the proposed action in this EIS along with other site activities) at the potential processing sites and of intersite transportation.

Issue 5: DOE must assure that funding will be provided for the alternatives selected (included comments for processing at the Savannah River Site and Rocky Flats); DOE must commit to a stable funding source and cover longer-term milestones; any decision should include a fully defined plan that includes a commitment for the necessary fiscal support.

DOE Response: Any commitment for funding must come from Congress. DOE will request the funding required to implement any decision that is made from this EIS and does not expect to commit to any course of action for which funding cannot reasonably be expected.

2.10 Summary of Impacts

In this section, DOE provides a summary of the products and wastes generated by each processing option, as well as the chemical and radiological risks due to incident-free operations and transportation of each processing option. The data for each material category or subcategory are presented in **Tables 2–8** through **2–22**. These data are discussed in detail in the appropriate sections of Chapter 4 (where the potential environmental impacts from processing each material category or subcategory are discussed), shown in the following list:

Residue Category	*Impact Discussion*
Incinerator Ash Residues	Section 4.2
Sand, Slag, and Crucible Residues	Section 4.2
Inorganic Ash Residues	Section 4.2
Graphite Fines Residues	Section 4.2
Electrorefining and Molten Salt Extraction Residues	Section 4.3
Direct Oxide Reduction Salt residues	Section 4.3
Combustible Residues	Section 4.4
Plutonium Fluoride Residues	Section 4.5
High-Efficiency Particulate Air Filter Residues	Section 4.6
Ful Flo Filter Residues	Section 4.6
Sludge Residues	Section 4.7
Glass Residues	Section 4.8
Graphite Residues	Section 4.9
Inorganic Residues	Section 4.10
Scrub Alloy	Section 4.11

In addition to estimating the potential environmental impacts that may be obtained from processing each material category, DOE estimated the potential impacts from processing several combinations of selected technologies and sites for each residue and scrub alloy material category. These combinations, described in Section 2.5, include the No Action Alternative, DOE's Preferred Management Approach, and six other combinations selected to illustrate particular management strategies. The potential environmental impacts for these management approaches are shown in **Table 2–23** and are presented in more detail in Sections 4.20 through 4.22.

Table 2–8 Impacts of Managing Incinerator Ash Residues

Impact	Calcine and Cement at Rocky Flats (No Action Processing Option)	Vitrify at Rocky Flats (Preferred Processing Option)	Calcine and Blend Down at Rocky Flats	Pretreat at Rocky Flats and Purex at Savannah River Site			Pretreat at Rocky Flats and MEO/Purex at Savannah River Site		
				Pretreat at Rocky Flats	Transport 116 Shipments	Purex at Savannah River Site	Pretreat at Rocky Flats	Transport 86 Shipments	MEO/Purex at Savannah River Site
Products and Wastes									
Stabilized Residues (drums)	4,800	0	0	0	0	0	0	0	0
Transuranic Waste (drums)	1,310	5,428	6,430	593	0	150	593	0	253
High-Level Waste (canisters)	0	0	0	0	0	4	0	0	26
Separated Plutonium (kg plutonium)	0	0	0	0	0	890	0	0	901
Low-Level Waste (drums)	2,860	1,187	1,187	1,187	0	394	1,187	0	373
Radiological Risks Due to Incident-Free Operations and Transportation									
Offsite Public Maximally Exposed Individual Risk (probability of a latent cancer fatality)	1.2×10^{-10}	1.7×10^{-11}	9.5×10^{-11}	2.8×10^{-11}	5.5×10^{-6}	7.5×10^{-10}	2.8×10^{-11}	5.5×10^{-6}	4.0×10^{-10}
Offsite Public Population Risk (number of latent cancer fatalities)	2.6×10^{-6}	7.0×10^{-7}	2.0×10^{-6}	1.2×10^{-6}	0.0057	0.000085	1.2×10^{-6}	0.0042	0.000044
Maximally Exposed Individual Involved Worker Risk (probability of a latent cancer fatality)	0.0008	0.0008	0.0008	0.0008	0.00004	0.0008	0.0008	0.00004	0.0008
Involved Worker Population Risk (number of latent cancer fatalities)	0.13	0.072	0.092	0.058	0.0072	0.092	0.043	0.0053	0.061
Hazardous Chemical Impacts Due to Incident-Free Operations and Transportation									
Offsite Public Maximally Exposed Individual									
• Probability of a latent cancer fatality	0	0	0	0	N/A	0	0	N/A	0
• Hazard Index	0	0	0	0	N/A	0.06	0	N/A	0.06
Offsite Public Population Risk (number of cancer incidences)	0	0	0	0	0.0015[a]	0	0	0.0011[a]	0
Maximally Exposed Individual Involved Worker									
• Probability of a cancer incidence	0	0	0	0	N/A	0	0	N/A	0
• Hazard Index	0	0	0	0	N/A	0.8	0	N/A	0.9
Worker Population Risk (number of cancer incidences)	0	0	0	0	[a]	0	0	[a]	0

MEO = mediated electrochemical oxidation N/A = not applicable

[a] Number of cancer fatalities due to vehicle emissions. The impact is listed only once under public population because the vehicle emissions affect the public and worker populations collectively; however, the risk to the public dominates.

Table 2–9 Impacts of Managing Sand, Slag, and Crucible Residues

Impact	Calcine and Cement at Rocky Flats (No Action Processing Option)	Vitrify at Rocky Flats	Calcine and Blend Down at Rocky Flats	Pretreat at Rocky Flats and Purex at Savannah River Site (Preferred Processing Option)		
				Pretreat at Rocky Flats	Transport 26 Shipments	Purex at Savannah River Site
Products and Wastes						
Stabilized Residues (drums)	1,046	0	0	0	0	0
Transuranic Waste (drums)	286	1,183	1,402	130	0	12
High-Level Waste (canisters)	0	0	0	0	0	4
Separated Plutonium (kg plutonium)	0	0	0	0	0	128
Low-Level Waste (drums)	607	242	242	242	0	58
Radiological Risks Due to Incident-Free Operations and Transportation						
Offsite Public Maximally Exposed Individual Risk (probability of a latent cancer fatality)	1.8×10^{-11}	2.3×10^{-12}	1.3×10^{-11}	1.4×10^{-12}	5.5×10^{-6}	6.5×10^{-11}
Offsite Public Population Risk (number of latent cancer fatalities)	3.6×10^{-7}	9.5×10^{-8}	2.9×10^{-7}	5.5×10^{-8}	0.0013	7.0×10^{-6}
Maximally Exposed Individual Involved Worker Risk (probability of a latent cancer fatality)	0.0008	0.0008	0.0008	0.0008	0.00004	0.0008
Involved Worker Population Risk (number of latent cancer fatalities)	0.018	0.010	0.060	0.011	0.0016	0.0068
Hazardous Chemical Impacts Due to Incident-Free Operations and Transportation						
Offsite Public Maximally Exposed Individual						
• Probability of a cancer incidence	0	0	0	0	N/A	0
• Hazard Index	0	0	0	0	N/A	0.02
Offsite Public Population Risk (number of cancer incidences)	0	0	0	0	0.00034[a]	0
Maximally Exposed Individual Worker						
• Probability of a cancer incidence	0	0	0	0	N/A	0
• Hazard Index	0	0	0	0	N/A	0.3
Worker Population Risk (number of cancer incidences)	0	0	0	0	[a]	0

N/A = not applicable

[a] Number of cancer fatalities due to vehicle emissions. The impact is listed only once under public population because the vehicle emissions affect the public and worker populations collectively; however, the risk to the public dominates.

Table 2–10 Impacts of Managing Inorganic Ash Residues

Impact	*Calcine and Cement at Rocky Flats (No Action Processing Option)*	*Vitrify at Rocky Flats (Preferred Processing Option)*	*Calcine and Blend Down at Rocky Flats*
Products and Wastes			
Stabilized Residues (drums)	698	0	0
Transuranic Waste (drums)	173	772	917
High-Level Waste (canisters)	0	0	0
Separated Plutonium (kg plutonium)	0	0	0
Low-Level Waste (drums)	395	152	152
Radiological Risks Due to Incident-Free Operations			
Offsite Public Maximally Exposed Individual Risk (probability of a latent cancer fatality)	6.5×10^{-12}	9.0×10^{-13}	5.2×10^{-12}
Offsite Public Population Risk (number of latent cancer fatalities)	1.4×10^{-7}	3.8×10^{-8}	1.1×10^{-7}
Maximally Exposed Individual Involved Worker Risk (probability of a latent cancer fatality)	0.0008	0.0008	0.0008
Involved Worker Population Risk (number of latent cancer fatalities)	0.0072	0.0039	0.024
Hazardous Chemical Impacts Due to Incident-Free Operations			
Offsite Public Maximally Exposed Individual			
• Probability of a cancer incidence	0	0	0
• Hazard Index	0	0	0
Offsite Public Population Risk (number of cancer incidences)	0	0	0
Maximally Exposed Individual Worker			
• Probability of a cancer incidence	0	0	0
• Hazard Index	0	0	0
Worker Population Risk (number of cancer incidences)	0	0	0

Table 2–11 Impacts of Managing Graphite Fines Ash Residues

Impact	Cement at Rocky Flats (No Action Processing Option)	Vitrify at Rocky Flats (Preferred Processing Option)	Calcine and Blend Down at Rocky Flats	Pretreat at Rocky Flats and MEO/Purex at Savannah River Site		
				Pretreat at Rocky Flats	Transport 7 Shipments	MEO/Purex at Savannah River Site
Products and Wastes						
Stabilized Residues (drums)	307	0	0	0	0	0
Transuranic Waste (drums)	87	350	414	41	0	16
High-Level Waste (canisters)	0	0	0	0	0	2
Separated Plutonium (kg plutonium)	0	0	0	0	0	73
Low-Level Waste (drums)	186	79	79	79	0	24
Radiological Risks Due to Incident-Free Operations and Transportation						
Offsite Public Maximally Exposed Individual Risk (probability of a latent cancer fatality)	1.0×10^{-11}	1.4×10^{-12}	5.2×10^{-12}	2.4×10^{-12}	5.5×10^{-6}	3.2×10^{-11}
Offsite Public Population Risk (number of latent cancer fatalities)	2.1×10^{-7}	5.5×10^{-8}	1.1×10^{-7}	9.5×10^{-8}	0.00035	3.6×10^{-6}
Maximally Exposed Individual Involved Worker Risk (probability of a latent cancer fatality)	0.0008	0.0008	0.0008	0.0008	0.00004	0.0008
Involved Worker Population Risk (number of latent cancer fatalities)	0.010	0.0060	0.0072	0.0035	0.00044	0.0048
Hazardous Chemical Impacts Due to Incident-Free Operations and Transportation						
Offsite Public Maximally Exposed Individual						
• Probability of a cancer incidence	0	0	0	0	N/A	0
• Hazard Index	0	0	0	0	N/A	0.007
Offsite Public Population Risk (number of cancer incidences)	0	0	0	0	0.00009[a]	0
Maximally Exposed Individual Worker						
• Probability of a cancer incidence	0	0	0	0	N/A	0
• Hazard Index	0	0	0	0	N/A	0.1
Worker Population Risk (number of cancer incidences)	0	0	0	0	[a]	0

MEO = mediated electrochemical oxidation N/A = not applicable

[a] Number of cancer fatalities due to vehicle emissions. The impact is listed only once under public population because the vehicle emissions affect the public and worker populations collectively; however, the risk to the public dominates.

Table 2–12 Impacts of Managing Electrorefining and Molten Salt Extraction Salt Residues

Impact	Pyro-Oxidize at Rocky Flats (No Action Processing Option)	Pyro-Oxidize and Blend Down at Rocky Flats	Pyro-Oxidize and Salt Distill at Rocky Flats (Preferred Processing Option)	Pyro-Oxidize and Water Leach at Rocky Flats	Pretreat at Rocky Flats and Salt Distill at Los Alamos National Laboratory			Pretreat at Rocky Flats and Purex at Savannah River Site		
					Pretreat at Rocky Flats	Transport 52 Shipments	Salt Distill at Los Alamos National Laboratory	Pretreat at Rocky Flats	Transport 24 Shipments	Purex at Savannah River Site
Products and Wastes										
Stabilized Residues (drums)	1,097	0	0	0	0	0	0	0	0	0
Transuranic Waste (drums)	590	12,911	655	13,994	590	0	467	1,409	0	101
High-Level Waste (canisters)	0	0	0	0	0	0	0	0	0	1
Separated Plutonium (kg plutonium)	0	0	881	855	0	0	881	0	0	867
Low-Level Waste (drums)	1,057	1,057	1,057	32,011	1,057	0	938	1,057	0	368
Radiological Risks Due to Incident-Free Operations and Transportation										
Offsite Public Maximally Exposed Individual Risk (probability of a latent cancer fatality)	2.3×10^{-11}	1.1×10^{-10}	4.6×10^{-11}	2.2×10^{-10}	2.0×10^{-11}	5.5×10^{-6}	1.2×10^{-10}	3.3×10^{-11}	5.5×10^{-6}	5.0×10^{-10}
Offsite Public Population Risk (number of latent cancer fatalities)	9.5×10^{-7}	2.4×10^{-6}	1.8×10^{-6}	5.0×10^{-6}	8.5×10^{-7}	0.0007	3.6×10^{-7}	1.4×10^{-6}	0.0003	0.000055
Maximally Exposed Individual Involved Worker Risk (probability of a latent cancer fatality)	0.0008	0.0008	0.0008	0.0008	0.0008	0.00004	0.0008	0.0008	0.00004	0.0008
Involved Worker Population Risk (number of latent cancer fatalities)	0.067	0.29	0.10	0.21	0.072	0.00088	0.0060	0.080	0.0015	0.042
Hazardous Chemical Impacts Due to Incident-Free Operations and Transportation										
Offsite Public Maximally Exposed Individual										
• Probability of a cancer incidence	0	0	0	0	0	N/A	0	0	N/A	0
• Hazard Index	0	0	0	0	0	N/A	0	0	N/A	0.022
Offsite Public Population Risk (number of cancer incidences)	0	0	0	0	0	0.00024[a]	0	0	0.00011[a]	0
Maximally Exposed Individual Worker										
• Probability of a cancer incidence	0	0	0	0	0	N/A	0	0	N/A	0
• Hazard Index	0	0	0	0	0	N/A	0	0	N/A	0.33
Worker Population Risk (number of cancer incidences)	0	0	0	0	0	[a]	0	0	[a]	0

N/A = not applicable

[a] Number of cancer fatalities due to vehicle emissions. The impact is listed only once under public population because the vehicle emissions affect the public and worker populations collectively; however, the risk to the public dominates.

Table 2–13 Impacts of Managing Direct Oxide Reduction Salt Residues

Impact	Pyro-Oxidize at Rocky Flats (No Action Processing Option)	Pyro-Oxidize and Blend Down at Rocky Flats	Pyro-Oxidize and Water Leach at Rocky Flats	Pretreat at Rocky Flats and Water Leach at Los Alamos National Laboratory (Preferred Processing Option)			Pretreat at Rocky Flats and Purex at Savannah River Site		
				Pretreat at Rocky Flats	Transport 13 Shipments	Water Leach at Los Alamos National Laboratory	Pretreat at Rocky Flats	Transport 4 Shipments	Purex at Savannah River Site
Products and Wastes									
Stabilized Residues (drums)	177	0	0	0	0	0	0	0	0
Transuranic Waste (drums)	96	2,082	2,265	96	0	2,234	228	0	16
High-Level Waste (canisters)	0	0	0	0	0	0	0	0	<1
Separated Plutonium (kg plutonium)	0	0	182	0	0	188	0	0	140
Low-Level Waste (drums)	167	167	5,157	167	0	5,141	167	0	59
Radiological Risks Due to Incident-Free Operations and Transportation									
Offsite Public Maximally Exposed Individual Risk (probability of a latent cancer fatality)	3.1×10^{-12}	1.6×10^{-11}	7.5×10^{-11}	7.0×10^{-12}	5.5×10^{-6}	4.2×10^{-11}	5.0×10^{-12}	5.5×10^{-6}	7.0×10^{-11}
Offsite Public Population Risk (number of latent cancer fatalities)	1.3×10^{-7}	3.3×10^{-7}	1.6×10^{-6}	2.8×10^{-7}	0.00018	1.2×10^{-7}	2.0×10^{-7}	0.0002	7.5×10^{-6}
Maximally Exposed Individual Involved Worker Risk (probability of a latent cancer fatality)	0.0008	0.0008	0.0008	0.0008	0.00004	0.0008	0.0008	0.00004	0.0008
Involved Worker Population Risk (number of latent cancer fatalities)	0.0092	0.040	0.046	0.0092	0.00022	0.0056	0.012	0.00025	0.0056
Hazardous Chemical Impacts Due to Incident-Free Operations and Transportation									
Offsite Public Maximally Exposed Individual									
• Probability of a cancer incidence	0	0	0	0	N/A	0	0	N/A	0
• Hazard Index	0	0	0	0	N/A	0	0	N/A	0.005
Offsite Public Population Risk (number of cancer incidences)	0	0	0	0	0.00006[a]	0	0	0.00002[a]	0
Maximally Exposed Individual Worker									
• Probability of a cancer incidence	0	0	0	0	N/A	0	0	N/A	0
• Hazard Index	0	0	0	0	N/A	0	0	N/A	0.07
Worker Population Risk (number of cancer incidences)	0	0	0	0	[a]	0	0	[a]	0

N/A = not applicable

[a] Number of cancer fatalities due to vehicle emissions. The impact is listed only once under public population because the vehicle emissions affect the public and worker populations collectively; however, the risk to the public dominates.

Table 2–14 Impacts of Managing Combustible Residues

Impact	Combination of Processes at Rocky Flats (No Action and Preferred Processing Options)	Sonic Wash at Rocky Flats	Catalytic Chemical Oxidation at Rocky Flats	Thermal Destruction at Rocky Flats	Shred and Blend Down at Rocky Flats	MEO at Rocky Flats
Products and Wastes						
Stabilized Residues (drums)	220	0	0	0	0	0
Transuranic Waste (drums)	92	423	1,276	219	220	1,220
High-Level Waste (canisters)	0	0	0	0	0	0
Separated Plutonium (kg plutonium)	0	0	0	0	0	21
Low-Level Waste (drums)	230	230	2,727	230	230	2,783
Radiological Risks Due to Incident-Free Operations						
Offsite Public Maximally Exposed Individual Risk (probability of a latent cancer fatality)	1.8×10^{-12}	3.5×10^{-12}	2.3×10^{-12}	4.5×10^{-13}	1.5×10^{-12}	3.7×10^{-12}
Offsite Public Population Risk (number of latent cancer fatalities)	4.1×10^{-8}	7.5×10^{-8}	4.8×10^{-8}	1.9×10^{-8}	3.2×10^{-8}	8.0×10^{-8}
Maximally Exposed Individual Involved Worker Risk (probability of a latent cancer fatality)	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
Involved Worker Population Risk (number of latent cancer fatalities)	0.015	0.0068	0.017	0.0064	0.0027	0.0044
Hazardous Chemical Impacts Due to Incident-Free Operations						
Offsite Public Maximally Exposed Individual						
• Probability of a cancer incidence	8×10^{-11}	5×10^{-11}	0	[a]	0	0
• Hazard Index	0	0	0.006	[a]	0	0
Offsite Public Population Risk (number of cancer incidences)	<1	<1	0	[a]	0	0
Maximally Exposed Individual Worker						
• Probability of a cancer incidence	4×10^{-9}	3×10^{-9}	0	[a]	0	0
• Hazard Index	0	0	0.2	[a]	0	0
Worker Population Risk (number of cancer incidences)	<1	<1	0	[a]	0	0

[a] The hazardous chemical impacts due to installing and operating an incinerator at Rocky Flats are not included in this EIS because DOE considers that this technology is not a reasonable alternative. If DOE decides to implement this option, extensive additional analysis will be required. This additional analysis could support additional NEPA documentation and a permit from the State of Colorado, both of which could provide opportunities for additional public input.

Table 2–15 Impacts of Managing Plutonium Fluoride Residues

Impact	Dissolve and Oxidize at Rocky Flats (No Action Processing Option)	Blend Down at Rocky Flats	Dissolve and Oxidize at Rocky Flats	Pretreat at Rocky Flats and Purex at Savannah River Site (Preferred Processing Option)		
				Pretreat at Rocky Flats	Transport 7 Shipments	Purex at Savannah River Site
Products and Wastes						
Stabilized Residues (drums)	141	0	0	0	0	0
Transuranic Waste (drums)	333	3,923	333	28	0	12
High-Level Waste (canisters)	0	0	0	0	0	<1
Separated Plutonium (kg plutonium)	0	0	141	0	0	141
Low-Level Waste (drums)	750	60	750	60	0	45
Radiological Risks Due to Incident-Free Operations and Transportation						
Offsite Public Maximally Exposed Individual Risk (probability of a latent cancer fatality)	2.2×10^{-11}	0	2.2×10^{-11}	5.0×10^{-12}	5.5×10^{-6}	1×10^{-10}
Offsite Public Population Risk (number of latent cancer fatalities)	4.9×10^{-7}	0	4.9×10^{-7}	1.1×10^{-7}	0.00035	0.000011
Maximally Exposed Individual Involved Worker Risk (probability of a latent cancer fatality)	0.0008	0.0008	0.0008	0.0008	0.00004	0.0008
Involved Worker Population Risk (number of latent cancer fatalities)	0.018	0.142	0.020	0.016	0.00044	0.013
Hazardous Chemical Impacts Due to Incident-Free Operations and Transportation						
Offsite Public Maximally Exposed Individual						
• Probability of a cancer incidence	0	0	0	0	N/A	0
• Hazard Index	0	0	0	0	N/A	0.007
Offsite Public Population Risk (number of cancer incidences)	0	0	0	0	0.00009[a]	0
Maximally Exposed Individual Worker						
• Probability of a cancer incidence	0	0	0	0	N/A	0
• Hazard Index	0	0	0	0	N/A	0.1
Worker Population Risk (number of cancer incidences)	0	0	0	0	[a]	0

N/A = not applicable

[a] Number of cancer fatalities due to vehicle emissions. The impact is listed only once under public population because the vehicle emissions affect the public and worker populations collectively; however, the risk to the public dominates.

Table 2–16 Impacts of Managing High-Efficiency Particulate Air Filter Residues

Impact	Neutralize/Dry at Rocky Flats (No Action Processing Option)	Vitrify at Rocky Flats	Blend Down at Rocky Flats	Thermal Destruction at Rocky Flats	Sonic Wash at Rocky Flats	MEO at Rocky Flats
Products and Wastes						
Stabilized Residues (drums)	465	0	0	0	0	0
Transuranic Waste (drums)	147	702	612	604	781	1,956
High-Level Waste (canisters)	0	0	0	0	0	0
Separated Plutonium (kg plutonium)	0	0	0	0	0	91
Low-Level Waste (drums)	385	385	385	385	385	4,373
Radiological Risks Due to Incident-Free Operations and Transportation						
Offsite Public Maximally Exposed Individual Risk (probability of a latent cancer fatality)	9.5×10^{-12}	2.1×10^{-12}	6.5×10^{-12}	3.0×10^{-12}	1.4×10^{-11}	1.3×10^{-11}
Offsite Public Population Risk (number of latent cancer fatalities)	2.0×10^{-7}	8.5×10^{-8}	1.4×10^{-7}	1.2×10^{-7}	2.8×10^{-7}	2.7×10^{-7}
Maximally Exposed Individual Involved Worker Risk (probability of a latent cancer fatality)	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
Involved Worker Population Risk (number of latent cancer fatalities)	0.0096	0.0092	0.010	0.027	0.016	0.012
Hazardous Chemical Impacts Due to Incident-Free Operations and Transportation						
Offsite Public Maximally Exposed Individual						
• Probability of a cancer incidence	0	0	0	[a]	9×10^{-11}	0
• Hazard Index	0	0	0	[a]	0	0
Offsite Public Population Risk (number of cancer incidences)	0	0	0	[a]	<1	0
Maximally Exposed Individual Worker						
• Probability of a cancer incidence	0	0	0	[a]	5×10^{-9}	0
• Hazard Index	0	0	0	[a]	0	0
Worker Population Risk (number of cancer incidences)	0	0	0	[a]	<1	0

[a] The hazardous chemical impacts due to installing and operating an incinerator at Rocky Flats are not included in this EIS because DOE considers that this technology is not a reasonable alternative. If DOE decides to implement this option, extensive additional analysis will be required. This additional analysis could support additional NEPA documentation and a permit from the State of Colorado, both of which could provide opportunities for additional public input.

Note: DOE has not yet selected a preferred processing option.

Table 2–17 Impacts of Managing Ful Flo Filter Residues

Impact	*Neutralize/Dry at Rocky Flats (No Action Processing Option)*	*Blend Down at Rocky Flats*	*Thermal Destruction at Rocky Flats*	*Sonic Wash at Rocky Flats*	*MEO at Rocky Flats*
Products and Wastes					
Stabilized Residues (drums)	206	0	0	0	0
Transuranic Waste (drums)	65	270	267	345	880
High-Level Waste (canisters)	0	0	0	0	0
Separated Plutonium (kg plutonium)	0	0	0	0	18
Low-Level Waste (drums)	167	167	167	167	1,929
Radiological Risks Due to Incident-Free Operations					
Offsite Public Maximally Exposed Individual Risk (probability of a latent cancer fatality)	2.2×10^{-12}	1.4×10^{-12}	6.5×10^{-13}	2.8×10^{-12}	2.8×10^{-12}
Offsite Public Population Risk (number of latent cancer fatalities)	4.5×10^{-8}	2.9×10^{-8}	2.6×10^{-8}	6.0×10^{-8}	6.0×10^{-8}
Maximally Exposed Individual Involved Worker Risk (probability of a latent cancer fatality)	0.0008	0.0008	0.0008	0.0008	0.0008
Involved Worker Population Risk (number of latent cancer fatalities)	0.0021	0.0022	0.0060	0.0036	0.0025
Hazardous Chemical Impacts Due to Incident-Free Operations					
Offsite Public Maximally Exposed Individual					
• Probability of a cancer incidence	0	0	[a]	3×10^{-11}	0
• Hazard Index	0	0	[a]	0	0
Offsite Public Population Risk (number of cancer incidences)	0	0	[a]	<1	0
Maximally Exposed Individual Worker					
• Probability of a cancer incidence	0	0	[a]	2×10^{-9}	0
• Hazard Index	0	0	[a]	0	0
Worker Population Risk (number of cancer incidences)	0	0	[a]	<1	0

MEO = mediated electrochemical oxidation

[a] The hazardous chemical impacts due to installing and operating an incinerator at Rocky Flats are not included in this EIS because DOE considers that this technology is not a reasonable alternative. If DOE decides to implement this option, extensive additional analysis will be required. This additional analysis could support additional NEPA documentation and a permit from the State of Colorado, both of which could provide opportunities for additional public input.

Note: DOE has not yet selected a preferred processing option.

Table 2–18 Impacts of Managing Sludge Residues

Impact	Filter/Dry at Rocky Flats (No Action Processing Option)	Vitrify at Rocky Flats	Blend Down at Rocky Flats	Dissolve and Oxidize at Rocky Flats
Products and Wastes				
Stabilized Residues (drums)	160	0	0	0
Transuranic Waste (drums)	60	218	218	661
High-Level Waste (canisters)	0	0	0	0
Separated Plutonium (kg plutonium)	0	0	0	26
Low-Level Waste (drums)	128	128	128	1,484
Radiological Risks Due to Incident-Free Operations				
Offsite Public Maximally Exposed Individual Risk (probability of a latent cancer fatality)	1.9×10^{-12}	6.5×10^{-13}	1.8×10^{-12}	3.8×10^{-12}
Offsite Public Population Risk (number of latent cancer fatalities)	4.0×10^{-8}	2.6×10^{-8}	4.0×10^{-8}	8.5×10^{-8}
Maximally Exposed Individual Involved Worker Risk (probability of a latent cancer fatality)	0.0008	0.0008	0.0008	0.0008
Involved Worker Population Risk (number of latent cancer fatalities)	0.0060	0.0026	0.0026	0.016
Hazardous Chemical Impacts Due to Incident-Free Operations[a]				
Offsite Public Maximally Exposed Individual				
• Probability of a cancer incidence	N/E	N/E	N/E	N/E
• Hazard Index	N/E	N/E	N/E	N/E
Offsite Public Population Risk (number of cancer incidences)	N/E	N/E	N/E	N/E
Maximally Exposed Individual Worker				
• Probability of a cancer incidence	N/E	N/E	N/E	N/E
• Hazard Index	N/E	N/E	N/E	N/E
Worker Population Risk (number of cancer incidences)	N/E	N/E	N/E	N/E

N/E = no emissions

[a] Releases of hazardous chemicals from these processes are not expected; therefore, impacts were not evaluated.

Note: DOE has not yet selected a preferred processing option.

Table 2–19 Impacts of Managing Glass Residues

Impact	*Neutralize/Dry at Rocky Flats (No Action and Preferred Processing Option)*	*Vitrify at Rocky Flats*	*Blend Down at Rocky Flats*	*Sonic Wash at Rocky Flats*	*MEO at Rocky Flats*
Products and Wastes					
Stabilized Residues (drums)	7	0	0	0	0
Transuranic Waste (drums)	11	41	41	48	145
High-Level Waste (canisters)	0	0	0	0	0
Separated Plutonium (kg plutonium)	0	0	0	0	5
Low-Level Waste (drums)	27	27	27	27	321
Radiological Risks Due to Incident-Free Operations					
Offsite Public Maximally Exposed Individual Risk (probability of a latent cancer fatality)	0	1.0×10^{-13}	3.6×10^{-13}	0	9.0×10^{-13}
Offsite Public Population Risk (number of latent cancer fatalities)	0	4.3×10^{-9}	7.5×10^{-9}	0	1.9×10^{-8}
Maximally Exposed Individual Involved Worker Risk (probability of a latent cancer fatality)	0.0008	0.0008	0.0008	0.0008	0.0008
Involved Worker Population Risk (number of latent cancer fatalities)	0.00060	0.00040	0.00044	0.00076	0.00076
Hazardous Chemical Impacts Due to Incident-Free Operations[a]					
Offsite Public Maximally Exposed Individual • Probability of a cancer incidence • Hazard Index	 N/E N/E	 N/E N/E	 N/E N/E	 N/E N/E	 N/E N/E
Offsite Public Population Risk (number of cancer incidences)	N/E	N/E	N/E	N/E	N/E
Maximally Exposed Individual Worker • Probability of a cancer incidence • Hazard Index	 N/E N/E	 N/E N/E	 N/E N/E	 N/E N/E	 N/E N/E
Worker Population Risk (number of cancer incidences)	N/E	N/E	N/E	N/E	N/E

N/E = no emissions

[a] Releases of hazardous chemicals from these processes are not expected; therefore, impacts were not evaluated.

Table 2–20 Impacts of Managing Graphite Residues

Impact	Repackage at Rocky Flats (No Action and Preferred Processing Option)	Cement at Rocky Flats	Vitrify at Rocky Flats	Blend Down at Rocky Flats	MEO at Rocky Flats	Pretreat at Rocky Flats and MEO/Purex at Savannah River Site		
						Pretreat at Rocky Flats	Transport 16 Shipments	MEO/Purex at Savannah River Site
Products and Wastes								
Stabilized Residues (drums)	575	0	0	0	0	0	0	0
Transuranic Waste (drums)	171	756	650	650	2,056	75	0	44
High-Level Waste (canisters)	0	0	0	0	0	0	0	8
Separated Plutonium (kg plutonium)	0	0	0	0	95	0	0	96
Low-Level Waste (drums)	376	376	153	153	4,495	153	0	63
Radiological Risks Due to Incident-Free Operations and Transportation								
Offsite Public Maximally Exposed Individual Risk (probability of a latent cancer fatality)	0	1.4×10^{-12}	2.0×10^{-12}	6.8×10^{-12}	1.7×10^{-11}	3.4×10^{-12}	5.5×10^{-6}	6.0×10^{-11}
Offsite Public Population Risk (number of latent cancer fatalities)	0	3.0×10^{-7}	8.0×10^{-8}	1.4×10^{-7}	3.6×10^{-7}	7.5×10^{-8}	0.0008	7.0×10^{-6}
Maximally Exposed Individual Involved Worker Risk (probability of a latent cancer fatality)	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.00004	0.0008
Involved Worker Population Risk (number of latent cancer fatalities)	0.0072	0.014	0.0076	0.0076	0.014	0.0060	0.0010	0.010
Hazardous Chemical Impacts Due to Incident-Free Operations and Transportation								
Offsite Public Maximally Exposed Individual								
• Probability of a cancer incidence	0	0	0	0	0	0	N/A	0
• Hazard Index	0	0	0	0	0	0	N/A	0.007
Offsite Public Population Risk (number of cancer incidences)	0	0	0	0	0	0	0.00021[a]	0
Maximally Exposed Individual Worker								
• Probability of a cancer incidence	0	0	0	0	0	0	N/A	0
• Hazard Index	0	0	0	0	0	0	N/A	0.1
Worker Population Risk (number of cancer incidences)	0	0	0	0	0	0	[a]	0

MEO = mediated electrochemical oxidation N/A = not applicable

[a] Number of cancer fatalities due to vehicle emissions. The impact is listed only once under public population because the vehicle emissions affect the public and worker populations collectively; however, the risk to the public dominates.

Table 2–21 Impacts of Managing Inorganic Residues

Impact	Repackage at Rocky Flats (No Action and Preferred Processing Option)	Vitrify at Rocky Flats	Blend Down at Rocky Flats	MEO at Rocky Flats	Pretreat at Rocky Flats and MEO/Purex at Savannah River Site		
					Pretreat at Rocky Flats	Transport 4 Shipments	MEO/Purex at Savannah River Site
Products and Wastes							
Stabilized Residues (drums)	106	0	0	0	0	0	0
Transuranic Waste (drums)	37	119	120	485	14	0	10
High-Level Waste (canisters)	0	0	0	0	0	0	1
Separated Plutonium (kg plutonium)	0	0	0	17	0	0	17
Low-Level Waste (drums)	94	40	40	1,075	40	0	12
Radiological Risks Due to Incident-Free Operations and Transportation							
Offsite Public Maximally Exposed Individual Risk (probability of a latent cancer fatality)	0	4.2×10^{-13}	1.2×10^{-12}	3.2×10^{-12}	6.5×10^{-13}	5.5×10^{-6}	1.0×10^{-11}
Offsite Public Population Risk (number of latent cancer fatalities)	0	1.7×10^{-8}	2.6×10^{-8}	6.5×10^{-8}	1.4×10^{-8}	0.0002	1.2×10^{-6}
Maximally Exposed Individual Involved Worker Risk (probability of a latent cancer fatality)	0.0008	0.0008	0.0008	0.0008	0.0008	0.00004	0.0008
Involved Worker Population Risk (number of latent cancer fatalities)	0.0013	0.0015	0.0019	0.0030	0.0014	0.0002	0.0018
Hazardous Chemical Impacts Due to Incident-Free Operations and Transportation							
Offsite Public Maximally Exposed Individual							
• Probability of a cancer incidence	0	0	0	0	0	N/A	0
• Hazard Index	0	0	0	0	0	N/A	0.001
Offsite Public Population Risk (number of cancer incidences)	0	0	0	0	0	0.0005[a]	0
Maximally Exposed Individual Worker							
• Probability of a cancer incidence	0	0	0	0	0	N/A	0
• Hazard Index	0	0	0	0	0	N/A	0.02
Worker Population Risk (number of cancer incidences)	0	0	0	0	0	[a]	0

MEO = mediated electrochemical oxidation N/A = not applicable

[a] Number of cancer fatalities due to vehicle emissions. The impact is listed only once under public population because the vehicle emissions affect the public and worker populations collectively; however, the risk to the public dominates.

Table 2–22 Impacts of Managing Scrub Alloy

Impact	Repackage at Rocky Flats (No Action Processing Option)	Calcine and Vitrify at Rocky Flats	Pretreat at Rocky Flats and Purex at Savannah River Site (Preferred Processing Option)		
			Pretreat at Rocky Flats	Transport 6 Shipments	Purex at Savannah River Site
Products and Wastes					
Stabilized Residues (drums)	276	0	0	0	0
Transuranic Waste (drums)	59	2,809	58	0	23
High-Level Waste (canisters)	0	0	0	0	<1
Separated Plutonium (kg plutonium)	0	0	0	0	200
Low-Level Waste (drums)	140	140	140	0	82
Radiological Risks Due to Incident-Free Operations and Transportation					
Offsite Public Maximally Exposed Individual Risk (probability of a latent cancer fatality)	2.1×10^{-11}	3.2×10^{-11}	3.3×10^{-11}	5.5×10^{-6}	1.2×10^{-10}
Offsite Public Population Risk (number of latent cancer fatalities)	8.5×10^{-7}	1.2×10^{-6}	7.0×10^{-7}	0.00030	0.000013
Maximally Exposed Individual Involved Worker Risk (probability of a latent cancer fatality)	0.0008	0.0008	0.0008	0.00004	0.0008
Involved Worker Population Risk (number of latent cancer fatalities)	0.013	0.057	0.014	0.0004	0.010
Hazardous Chemical Impacts Due to Incident-Free Operations and Transportation					
Offsite Public Maximally Exposed Individual					
• Probability of a cancer incidence	0	0	0	N/A	0
• Hazard Index	0	0	0	N/A	0.007
Offsite Public Population Risk (number of cancer incidences)	0	0	0	0.00008[a]	0
Maximally Exposed Individual Worker					
• Probability of a cancer incidence	0	0	0	N/A	0
• Hazard Index	0	0	0	N/A	0.1
Worker Population Risk (number of cancer incidences)	0	0	0	[a]	0

N/A = not applicable

[a] Number of cancer fatalities due to vehicle emissions. The impact is listed only once under public population because the vehicle emissions affect the public and worker populations collectively; however, the risk to the public dominates.

Table 2–23 Impacts of the Management Approaches

Impact	Management Approaches							
	No Action	Preferred[a]	Minimize Total Process Duration at Rocky Flats	Minimize Cost	Conduct all Processes at Rocky Flats	Conduct Fewest Actions at Rocky Flats	Process with Maximum Plutonium Separation	Process Without Plutonium Separation
Products and Wastes								
Stabilized Residues (drums)	10,300	900	0	681	900	900	0	900
Transuranic Waste (drums)	3,500	11,200 - 13,600	5,800	11,200	15,400	6,900	9,900	31,000
High-Level Waste (canisters)	0	< 6	37	4	0	34	43	0
Separated Plutonium (kg)[b]	0	1,538–1,673	2,467	1,348	1,204	2,512	2,786	0
Low-Level Waste (drums)	7,600	9,800–16,900	5,500	5,000	10,200	11,200	20,000	4,500
Public and Occupational Health and Safety								
Incident-Free Radiological Risk to the Public Maximally Exposed Individual (Probability of a Latent Cancer Fatality)	2.4×10^{-10}	5.5×10^{-6}	5.5×10^{-6}	5.5×10^{-6}	2.4×10^{-10}	5.5×10^{-6}	5.5×10^{-6}	2.4×10^{-10}
Incident-Free Radiological Risk to the Public Population (Latent Cancer Fatalities)	6.0×10^{-6}	0.0022	0.0089	0.0021	6.2×10^{-6}	0.0074	0.0078	3.9×10^{-6}
Incident-Free Radiological Risk to the Maximally Exposed Individual Worker (Probability of a Latent Cancer Fatality per year)	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
Incident-Free Radiological Risk to the Worker Population (Latent Cancer Fatalities)	0.31	0.31– 0.33	0.37	0.31	0.36	0.33	0.37	0.66
Incident-Free Worker Hazard Index[c]	0	0.5	2	0.6	0	1.5	1.6	0
Accident Risk to the Public Maximally Exposed Individual (Probability of a Latent Cancer Fatality)	0.000023	0.000030-0.000031	0.000018	0.000017	0.000024	0.000050	0.000031	0.000027
Accident Risk to the Public Population (Latent Cancer or Traffic Fatalities)	0.41	0.47-0.48	0.34	0.31	0.43	0.53	0.50	0.47
Accident Risk to the Onsite Noninvolved Worker (Probability of a Latent Cancer Fatality)	0.00041	0.00054	0.00039	0.00035	0.00042	0.00090	0.00059	0.00046

Impact	Management Approaches							
	No Action	Preferred*	Minimize Total Process Duration at Rocky Flats	Minimize Cost	Conduct all Processes at Rocky Flats	Conduct Fewest Actions at Rocky Flats	Process with Maximum Plutonium Separation	Process Without Plutonium Separation
Other Impacts								
Intersite Round-Trip Transportation (1,000 km)[d]	0	223	847	204	0	786	815	0
Cost (million $)[e]	633[f]	520[g]	670	483	628	645	816	718
Processing Duration at Rocky Flats (years)[h]	7.1	3.6	2.5	4.0	6.4	3.8	3.5	13.4
Air Quality Impacts	Very small (See Sections 4.12 and 4.25)	Very small (See Sections 4.12 and 4.25)	Very small (See Sections 4.12 and 4.25)	Very small (See Sections 4.12 and 4.25)	Very small (See Sections 4.12 and 4.25)	Very small (See Sections 4.12 and 4.25)	Very small (See Sections 4.12 and 4.25)	Very small (See Sections 4.12 and 4.25)
Proliferation Risk	See note *i*	See Note *j*	See Note *j*	See Note *j*	See Note *j*	See Note *j*	See Note *j*	See Note *j*

SRS = Savannah River Site; LANL = Los Alamos National Laboratory; kg = kilograms; km = kilometers.

[a] These impacts may be expressed as ranges because DOE has not yet selected processing options for some residues.

[b] To convert to pounds, multiply by 2.2.

[c] The Hazard Index indicates the potential for noncancer health effects. When this index is greater than one, the potential for adverse health effects exists.

[d] To convert thousands of kilometers to thousands of miles, multiply by 0.62.

[e] Undiscounted 1997 Dollars. Fully allocated including all site overheads, common facility costs, and technology development costs.

[f] Of which $426 million is attributable to facilities costs and processing costs and $207 million is attributable to interim onsite storage at Rocky Flats from 2001 through 2015 plus offsite shipping. Assumes no STL waivers.

[g] Assumes STL waivers and no onsite interim storage for neutralize/dry for aqueous combustibles, thermal desorption/steam passivation for organic combustibles, repackaging for dry combustibles, neutralize/dry for glass, repackaging for graphite, and repackaging for inorganics. Assumes blenddown for filter media and furnace vitrification for sludge.

[h] Assumes all processes at different buildings or modules at Rocky Flats are conducted concurrently. Canyon depends on schedules for materials in programs outside the scope of this EIS. Processing duration at Los Alamos National Laboratory is 0.75 years in the Preferred and Maximum Separation Management Approaches and zero in the others.

[i] The plutonium residues and scrub alloy would be left in a form that cannot be disposed of due to proliferation concerns (except for any material disposed of through use of safeguards termination limit variances).

[j] The plutonium residues and scrub alloy would be managed and placed in a form that can be disposed of in a manner that supports U.S. nuclear weapons nonproliferation policy.

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Chapter 3

The Affected Environment

3. THE AFFECTED ENVIRONMENT

The affected environment descriptions in this chapter provide the background for understanding the environmental consequences described in Chapter 4 and serve as a baseline from which to identify and evaluate any environmental changes that may result from implementation of the proposed actions and alternatives. The resources that may be affected by the proposed action are grouped into the following interest areas for analysis in this Environmental Impact Statement (EIS):

- site infrastructure,
- air quality,
- socioeconomics,
- public and occupational health and safety, and
- waste management.

As discussed in Chapter 4, Section 4.1.1, impacts on the following resource areas are not expected to occur and, so, were not evaluated quantitatively: land and water, noise, geology and soils, ecology, and culture and paleontology. The potential impacts of the proposed action involve consideration only of the existing conditions for site infrastructure, air quality, socioeconomics, public and occupational health and safety, and waste management; therefore, only these resource areas are described in detail in this chapter. Pertinent summary information and references to sources providing additional information are provided for the other resource areas, however.

The following paragraphs describe the resource areas potentially impacted by the actions assessed in this EIS. Sections 3.1 through 3.3 present information on the resources that exist at each of the sites being evaluated.

❒ **Site Infrastructure**—Site infrastructure includes those utilities and other resources required to support construction and continued operation of mission-related facilities identified under the various alternative actions. The resources described and analyzed in this EIS include electrical power and electrical load capacity requirements; natural gas, coal, and oil fuel requirements; and transportation networks, including roads and rail interfaces.

❒ **Air Quality**

- *Meteorology and Climatology*—Meteorology and climatology combine to provide an overall description of regional temperature, precipitation, and wind directions and speeds, as well as an overall characterization of the regional climate (e.g., mild winters and long, humid summers).

- *Air Quality*—Air quality is affected by air pollutant emission characteristics, meteorology, and topography. Air pollution refers to any substance in the air that could harm human or animal populations, vegetation, or structures or that unreasonably interferes with the comfortable enjoyment of life and property. For the purpose of this EIS, only outdoor air pollutants are addressed. Pollutants may include almost any natural or artificial compound capable of being airborne and may be in the form of solid particles, liquid droplets, gases, or combinations of these forms. Generally, pollutants can be categorized as primary pollutants (those emitted directly from identifiable sources) and secondary pollutants (those produced in the air by interaction between two or more primary pollutants, or by reaction with normal atmospheric constituents, with or without photoactivation). Air pollutants are transported, dispersed, or concentrated by meteorological and topographical conditions.

Ambient air quality in a given location is the concentration of various pollutants in the atmosphere compared to the corresponding standards. Ambient air quality standards have been established by Federal and State agencies, allowing an adequate margin of safety for protection of public health and welfare from adverse effects associated with pollutants in the ambient air. Pollutant concentrations higher than the corresponding standards are considered unhealthy. Maintaining concentrations below the corresponding standards would protect most members of the public from adverse health effects.

The primary pollutants of concern are those for which Federal and State ambient air quality standards have been established, including criteria pollutants, hazardous air pollutants, and other toxic air compounds. Criteria pollutants are those defined in Title 40 of the Code of Federal Regulations (CFR) Part 50, "National Primary and Secondary Ambient Air Quality Standards." Hazardous air pollutants and other toxic compounds include those listed in Title III of the 1990 Clean Air Act, and those that have been proposed or adopted in regulations or are listed in guidelines by the respective States.

- **Socioeconomics**—Socioeconomics comprises the social, economic, and demographic characteristics of an area. The socioeconomic environment can be affected by changes in employment, income, and population, which, in turn, can affect area resources such as housing, community services, and infrastructure.

  The socioeconomic analysis assesses the environmental consequences of demographic and economic changes resulting from proposed alternatives, especially the potential impacts of additional workers and their families on the economy, housing availability, community services, and infrastructure.

- **Public and Occupational Health and Safety**—Public and occupational health and safety issues include the determination of potentially adverse effects on human health that result from exposure to ionizing radiation and hazardous chemicals. The degree of hazard is directly related to the type and quantity of the particular radioactive or chemical material to which the person is exposed and to the duration of the exposure. Human health assessments were performed for both incident-free operations and postulated accident situations.

  The current radiological and chemical environments at the various sites considered in this EIS help characterize the setting and serve as baselines against which impacts associated with the various program actions can be compared. Of particular importance are the radiological and hazardous chemical doses that workers and the public receive from exposures associated with both the natural background and existing site operations. These doses may result in adverse health effects.

- **Waste Management**—Waste management includes minimization, characterization, treatment, storage, transportation, and disposal of waste generated from ongoing U.S. Department of Energy (DOE) activities. Waste management covers waste produced by DOE's processing, manufacturing, remediation, decontamination and decommissioning, and research activities. The waste is managed using appropriate treatment, storage, and disposal technologies in compliance with all applicable Federal and State statutes and DOE Orders. Wastes are generated and categorized by their health hazard and handling requirements. Treated waste is waste that, following generation, has been altered chemically or physically to reduce its toxicity or to prepare it for storage or disposal. Waste treatment can include volume reduction activities, such as incineration or compaction, which may be performed on waste before either storage, disposal, or both. Stored waste is waste that, following generation (and usually some treatment), is being retained (temporarily) in a retrievable manner and monitored pending disposal. Disposed waste is waste that has been put in final emplacement to ensure its isolation from the environment with no intention of retrieval. Deliberate action would be required to regain access to the waste. Disposed wastes include materials placed in a geological repository or buried in landfills.

3.1 ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

Rocky Flats Environmental Technology Site (Rocky Flats) is located in rural northern Jefferson County, Colorado, 26 kilometers (km) (16 miles [mi]) northwest of downtown Denver and approximately 19 km (12 mi) south of Boulder. Once a remote site, Rocky Flats is now next to a large and growing metropolitan area that includes the communities of Boulder, Arvada, Westminster, Broomfield, and Golden. The Rocky Flats Industrial Area occupies approximately 155 hectares (ha) (384 acres [ac]) in the middle of the site. The remaining 2,495 ha (6,165 ac) form a buffer zone around the active part of Rocky Flats and provide more than 1.6 km (1 mi) between the developed portion of the site and any public road or private property. DOE property boundaries for the site are shown in **Figure 3–1**.

Rocky Flats' mission is to perform environmental restoration, cleanup, and waste management. The locations of major plutonium facilities at Rocky Flats are shown in **Figure 3–2**. Current activities at Rocky Flats are all related to DOE activities. Rocky Flats missions are listed in **Table 3–1**.

Table 3–1 Current Missions at Rocky Flats

Mission	Description
Interim Plutonium Storage	Maintain Buildings 371, 559, 707, 771, and 776/777 for interim plutonium storage, with eventual consolidation into a single facility.
Rocky Flats Environmental Restoration and Waste Management	As buildings are released from storage and stabilization missions, decontaminate and decommission; remove all plutonium and other toxic and/or hazardous materials; prepare plutonium wastes for final transport to long-term storage facility.

Source: DOE 1996a.

- **DOE Activities**—The site will continue its plutonium storage function, using existing buildings for nonsurplus and surplus plutonium materials. Plutonium component fabrication and production support activities have been stopped permanently; any future activities would take place at other DOE sites.

  The current Rocky Flats long-term mission is to prepare plutonium processing and fabrication facilities for decontamination and decommissioning with final disposition by DOE's Office of Environmental Management. The plutonium storage mission involves materials designated as either strategic reserve for current or anticipated program needs, surplus that can be converted to stable metal or oxide forms for storage and transport, or residue that is destined for disposal as waste. Plutonium storage capabilities would be maintained in Buildings 371, 707, 771, and 776/777, with eventual consolidation into a single facility.

  The previous primary mission of Rocky Flats was to produce components for nuclear weapons from such materials as plutonium, uranium, beryllium, and various alloys of stainless steel. Production was stopped in 1989. Until that time, the details of plant operations were classified, with little mission and management information given to the public. The site was off-limits to the general public. In 1992, the plant's production of nuclear weapon components was officially discontinued with the end of the Cold War.

  Rocky Flats now has a new mission—focusing on environmental restoration, waste management, management of special nuclear materials onsite (including plutonium), decontamination and decommissioning of facilities, and economic development. Although the site remains off-limits to the general public for health and safety considerations, DOE provides information to the public concerning management and operations and works closely with the public on issues related to Rocky Flats.

- **Non-DOE Activities**—None.

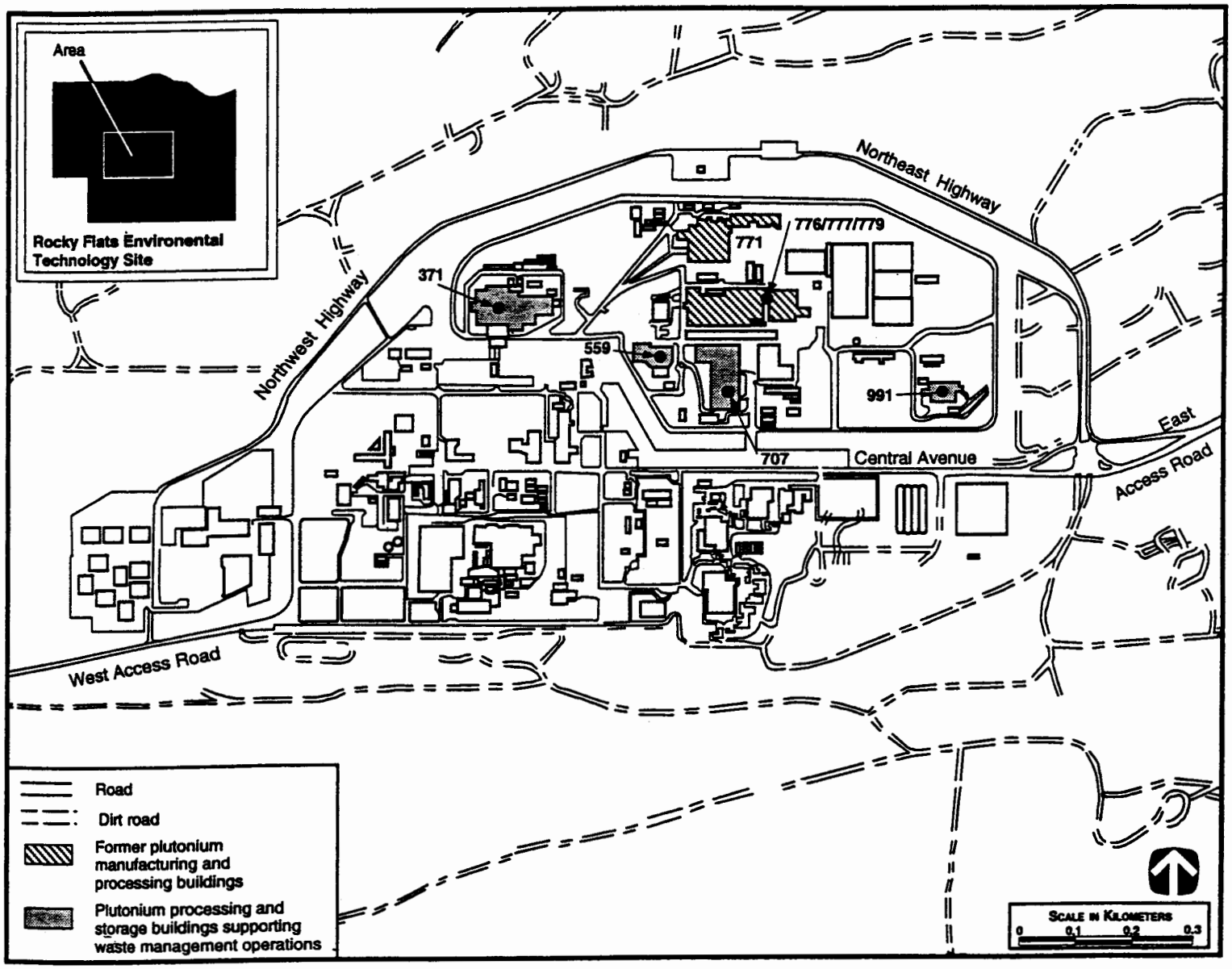


Figure 3–1 Site Designations, Principal Facilities, and Testing Areas at Rocky Flats

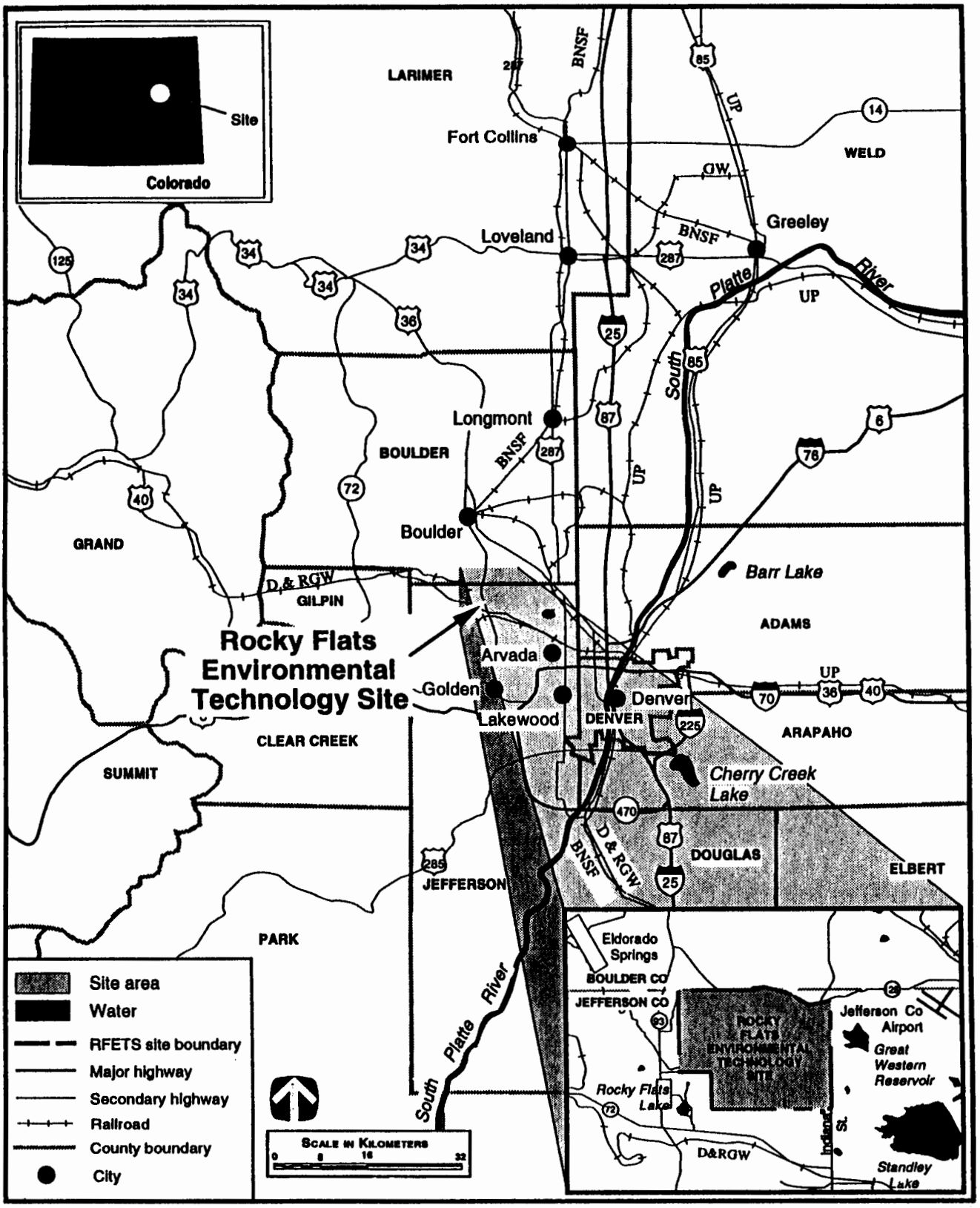


Figure 3–2 Rocky Flats, Colorado and Region

3.1.1 Land Resources

❒ **Land Use**—The 2,650-ha (6,550-ac) Rocky Flats Site is located in northern Jefferson County, Colorado, approximately 26 km (16 mi) northwest of downtown Denver. All land within Rocky Flats is owned by the Federal Government and managed and controlled by DOE.

Generalized land uses within Rocky Flats and the immediate vicinity are illustrated in **Figure 3–3**. Rocky Flats contains two major categories of land use: industrial and undeveloped. Former production facilities occupy approximately 155 ha (384 ac), or 6 percent of the site, and are centrally located on the site. The approximately 2,495 ha (6,165 ac) that remain are used as a security buffer zone and are mostly open space (undeveloped). However, there are several other uses, including approximately 8 ha (20 ac) of former production support facilities, approximately 45 ha (111 ac) of sanitary waste disposal, and 211 ha (523 ac) of aggregate and clay mining. No prime farmland exists onsite. There are no public recreation facilities onsite. Land uses surrounding the site include primarily open space, industrial, and rural residential and agricultural (grazing and hay production) (DOE 1993a).

Land use planning does not occur at the State level within Colorado; however, regional planning within the Rocky Flats vicinity occurs through the advisory Denver Regional Council of Governments. Rocky Flats is located within Jefferson County, one of six counties that comprise the Denver Regional Council of Governments. Jefferson County does not currently have a countywide comprehensive plan; however, the county has adopted community plans. Community plans function as land-use plans for specific areas of the county; their recommendations are used for making and granting future land-use decisions. The North Plains Community Plan designates Rocky Flats as a "Special Use Area" (JCPD 1990). The zoning resolution for Jefferson County classifies Rocky Flats land with the following zoning districts: agricultural, industrial, and special use.

❒ **Visual Resources**—The terrain of Rocky Flats is mostly grazing land with low hills and ridges. Construction and operation of DOE's facilities have heavily disturbed the character of the landscape. The most dominant features of the site include two large stacks and a water tank. Existing facilities are separated from public roads by the open land in the buffer area. The Rocky Mountains start to rise approximately 3.2 km (2 mi) to the west of Rocky Flats. Because access to the site is limited to authorized personnel, public visual access is limited to views from the outside (DOE 1993a). The facilities are brightly lit at night and are highly visible from many areas within a 4.8- to 8-km (3- to 5-mi) radius of the site. The area within the central developed area is consistent with the Bureau of Land Management's designation of Visual Resource Management Class 5. Class 5 designates areas in which cultural activities are dominant features of the landscape. For the remainder of the site, the natural landscape dominates or natural features are discernible.

3.1.2 Site Infrastructure

❒ **Baseline Characteristics**—Activities at Rocky Flats are concentrated in facilities located near the middle of the site. Baseline site infrastructure characteristics are shown in **Table 3–2**.

Two-lane county and State highways pass around the site, including State Highway 93 to the west, State Route 128 to the north, and Indiana Street to the east. No roads exist along the southern boundary of the site and no public access roads extend across Rocky Flats. Rocky Flats has controlled access gates to the east and west; a controlled access paved road runs through the middle of the site, connecting Highway 93 to Indiana Street. The site also has numerous dirt firebreak and access roads for management. Nuclear wastes from Rocky Flats are transported by truck primarily along the interstate highway system. Nuclear shipments are restricted to off-peak periods when traffic activity is low.

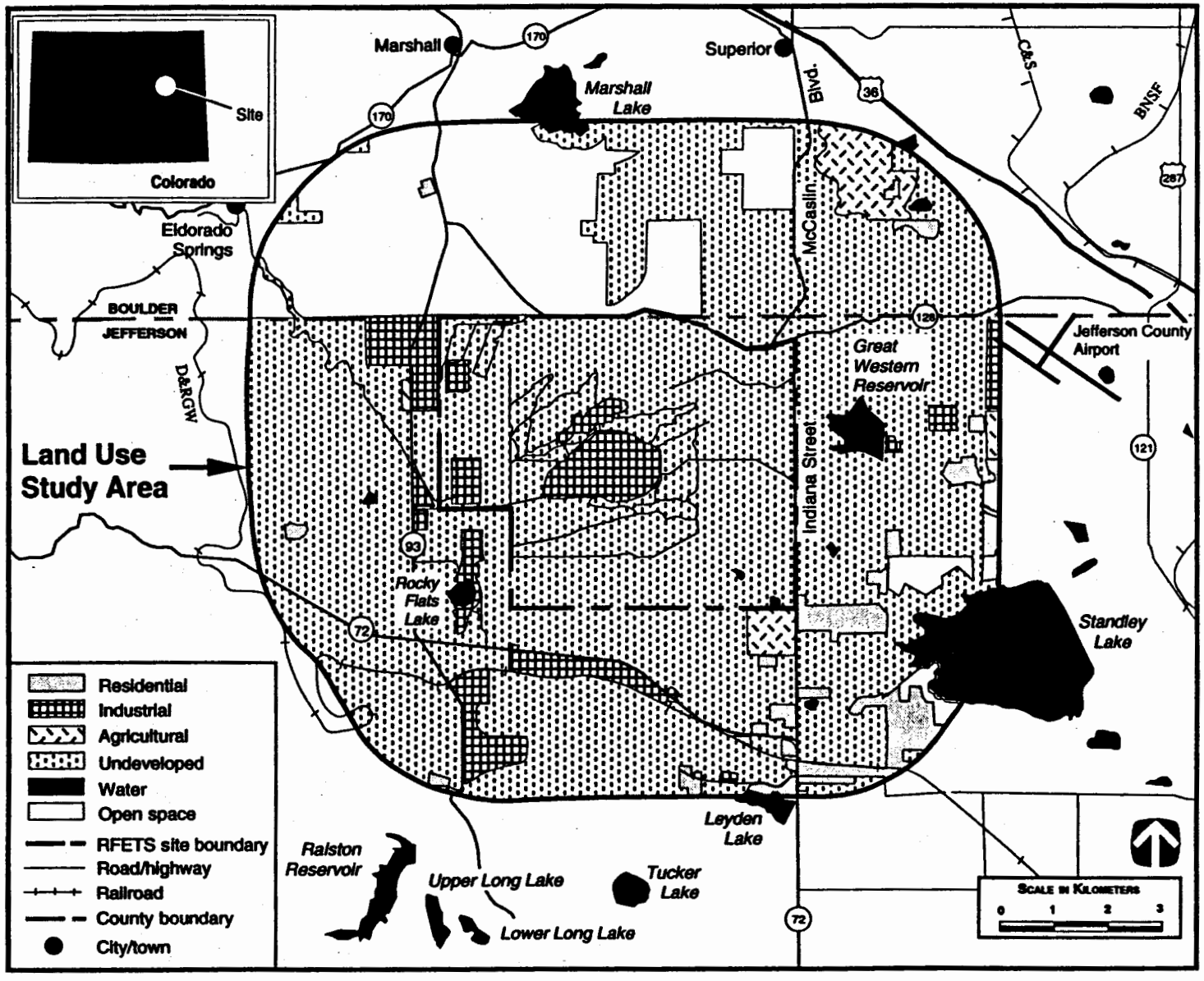


Figure 3–3 Generalized Land Use at Rocky Flats and Vicinity

Table 3–2 Rocky Flats Baseline Characteristics

Characteristics	Current Usage	Site Availability
Transportation		
Roads (km)	40	40
Railroads (km)	5	5
Electrical		
Energy consumption (MWh/yr)	184,000	184,000
Peak Load (MWe)	26	26
Fuel		
Natural gas (m^3/yr)	18,600,000	18,600,000
Oil (L/yr)	8,140,000	8,140,000
Coal (t/yr)	0	0
Steam (kg/hr)	41,000	41,000

km = kilometer MWh/yr = megawatt hours per year MWe = megawatts electric m^3/yr = cubic meters per year
L/yr = liters per year t/yr = tons per year kg/hr = kilograms per hour
Source: Adapted from DOE 1996a.

Normal and alternate power is supplied by the Public Service Company of Colorado through two electrical switching stations. Currently, one station (to the north of the site) supplies primary services, and the other (just outside the west gate) supplies service to a small portion of the western side of the site and serves as backup electrical power. Emergency diesel generators provide additional backup power capabilities. The subregional electric power pool from which Rocky Flats draws its power is the Rocky Mountain Power Area. Capabilities of this power pool are summarized in **Table 3–3**.

Table 3–3 Rocky Mountain Area Subregional Power Pool Electrical Summary

Characteristics	Energy Production
Type Fuel	
Coal	71%
Nuclear	0%
Hydro/geothermal	15%
Oil/gas	5%
Other[a]	9%

[a] Includes power from both utility and nonutility sources.
Source: NERC 1993.

The site is connected to a Public Service Company natural gas line. The line passes through the site and continues west to serve residential customers in the Coal Creek Canyon area.

The site acquires water by either of two methods; the method used at any particular time is at the discretion of the Denver Water Board. The preferred supply comes from a diversionary canal between Gross and Ralston Reservoirs. The canal passes the site between the west gate and Route 93 and provides gravity-fed flow to a holding pond, also to the west of the site. The second method involves pumping water directly from Ralston Reservoir to the holding pond, overcoming more than 300 feet of head pressure.

The locations of buildings at Rocky Flats were shown earlier in Figure 3–2. Descriptions of pertinent buildings follow.

- **Building 371**—Building 371 currently stores Category I and II special nuclear material and will be the primary special nuclear material consolidation and interim storage facility until long-term storage and disposition actions are decided and implemented. Currently, some of Rocky Flats plutonium residues, transuranic waste, and Resource Conservation and Recovery Act waste inventories are stored in Building 371. The 4-level facility has approximately 17,300 m^2 (186,000 ft^2) of floor space and contains 6 plutonium storage vaults and vault-type rooms. A stacker/retriever moves radioactive materials between the central storage vault and the input and output stations. In addition to this transport capability, the central storage vault was designed for storage of Category I and II special nuclear material. Building 371 was built to nuclear design standards; other buildings at the site were constructed to industrial standards.

- **Building 707**—Building 707 formerly was the location for plutonium foundry, machining, and assembly operations related to plutonium weapons components. Currently, small amounts of residue and waste inventories and the majority of plutonium metal at the site are stored in this building. The facility is a two-story building with a single-story section on the east side. The 2-story section has 6,900 m^2 (74,240 ft^2) per floor and the single-story section has 1,724 m^2 (18,560 ft^2). There is a small basement with an area of 93 m^2 (1,000 ft^2). The annex, Building 707A, is a 2-story, freestanding structure with 1,210 m^2 (13,000 ft^2) per floor. The main floor of the building is compartmentalized into eight modules (Modules A through H). There are two additional modules within the annex, Modules J and K. Several of the modules in both the main building and the annex are proposed for processing of the plutonium residues. The main facility has a remote-handled plutonium storage vault.

3.1.3 Air Quality and Noise

- **Meteorology and Climatology**—The Rocky Flats region is characterized as a dry climate, middle-latitude steppe, with mild, sunny, semiarid conditions and few temperature extremes. The average annual temperature at Rocky Flats is 10.2°C (50.3°F); temperatures vary from an average daily minimum of -8.8°C (16.1°F) in January to an average daily maximum of 31.2°C (88.2°F) in July. The average annual precipitation at Rocky Flats is 39.1 centimeters (15.4 inches) (DOE 1994a).

  Annual mean windspeeds and wind direction frequencies for Rocky Flats for 1990 are presented in **Figure 3–4**. The wind rose shows that the predominant wind direction frequency is from the west-northwest with a secondary maximum from the west. The mean windspeed from the west-northwest is 6.3 m/s (14.1 mph) and the maximum mean windspeed from the west is 5.7 m/s (12.8 mph). The average annual windspeed is 3.8 m/s (8.6 mph). Winter storms in the Rocky Flats area can generate winds with speeds as high as 21.5 m/s (48 mph). The fastest 1-minute windspeed recorded in Denver, Colorado, was 20.6 m/s (46 mph). Meteorological monitoring station data collected at Rocky Flats indicate that unstable conditions occurred about 59 percent of the time in 1990, neutral conditions occurred about 26 percent, and stable conditions occurred about 15 percent of the time (DOE 1996a).

- **Air Quality**—Rocky Flats is located within the Metropolitan Denver Intrastate Air Quality Control Region No. 36. This Air Quality Control Region is designated nonattainment with respect to the National Ambient Air Quality Standards for particulate matter ($\leq$10 microns in diameter), ozone, and carbon monoxide and is listed as attainment for sulfur dioxide and nitrogen dioxide (Title 40 CFR 81.306). The particulate matter ($\leq$10 microns in diameter) standard is exceeded primarily because of fugitive dust. Vehicular traffic is a major contributor to the high concentrations of ozone and carbon monoxide in the region (DOE 1996a).

  Since the creation of the Prevention of Serious Deterioration program in 1977, Prevention of Significant Deterioration permits have not been required for any new Rocky Flats emission sources. Several

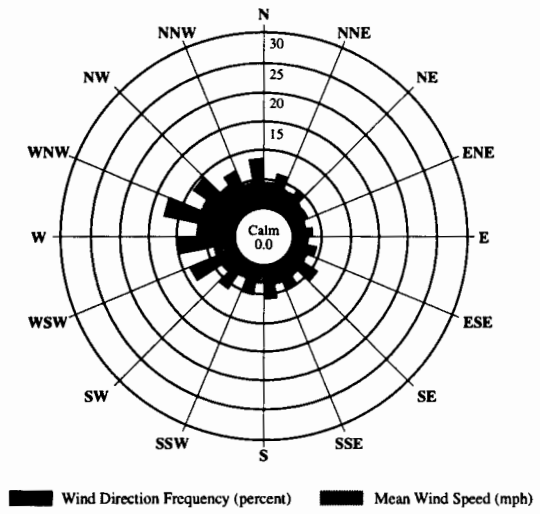


Figure 3–4 Wind Rose for the Rocky Flats Environmental Technology Site (1990) (61-meter level)

Prevention of Significant Deterioration (40 CFR 52.21) Class I areas exist near Rocky Flats. The closest, Rocky Mountain National Park, is located approximately 46 km (30 mi) northwest of Rocky Flats.

The emissions inventory from sources at Rocky Flats is shown in **Table 3–4**. Historically, the principal sources of criteria pollutants at Rocky Flats are the steam plant boilers. Minor combustion sources include various small boilers and diesel generators. Other sources of criteria pollutants included coating operations and particulate matter from various manufacturing operations.

National hazardous and toxic air pollutant standards have not been adopted by the State of Colorado Department of Public Health and Environment. The annual emission rates of hazardous/toxic air pollutants from existing Rocky Flats facilities for the period 1991 through 1993 are listed in Table 3–4. Table 3–4 presents the baseline ambient air concentration for criteria pollutants and other pollutants of concern at Rocky Flats. As shown in the table, baseline concentrations are in compliance with applicable guidelines and regulations.

- **Noise**—Major noise sources at Rocky Flats include various facilities, equipment, and machines (e.g., cooling systems, transformers, engines, pumps, boilers, steam vents, paging systems, construction and materials-handling equipment, and vehicles). No sound-level measurements have been made at Rocky Flats to determine background sound levels. Most Rocky Flats industrial facilities are far enough from the site boundary that their noise is barely distinguishable from background noise.

  The acoustic environment along the Rocky Flats boundary and at nearby residences away from traffic noise is typical of a rural location or quiet suburban residential area, with noise levels in the range of 35 to 52 decibels A-weighted (EPA 1974). Traffic is the primary source of noise at the site boundary and at nearby residences. Rocky Flats onsite traffic contributes little to overall traffic noise; however, traffic noise from other sources is expected to dominate sound levels along major roads in the area. Except for the prohibition of nuisance noise, neither the State of Colorado nor its local governments have established environmental noise standards applicable to Rocky Flats.

Table 3–4 Comparison of the Rocky Flats Contribution to Baseline Air Pollutant Concentrations with Most Stringent Applicable Regulations and Guidelines at Rocky Flats, 1991–1994

Pollutant	Averaging Time	Most Stringent Regulations or Guidelines[a] ($\mu g/m^3$)	Modeled Baseline Concentration[b] ($\mu g/m^3$)
Criteria Pollutants			
Carbon monoxide	8-hour	10,000[c]	145
	1-hour	40,000[c]	534
Lead	Calendar Quarter	1.5[c]	[d]
	30-day	1.5[e]	[d]
Nitrogen dioxide	Annual	100[c]	4.14
Ozone	1-hour	160[e, f]	[f]
Particulate matter less than or equal to 10 microns in diameter[g]	Annual	50[c]	0.235
	24-hour	150[c]	17.4
Sulfur dioxide	Annual	80[c]	0.295
	24-hour	365[c]	21.8
	3-hour	700[e]	64.6
Mandated by the State of Colorado			
Hydrogen sulfide	1-hour	142[e]	<0.01
Total suspended particulates	Annual	75[e]	0.284
	24-hour	150[e]	21.0
Hazardous and Other Toxic Pollutants			
1,1,2-Trichloro-1,2,2 trifluoroethane	Annual	[h]	0.01
Carbon tetrachloride	Annual	[h]	0.01
Dioctyl phthalate	Annual	[h]	<0.01
Methylene chloride	Annual	[h]	<0.01
Nitric acid	Annual	[h]	<0.01
Trichloroethane	Annual	[h]	<0.01

[a] The more stringent of the Federal and State standards is presented.
[b] Modeled concentration based on permit data.
[c] Federal and State standard.
[d] Data not available from the source document.
[e] State standard.
[f] Ozone, as a criteria pollutant, is not directly emitted or monitored by the site. In July 1997, the Environmental Protection Agency established a new 8-hour primary ambient standard of 0.08 ppm for ozone that replaces the previous 1-hour, 0.12 ppm standard; see Chapter 5 of this EIS for additional information.
[g] In July 1997, the Environmental Protection Agency established new standards for particles with an aerodynamic diameter less than or equal to a nominal 2.5 micrometers; see Chapter 5 of this EIS for additional information.
[h] No State or Federal standards exist.
Source: Adapted from DOE 1996a.

3.1.4 Water Resources

❒ **Surface Water**—The main surface water features at Rocky Flats are Walnut Creek, North Walnut Creek, South Walnut Creek, and Woman Creek (**Figure 3–5**). Streams at Rocky Flats are considered part of the Big Dry Creek drainage basin, although Big Dry Creek is not directly affected by Rocky Flats activities.

Rocky Flats lies on the divide between the Walnut Creek and Woman Creek drainage basins. North Walnut Creek and South Walnut Creek drain the central and northern areas of Rocky Flats, and Woman Creek drains the southern areas. South and North Walnut Creeks flow together and form Walnut Creek, which flows downstream from Rocky Flats and empties into the Broomfield Diversion Ditch. The Broomfield Diversion Ditch routes water around the Great Western Reservoir, which is a public water supply, then into Big Dry Creek, and eventually into the South Platte River.

Woman Creek flows east across the southern portion of Rocky Flats into Standley Lake, which provides irrigation storage and municipal water for surrounding communities. At times, Woman Creek may be diverted into Mower Reservoir, which also flows into Standley Lake. Standley Lake flows into Big Dry Creek, which flows into the South Platte River.

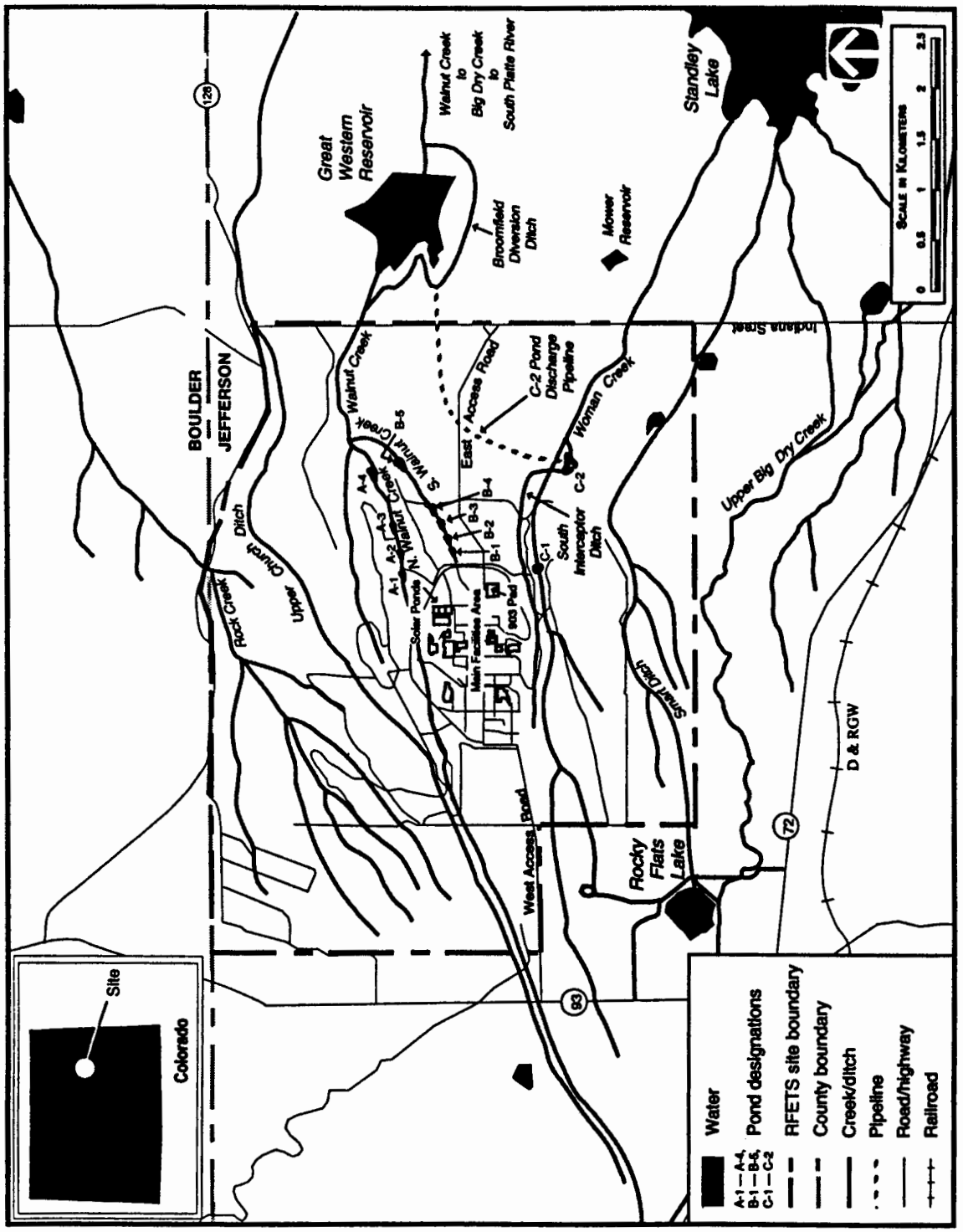


Figure 3–5 Surface Water Features at Rocky Flats

All natural surface water flow on Rocky Flats occurs in temporary channels that flow only as a result of precipitation, discharge of site effluents, surface seeps, or release of water from storage areas west of the site to supplement water supplies in the Great Western Reservoir or Standley Lake. On North Walnut Creek, South Walnut Creek, and Woman Creek, a series of unlined ponds serve to impound waters from the site. Along North Walnut Creek, the ponds are numbered A-1 through A-4; on South Walnut Creek, the ponds are numbered B-1 through B-5; and on Woman Creek, the ponds are numbered C-1 and C-2. Pond C-2 does not receive direct flow from Woman Creek; flow into Pond C-2 is from runoff into South Interceptor Ditch and then into Pond C-2.

Wastewater from industrial processes is treated at a treatment plant that is isolated from other sources and does not discharge to surface water features. Existing sanitary wastewater generation is estimated at approximately 150 million liters per year (L/yr) (39.6 million gallons per year [gal/yr]). Sanitary wastewater is treated and discharged to Pond B-3. Storm water runoff from the plant is conveyed in storm sewers that discharge to creeks on the undeveloped portion of the site. Discharges from Ponds A-3, A-4, B-3, B-5, and C-2 are monitored under the National Pollutant Discharge Elimination System permit program.

Terminal ponds (A-4, B-5, and C-2) are designed to capture the flow from a 100-year storm if maintained at less than 10 percent of capacity. Rocky Flats has exceeded the 10 percent capacity limit because of the large quantities of water treated and the delays in receiving approval for certain discharges.

Rocky Flats does not withdraw any water from streams on or near the site. All water for the plant is obtained from surface waters from the City of Denver via the South Boulder Diversion Canal from the South Boulder Creek and Ralston Reservoir. The water supply contract with the City and County of Denver through the Denver Water Board is for an unguaranteed supply of up to 5.7 million L/day (1.5 million gal/day). The current average water consumption is approximately 485 million L/yr (128 million gal/yr). Raw water is stored in a 5.7 million L (1.5 million gal) storage pond west of the plant.

- *Surface Water Quality*—The water from Woman Creek, North Walnut Creek, and South Walnut Creek flows into ponds that restrict offsite discharges, allow water testing, and permit any treatment necessary to meet water quality standards. A treatment facility is located at Pond A-4, and water from Pond B-5 is transferred to Pond A-4. Treatment consists of filtration and carbon absorption to reduce potential radionuclides and organic chemical contaminants.

  With permission from the Colorado Department of Health, water is released from Pond A-4 to Walnut Creek and from Pond C-2 to the Broomfield Diversion Ditch or, in an emergency, to Ponds A-4 or B-5.

  Discharges from Ponds A-4 and B-5 enter Walnut Creek and are diverted around the Great Western Reservoir by the Broomfield Diversion Ditch. Untreated water is discharged from Pond C-2 through a 2,438-meter (m) (7,999-foot [ft]) pipeline into the Broomfield Diversion Ditch and around the Great Western Reservoir. The release of untreated water from Pond C-2 has been approved by the Environmental Protection Agency (EPA) because sampling indicates that the water meets all Woman Creek standards except gross beta. The gross beta standards for Walnut Creek (the eventual destination of the piped discharge) are higher, and no standard is exceeded.

  An unlined surface water control pond exists immediately downstream and downhill from the landfill and from current waste disposal operations at the eastern end of the landfill. The landfill is considered a hazardous waste management landfill due to the past disposal of some materials that may now qualify as regulated hazardous wastes. The landfill pond routinely exceeds the Rocky Flats standard for strontium and has exceeded standards for copper, iron, lithium, manganese, mercury, nickel, plutonium, and zinc. The landfill pond does not discharge to natural surface waters. No Notices of Violation were received by Rocky Flats in 1993 for National Pollutant Discharge Elimination System limitations.

Additional information about surface water quality at the site can be found in the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996a).

- *Surface Water Rights and Permits*—Surface water rights are not an issue at Rocky Flats because Rocky Flats facilities do not withdraw surface water for use. As previously mentioned, the water supply contract with the City and County of Denver is for an unguaranteed supply of up to 5.7 million L/day (1.5 million gal/day).

❒ **Groundwater**—Two nonhydraulically connected groundwater systems are present at Rocky Flats. The upper unit exists as an unconfined aquifer and the lower unit as a confined aquifer. The contact separating the two units is identified as the base of the weathered zone.

The unconfined aquifer at Rocky Flats is primarily unconsolidated material, such as sand and gravel material. The average depth to the water table in the unconsolidated surficial deposits ranges from about 21 m (70 ft) at the western boundary of Rocky Flats to less than 3 m (10 ft) in the industrial area. Seeps are common along stream drainage. Groundwater flow direction is generally toward the east. Recharge to the unconfined aquifer occurs from infiltration of precipitation and as seepage from ditches, creeks, and ponds. In addition, retention ponds along South Walnut and Woman Creeks probably recharge this unit.

In the confined aquifer, groundwater is in the sandstone lenses below most of the plant. Flow within the sandstones is assumed to be from west to east. In some places, the sandstones are in contact with the alluvium so that the unit is part of the unconfined system at those places. Recharge to the sandstones occurs where they are in direct contact with the alluvium and valley fill of the upper aquifer or by leakage through claystones in contact with alluvium. The sandstone units discharge along the South Platte River, approximately 47 km (29 mi) east of Rocky Flats.

- *Groundwater Quality*—Groundwater monitoring has been conducted at Rocky Flats since 1960. By the end of 1994, approximately 300 wells were monitored to determine the groundwater quality and the distribution of contaminant constituents in groundwater at Rocky Flats. Groundwater quality in uncontaminated portions in surficial materials (alluvium, colluvium, valley fill, and weathered bedrock) is relatively good and can be classified as calcium bicarbonate water. The unweathered bedrock groundwater system can be distinguished from the surficial system by relatively higher sodium and sulfate content.

  The unconfined aquifer contains both radiological and nonradiological contaminants. To date, there are no known bedrock pathways through which groundwater contamination can directly leave Rocky Flats and migrate into the confined aquifer system offsite (DOE 1996a). Additional information about groundwater quality at the site can be found in the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996a).

- *Groundwater Availability, Use, and Rights*—Currently, no groundwater is used for drinking purposes by the facility. Approximately 10.6 million L/yr (2.8 million gal/yr) of groundwater is withdrawn from the site for contaminant removal as part of the environmental restoration program.

  Generally, the rights to groundwater resources in Colorado are unrelated to ownership of the land over those groundwater resources. For the Denver Basin aquifers, which include the lower aquifers at Rocky Flats, however, the right to groundwater resources derives from land ownership as long as the water is not tributary to any surface water supplies.

3.1.5 Geology, Soils, and Seismology

- **Geology**—Rocky Flats is located on the western edge of the Colorado Piedmont section of the Great Plains Province. The site is located on the west flank of the Denver Basin, an extensive sedimentary basin bordered on the west by the base of the Colorado Front Range. The site is located on a geomorphic surface composed of gravel on sand and clay.

  The surface geology at Rocky Flats consists of rock fragments, sand, and gravel deposits that range in thickness from several centimeters to more than 30.5 m (100 ft). The most important unit is Rocky Flats Alluvium, which consists of deposits of sand, gravel, and cobbles in a clay matrix that thins from west to east across the site (DOE 1985). The Arapahoe Formation (Cretaceous period, formed from 65 million to 130 million years ago), which immediately underlies the Rocky Flats Alluvium at Rocky Flats, is approximately 0 to 36.5 m (0 to 120 ft) thick and consists of claystones with interbedded sandstones and siltstones (DOE 1985; DOE 1994a).

  Landslides and other mass earth movements are present as shallow features where slopes are steep. Nearly all of the site, however, has slopes averaging only 2 percent. Slopes may be greater than 2 percent along the sides of washes.

- **Soils**—Rocky Flats is underlain mainly by soils of the Denver-Kutch and Flatirons-Velscamp soil associations. The erosion potential of the Denver-Kutch soil is low to moderate; shrink-swell potential is moderate to high. The Flatirons-Velscamp soil does not pose an erosion hazard; its shrink-swell potential is low to moderate.

- **Seismology**—Rocky Flats lies in Seismic Zone 1, indicating minor damage could occur as a result of earthquakes. No major faults cut the Arapahoe Formation or overlying alluvium in the vicinity of Rocky Flats. The Livingston fault, located approximately 5 km (3 mi) to the west, and the Golden fault, located approximately 8 km (5 mi) to the south, are the mountain-front faults closest to the facility. Neither fault is recognized as a capable fault according to 10 CFR Part 100, Appendix A. No other capable faults are present in the immediate vicinity of Rocky Flats. There are no active volcanos in the Denver Basin (DOE 1996a). Additional details are in Appendix D, Section 3.3.3.1.

3.1.6 Ecology

Detailed information about ecological resources at Rocky Flats can be found in the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996a). Federal threatened, endangered, and candidate species that may be found on or in the vicinity of the site include the Swift fox, American peregrine falcon, Arctic peregrine falcon, Bald eagle, Least tern, Mountain plover, Piping plover, Southwestern willow flycatcher, Whooping crane, Colorado butterfly plant, and Ute ladies'-tresses (DOE 1996a). Note that in March 1997, the U.S. Fish and Wildlife Service published a proposal to list the Preble's meadow jumping mouse as an endangered species (DOE 1997b). The final listing decision is not expected until March 1998 (USFWS 1997).

3.1.7 Cultural and Paleontological Resources

Thirty-five historic sites have been identified at Rocky Flats. Most of the historic resources in the area are archaeological sites or standing structures associated with ranching or transportation routes. Several Native American groups, including the Plains Apache, Comanche, Ute, Arapaho, and Cheyenne, historically occupied or crossed the foothills around Rocky Flats. No paleontological materials have been recovered from the Rocky Flats alluvium, and it is considered nonfossiliferous. Additional information about cultural resources at the site can be found in the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996a).

3.1.8 Socioeconomics

- **Regional Economy Characteristics**—Between 1980 and 1990, the civilian labor force in the regional economic area increased 39.9 percent to the 1990 level of 1,868,628. The regional economic area encompasses 49 counties around Rocky Flats located in Colorado, Nebraska, and Kansas. The 1994 unemployment rate in the regional economic area was 4.1 percent, which parallels the unemployment rate for Colorado. The unemployment rate for Kansas is approximately 1 percent higher than that of the regional economic area, and Nebraska is about 1 percent lower than the regional economic area unemployment rate. The region's per capita income of $21,958 in 1993 was approximately 2 percent greater than Colorado's per capita income of $21,498. The Kansas per capita income ($19,849) was 9.6 percent lower than the region's, and Nebraska's per capita income ($19,673) was 10.4 percent lower (DOE 1996a).

  The composition of the regional economic area economy was similar to that of the statewide economy of Colorado. During 1993, the services sector constituted more than 31 percent of the region's total employment, followed by retail trade (approximately 17 percent) and manufacturing (approximately 9 percent). For Colorado, the service sector accounted for slightly more than 30 percent of the total employment, retail trade accounted for 17 percent, and manufacturing accounted for 8 percent. Kansas and Nebraska paralleled each other, with the service sector representing 25 and 26 percent, respectively, of total employment, retail trade representing 17 percent for both States, and manufacturing representing 12 and 10 percent, respectively (DOE 1996a).

- **Population and Housing**—In 1994, the region of influence population totaled 1,957,797. The region of influence is a five-county area (Adams County, Araphahoe County, Boulder County, Denver County, and Jefferson County) located in Colorado in which over 90 percent of all Rocky Flats employees reside. From 1980 to 1994, the region of influence population grew by 22.9 percent, compared to 26.5 percent for Colorado. Within the region of influence, Arapahoe County experienced the greatest population increase, 51.2 percent; Denver County's population increased by only 0.2 percent (DOE 1996a).

  The increase in number of housing units in the region of influence between 1980 and 1990, 22.5 percent, was about 1 percent less than the increase in Colorado housing units. The total number of housing units in the region of influence for 1990 was 788,480. The 1990 region of influence homeowner and renter vacancy rates, 3.2 and 11.7 percent, respectively, were similar to those in Colorado (DOE 1996a).

  Figure 3–6 shows the racial and ethnic composition of minorities residing within an 80-km (50-mi) radius of Rocky Flats at the time of the 1990 census. This 80-km (50-mi) radius defines the region of potential influence for radiological impacts evaluated in Chapter 4 of this EIS. The minority population as a percentage of total population residing in the region of influence was approximately 5 percent less than the national percentage of minorities residing in the continental United States at the time of the 1990 census (24.2 percent). Hispanics comprised nearly 63 percent of the minority population in the region of influence (DOE 1996a).

  Figure 3–7 illustrates the geographical distribution of the minority population living within the region of influence expressed as a percentage of the total population. Areas in which the percentage minority population exceeded the national average by a factor of 1.5 or more are designated with horizontal and vertical crosshatching. Areas with the largest percentage minority population are found within the City of Denver and along Highway 85 near Fort Lupton and Greeley. As shown in Table F-3 of Appendix F of this EIS, at the time of the 1990 census, approximately 41 percent of the 857,629 households residing within the region of influence had a self-reported income less than 80 percent of the median income for the county of residence. These households qualify as low-income households under rules of the Department of Housing and Urban Development (DOE 1996a).

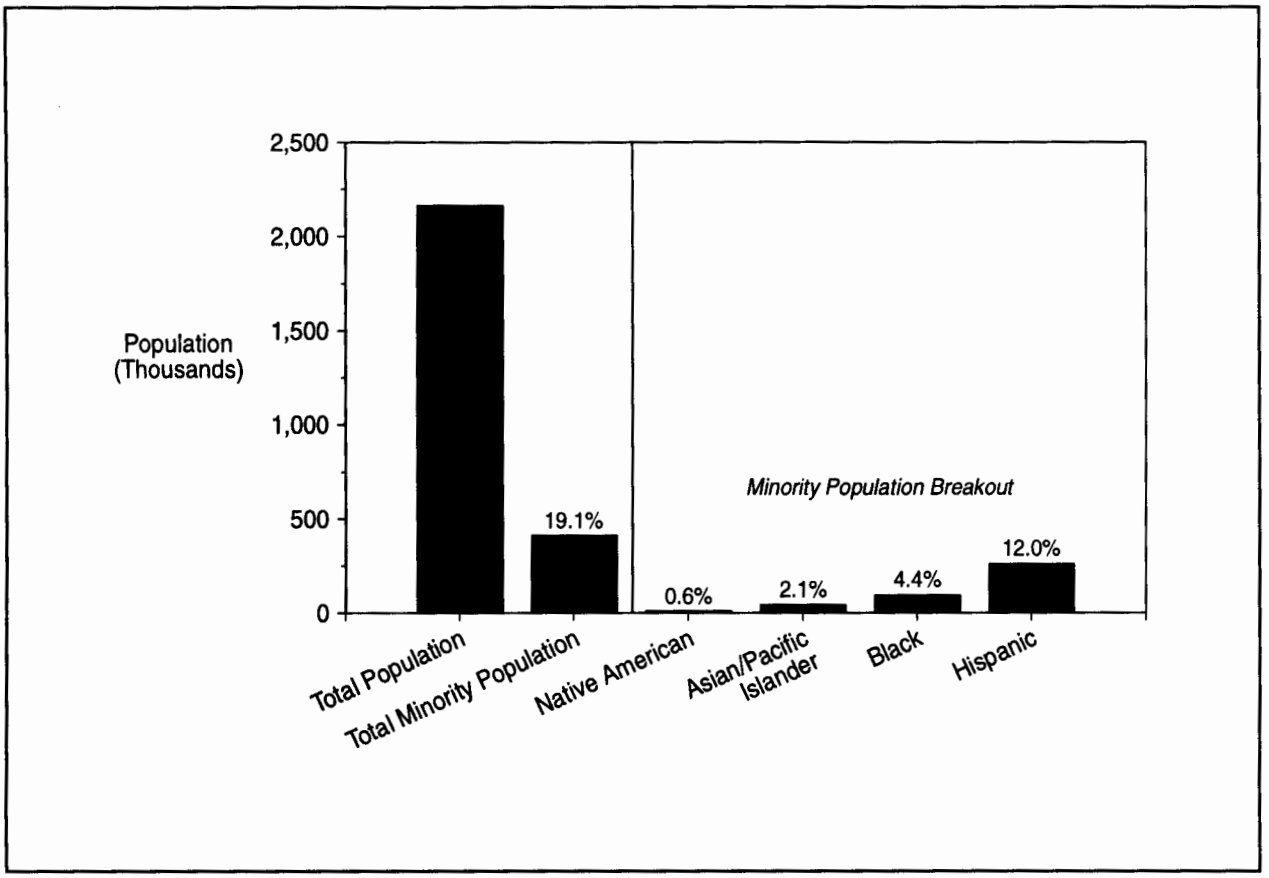
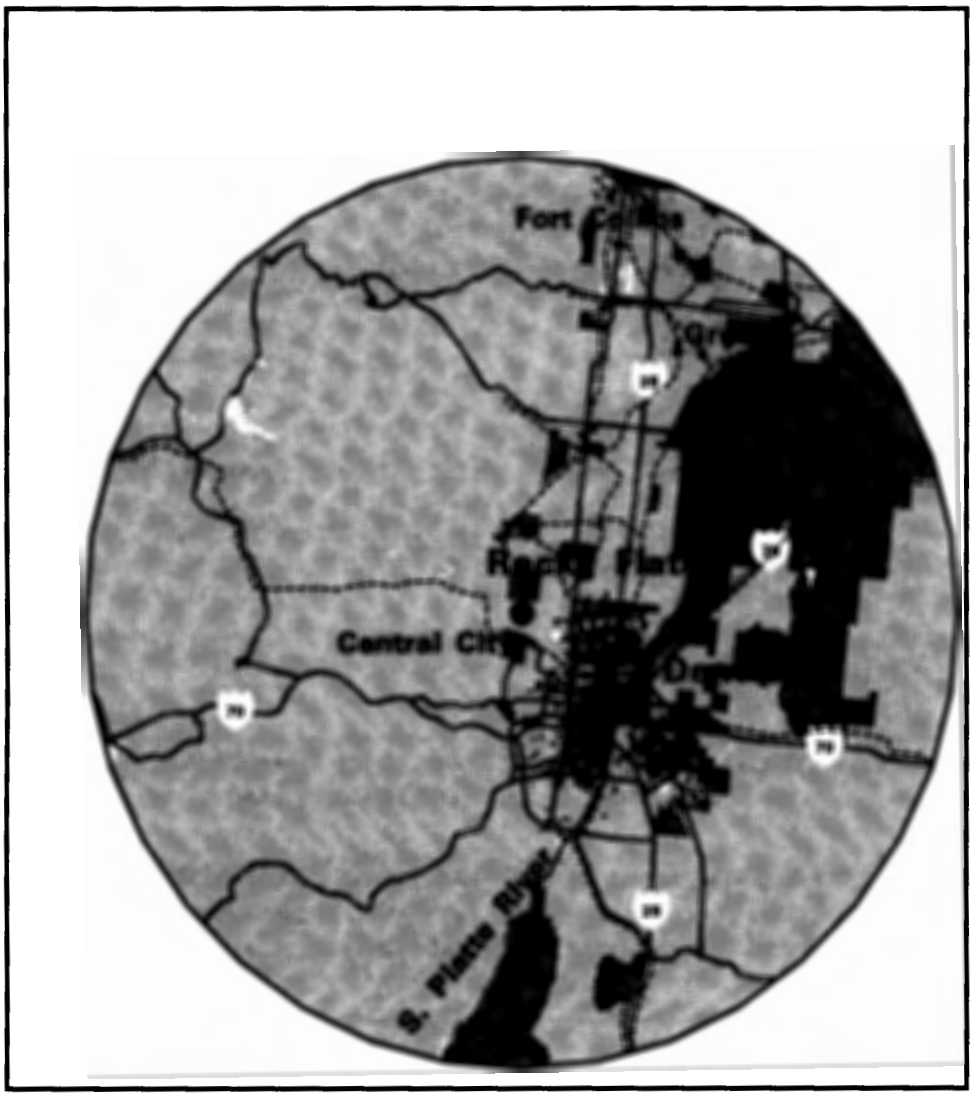


Figure 3–6 Racial and Ethnic Composition of the Minority Population Residing Within 80 km (50 mi) of Rocky Flats

As shown in Table F-4 of Appendix F, approximately 10 percent of the individuals living within the region of influence had a self-reported income less than the poverty level. The poverty level is a function of family size and number of unmarried children in the family under 18 years of age (Appendix F). The national percentage of individuals with income less than the poverty-level in 1995 is estimated by the Census Bureau to be 13.8 percent. At the time of the 1990 census, the national percentage of individuals with income less than the poverty level for the continental United States was 13.3 percent. **Figure 3–8** shows the distribution of poverty-level individuals living within the region of influence.

- **Education**—In 1994, 18 school districts provided public education services and facilities in the Rocky Flats region of influence. These school districts operated at between 67.5-percent (Denver County School District) and 102.5-percent (Byers School District) capacity. The average student-to-teacher ratio for the Rocky Flats region of influence in 1994 was 19:1. The Jefferson County School District had the highest ratio at 23.7:1.

- **Public Safety**—City, county, and State law enforcement agencies provided police protection to the residents of the region of influence. In 1994, a total of 3,811 sworn police officers were serving the 5-county region of influence. The City of Denver employed the largest number of officers (1,378) and had the highest officer-to-population ratio (2.8 sworn officers per 1,000 persons). The average region of influence officer-to-population ratio was 2.0 officers per 1,000 persons.



LEGEND

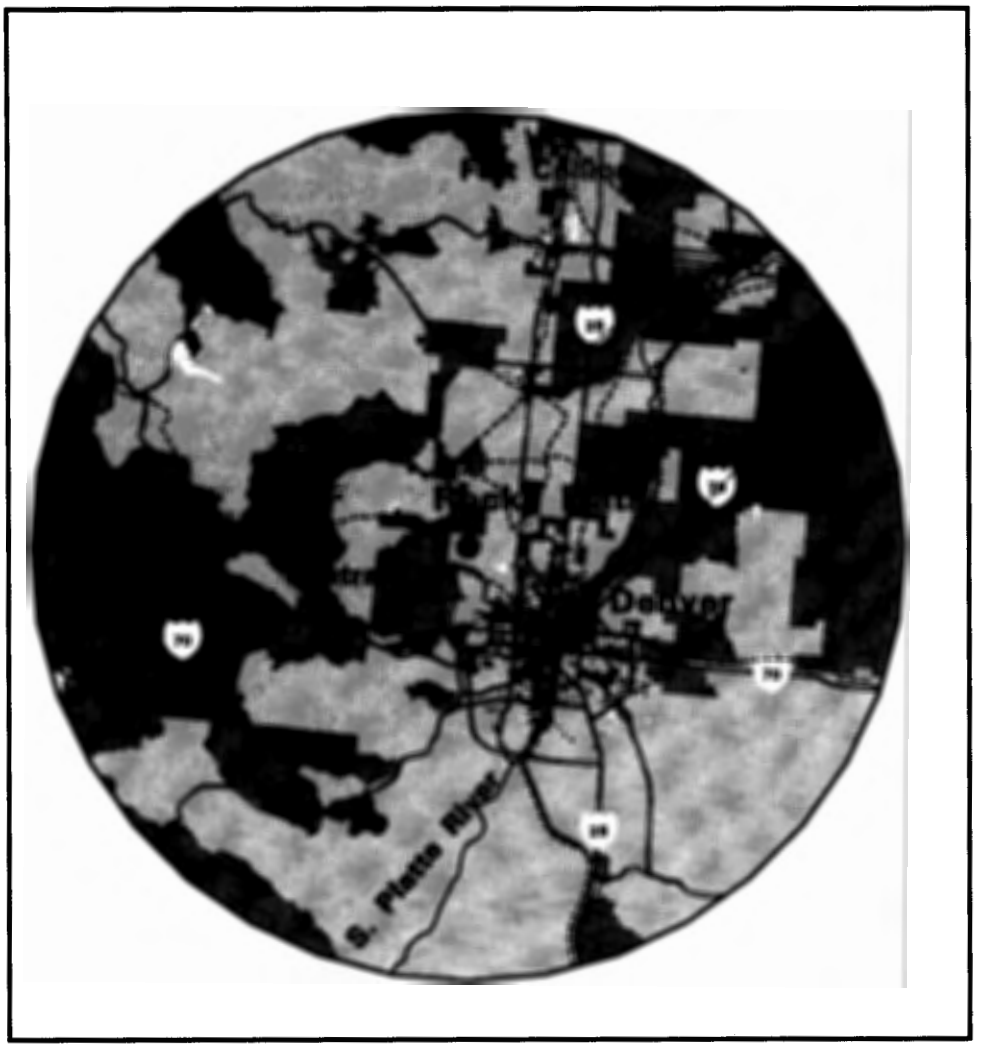
- Site
- Surface Water Shoreline
- Rail Lines
- State & US Highways

- 0 <= Pm < 12%
- 12% <= Pm < 24%
- 24% <= Pm < 48%
- Pm >= 48%

SUMMARY STATISTICS	
WITHIN 80 KM (50 MILES) RADIUS OF THE SITE	
TOTAL POPULATION	2,165,727
MINORITY POPULATION	414,505
PERCENTAGE	19%

0 5 10 15 20 25 30
miles

Figure 3–7 Distribution of Minority Population Living Within 80 km (50 mi) of Rocky Flats



LEGEND

- Site
- Surface Water Shoreline
- Rail Lines
- State & US Highways

- 0 <= Pp < 6.5%
- 6.5% <= Pp < 13%
- 13% <= Pp < 26%
- Pp >= 26%

SUMMARY STATISTICS	
WITHIN 80 KM (50 MILES) RADIUS OF THE SITE	
TOTAL POPULATION	2,165,727
POVERTY-LEVEL POPULATION	219,263
PERCENTAGE	10%

0 5 10 15 20 25 30
miles

Figure 3–8 Distribution of Poverty-Level Population Living Within 80 km (50 mi) of Rocky Flats

Fire protection services in the Rocky Flats region of influence were provided by 5,408 regular and volunteer firefighters in 1995. The fire district with the highest firefighter-to-population ratio was Adams County, with 9.5 firefighters per 1,000 persons. Adams County also employed the greatest number of firefighters (1,396). The average firefighter-to-population ratio in the region of influence was 2.7 firefighters per 1,000 persons.

- **Health Care**—Nineteen hospitals served the five-county region of influence in 1994. More than 64 percent of the hospital bed capacity was located in 9 hospitals in the city of Denver. During 1994, all 19 hospitals operated at below capacity, with bed occupancy rates ranging from 22.4 percent in Adams County to 60.2 percent in Denver County.

  During 1994, 5,017 physicians practiced in the region of influence with the majority (2,649) operating in Denver County. Physician-to-population ratios ranged from 1.2 physicians per 1,000 persons in Jefferson County to 5.4 physicians per 1,000 persons in Denver County. The average region of influence physician-to-population ratio was 2.6 physicians per 1,000 persons.

- **Local Transportation**—Vehicular access to Rocky Flats is provided by Colorado State Highway 93 to the west and Jefferson County Road 17 (Indiana Street) to the east. Road improvements for segments providing access to Rocky Flats include bridge replacement and reconstruction along Colorado State Highway 93 before the year 2000. There are no current road improvements that would affect access to Rocky Flats. There is no public transportation to Rocky Flats (DOE 1995c).

  Major railroads in the region of influence include the Denver and Rio Grande Western Railroad, the Burlington Northern and Santa Fe Railroad, and the Union Pacific Railroad. A single-track spur from the Denver and Rio Grande Western Railroad main line enters Rocky Flats from the west. No navigable waterways within the region of influence are capable of accommodating waterborne transportation of material shipments to Rocky Flats (DOE 1993a). The Denver International Airport, which began operation in 1995, provides passenger and cargo service in the region of influence on national and international carriers.

3.1.9 Public and Occupational Health and Safety

- **Radiation Environment**—Major sources and levels of background radiation exposure to individuals in the vicinity of Rocky Flats are shown in **Table 3–5.** Annual background radiation doses to individuals remain constant over time. The total dose to the population changes as the population size changes. Background radiation doses are unrelated to Rocky Flats operations.

Table 3–5 Sources of Radiation Exposure to Individuals in the Vicinity, Unrelated to Rocky Flats Operations

Source	Effective Dose Equivalent (mrem/yr)
Natural Background Radiation[a]	
Cosmic and cosmogeneric radiation	51
External terrestrial radiation	63
Internal terrestrial radiation	39
Radon in homes (inhaled)	200
Other Background Radiation[b]	
Diagnostic x-rays and nuclear medicine	53
Weapons test fallout	<1
Air travel	1
Consumer and industrial products	10
Total	418

[a] DOE 1994a.
[b] NCRP 1987.
Note: Value for radon is an average for the United States.

Releases of radionuclides to the environment from Rocky Flats operations provide another source of radiation exposure to individuals in the vicinity of Rocky Flats. Types and quantities of radionuclides released from Rocky Flats operations in 1994 are listed in the *Site Environmental Report for 1994* (Kaiser-Hill 1995). Doses to the public resulting from these releases are presented in **Table 3–6.** These doses fall within radiological limits stated in DOE Order 5400.5 and are small in comparison to background radiation.

Table 3–6 Radiation Doses to the Public from Incident-Free Rocky Flats Operations in 1994 (Committed Effective Dose Equivalent)

Members of the General Public	Atmospheric Releases		Liquid Releases		Total	
	Standard[a]	Actual	Standard[a]	Actual	Standard[a]	Actual
Maximally exposed individual (mrem)	10	0.14	4	~0	100	0.14
Population within 80 km (50 mi)[b] (person-rem)	None	0.26	None	0[c]	None[d]	0.26
Average individual within 80 km (50 mi)[e] (mrem)	None	0.00012	None	0[c]	None	0.00012

[a] The standards for individuals are given in DOE Order 5400.5. As discussed in that Order, the 10 mrem/yr limit from airborne emissions is required by the Clean Air Act, the 4 mrem/yr limit is required by the Safe Drinking Water Act, and the total dose of 100 mrem/yr is the limit from all pathways combined.
[b] In 1994, this population was approximately 2,200,000.
[c] No population groups are exposed to any liquid pathways.
[d] A 100 person-rem value for the population is given in proposed 10 CFR Part 834 (58 *Federal Register* 16268). If the potential total dose exceeds this value, it is required that the contractor operating the facility notify DOE.
[e] Obtained by dividing the population dose by the number of people living within 80 km (50 mi) of the site.
Source: Rocky Flats 1995a.

Workers at Rocky Flats receive the same dose as the general public from background radiation; they receive an additional dose from working in the facilities. **Table 3–7** presents the average and cumulative dose to Rocky Flats workers from operations in 1996.

Table 3–7 Radiation Doses to Workers from Incident-Free Rocky Flats Operations in 1996 (Committed Effective Dose Equivalent)

Occupational Personnel	Onsite Releases and Direct Radiation	
	Standard[a]	Actual
Average worker (mrem)	None	57
Total workers[b] (person-rem)	None	263

[a] DOE's goal is to maintain radiological exposures as low as reasonably achievable. This includes maintaining doses to individual workers so far below the DOE limit of 5,000 mrem/year (10 CFR Part 835) that no dose is expected to exceed the DOE Administrative Control Level of 2,000 mrem/year (DOE/EH-0256T).
[b] The number of badged workers in 1996 was approximately 4,600.
Source: DOE 1997b.

A more detailed presentation of the radiation environment, including background exposures and radiological releases and doses, is presented in the *Site Environmental Report for 1994* (RFP-ENV-94). Concentrations of radioactivity in various environmental media (including air, water, and soil) in the site region (onsite and offsite) are also presented in this reference.

❒ **Chemical Environment**—The background chemical environment important to human health consists of the atmosphere (hazardous chemicals may be inhaled), drinking water (hazardous chemicals may be swallowed), and other parts of the environment people encounter (such as surface waters during swimming and soil through direct contact or via the food pathway).

Effective administrative and design controls help minimize potential health impacts to the public by decreasing hazardous chemical releases to the environment and by helping achieve compliance with permit requirements, such as air emissions and National Pollutant Discharge Elimination System permit requirements. The effectiveness of these controls is verified through the use of monitoring information and the inspection of mitigation measures. During incident-free operations at Rocky Flats, health impacts to the public may occur from breathing air containing hazardous chemicals released to the atmosphere by Rocky Flats operations. Other risks to public health, such as drinking contaminated water or direct exposure, are low compared to risks from breathing.

Baseline air emission concentrations for hazardous chemicals and their applicable standards are included in the data already presented in Section 3.1.3. These concentrations are estimates of the highest existing offsite concentrations and represent the highest concentrations to which members of the public could be exposed. These concentrations are in compliance with applicable guidelines and regulations.

Exposure pathways to Rocky Flats workers during incident-free operations may include inhaling the workplace atmosphere and direct contact with hazardous materials associated with work assignments. The potential for health impacts varies from facility to facility and from worker to worker, and available information is not sufficient to allow a detailed estimation and summation of these impacts. However, the workers are protected from hazards specific to the workplace through appropriate training, protective equipment, monitoring, and management controls. Rocky Flats workers are also protected by adherence to Occupational Safety and Health Administration and EPA standards that limit workplace atmospheric and drinking water concentrations of potentially hazardous chemicals. Appropriate monitoring that shows the frequency and amounts of chemicals used in the operational processes ensures that these standards are not exceeded. Additionally, DOE requirements (DOE Order 440.1) ensure that conditions in the workplace are as free as possible from recognized hazards that cause or are likely to cause illness or physical harm.

- **Emergency Preparedness**—Each of DOE's sites have established an emergency management program that would be activated in the event of an accident. Each program has been developed and maintained to ensure adequate response for most accident conditions. The emergency management program incorporates activities associated with emergency planning, preparedness, and response.

  Rocky Flats has emergency plans that provide guidance and procedures designed to protect: (1) life and property within the facility, (2) the health and welfare of surrounding metropolitan communities, and (3) the defense interests of the nation during any credible emergency situation. Mutual assistance and coordination with Federal, State, and local agencies is provided on a cooperative basis.

  DOE's Rocky Flats Area Office Manager coordinates activities for emergencies affecting offsite personnel or property and is responsible for communication with the supporting Federal, State, and local agencies. The Rocky Flats Area Office Manager may obtain further assistance through the Interagency Radiological Assistance Plan, which provides that each of the signatory Federal agencies will assist one another in the event of a major emergency involving radioactivity.

  The Rocky Flats Emergency Plan is designed to enable Rocky Flats to be as self-sufficient as possible in handling onsite emergency situations. Assistance may be requested from outside sources through written agreements with St. Anthony Hospital, St. Luke's Hospital, the University of Colorado, the Jefferson County Sheriff's Office, and the Federal Bureau of Investigation.

  In the event of an offsite emergency, the *Rocky Flats Radiological Assistance Plan* interfaces with the *DOE Radiological Assistance Plan*, the *Interagency Radiological Assistance Plan*, and the Joint Nuclear Accident Coordinating Center through the DOE Rocky Flats Area Office at Rocky Flats. Additionally, in the event of an incident at Rocky Flats involving the release of radioactive material that may endanger the

health and safety of the general public, the *Colorado Radiological Emergency Response Plan* would be activated.

3.1.10 Waste Management

Table 3–8 presents a summary of waste management activities at Rocky Flats for 1995. DOE is working with Federal and State regulatory authorities to address compliance and cleanup obligations arising from its past operations at Rocky Flats. DOE engaged in several activities to bring its operations into regulatory compliance. These activities are set forth in negotiated agreements that contain schedules for complying with applicable requirements and financial penalties for not meeting agreed-upon milestones.

The focus of the Rocky Flats mission is on stabilization, decommissioning, and environmental restoration. The legal framework establishing the scope, schedule, and approach for projects in the cleanup program is the Rocky Flats Cleanup Agreement which provides a uniform framework for decommissioning, waste management, and environmental restoration onsite. The agreement integrates the actions required under the authority and jurisdiction of the Comprehensive Environmental Response, Compensation, and Liability Act and Resource Conservation and Recovery Act. The primary objective of the environmental restoration program is to assess and to clean up Rocky Flats in compliance with applicable environmental laws and regulations.

Rocky Flats manages the following waste categories: transuranic, low-level, hazardous, toxic substances, mixed, and nonhazardous. Waste management includes the treatment, storage, shipment, and disposal of waste. Waste disposal activities include disposal of low-level waste, low-level mixed waste, and low-level toxic substances waste at the Nevada Test Site, Envirocare of Utah, and the Hanford Site; preparing, transporting, and disposing of hazardous and other regulated wastes by commercial vendors; and the disposing of sanitary waste in the onsite landfill. A discussion of the waste management operations associated with each waste category follows.

- **Transuranic Waste**—Transuranic and mixed transuranic wastes generated at Rocky Flats before 1970 were shipped to Idaho National Environmental Engineering Laboratory and disposed of underground. After 1970, this waste was shipped to Idaho National Environmental Engineering Laboratory for interim storage until a permanent disposal facility becomes available. As a result of delays in opening the Waste Isolation Pilot Plant (WIPP) in Carlsbad, New Mexico, the Governor of Idaho placed a moratorium on out-of-State waste shipments to Idaho National Environmental Engineering Laboratory in October 1988, forcing Rocky Flats to store transuranic and mixed transuranic wastes onsite.

  This onsite storage violated Resource Conservation and Recovery Act storage provisions and led to several interim agreements. Storage of transuranic and mixed transuranic wastes at Rocky Flats is governed by the provisions of the Colorado Department of Health Settlement Agreement and Compliance Order on Consent, Number 89-07-10-01, related to mixed wastes, that was signed on July 14, 1989. The Order required Rocky Flats to submit a Part A Permit Application for all its interim status mixed transuranic and mixed low-level waste storage and treatment units. The Order granted interim status to all mixed transuranic waste units, except unit 60, included in applications filed by July 1, 1988, and also granted interim status to units used for storage and treatment of hazardous and mixed low-level waste identified in an August 2, 1988, Part A Application. The mixed residues were subsequently incorporated into the existing Rocky Flats Part B Permit for the treatment and storage of mixed and hazardous waste.

Table 3–8 Waste Management Activities at Rocky Flats

Waste Category	1996 Generation[a] (m^3)	Treatment Method	Treatment Capacity (m^3/yr)	Storage Method	Storage Capacity (m^3)	Disposal Method	Disposal Capacity
Transuranic							
Liquid	None	Solidification	Included in liquid mixed low-level waste	None	N/A	NA	NA
Solid	25	Compaction	Included in solid mixed low-level waste	Drums on pads	1,500[b]	None - WIPP or alternate facility in the future	NA
Transuranic (Mixed)							
Liquid	None	Solidification	Included in liquid mixed low-level waste	None	N/A	NA	NA
Solid	5	Compaction	Included in solid mixed low-level waste	Drums on pads	1,300[c]	None - WIPP or alternate facility in the future	NA
Low-Level							
Liquid	5	Evaporation and Solidification	Included in liquid mixed low-level waste	Staged	105[d]	NA	NA
Solid	617	None	None	Staged	4,540[d]	Offsite - DOE	NA
Hazardous							
Liquid	None	Neutralization & Precipitation	None	Staged in Department of Transportation containers	Included in solid hazardous waste	Offsite	NA
Solid	23 (tonnes)	None	None	Staged in Department of Transportation containers	263[e]	Offsite	NA

Waste Category	1996 Generation[a] (m^3)	Treatment Method	Treatment Capacity (m^3/yr)	Storage Method	Storage Capacity (m^3)	Disposal Method	Disposal Capacity
Mixed (Low-Level)							
Liquid	4	Solidification	47,700[f]	Staged for treatment	Included in solid mixed low-level waste	None	N/A
Solid	47	None	7,100[g,h]	Department of Transportation containers	13,600[i]	Offsite	N/A
Nonhazardous (Sanitary)							
Liquid	None	Sedimentation	568,000	None	N/A	Surface water	N/A
Solid	10,268 (tonnes)	None	None	None	N/A	Onsite landfill	Expandable

N/A = Not applicable.

[a] Values per *Rocky Flats Comprehensive Waste Management Plan.*

[b] Value taken from *Draft Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste.*

[c] Value taken from *Rocky Flats Proposed Site Treatment Plan* dated March 1995 and is based on the sum of the current mixed-transuranic storage and the expected 20-year generation.

[d] Cumulative volume of low-level waste stored at the end of 1993 as per memorandum from McGlochlin, EG&G, to Reece, DOE, on updated information for non-nuclear consolidation Environmental Assessment.

[e] Value based on the 1991 Waste Storage Inventory Report and the memorandum from McGlochlin, EG&G, to Reece, DOE, on updated information for non-nuclear consolidation Environmental Assessment.

[f] Based on the operating capacities of Buildings 374 and 774 as described in the 1995 Mixed Waste Inventory Report.

[g] Based on the operating capacities of Building 776 as described in the 1995 Mixed Waste Inventory Report.

[h] Value calculated using the conversion ratio of 1,500 kg/m^3.

[i] Value taken from Rocky Flats Proposed Site Treatment Plan dated March 1995 and based on the mixed low-level waste in storage at Rocky Flats.

Sources: Adapted from DOE 1996a and DOE 1997a.

Finally, the Order set the total capacity limit for interim status container storage for mixed transuranic waste at 1,220 cubic meters (m^3) (1,601 cubic yards [yd^3]) (DOE 1996a), although a capacity exists for 1,500 m^3 (1,960 yd^3). The Federal Facility Compliance Act of 1992 requires DOE to develop site-specific mixed waste treatment plans and to submit the plans to the EPA or the authorized State for approval. The final proposed plan was published in March 1995.

Residues are process byproducts that contain radioactive materials in concentrations greater than the economic discard limit. As previously discussed, these residues would have been recycled to recover the radioactive materials. DOE did not consider residues at Rocky Flats to be a waste form. Events at Rocky Flats have led to the classification of some of these plutonium residues as waste in the State of Colorado. Those residues that contain hazardous constituents have undergone characterization to determine compliance with the Resource Conservation and Recovery Act and court orders.

On November 3, 1989, DOE and the State of Colorado signed the Residue Compliance Agreement and Consent Order, which requires DOE to submit a plan for removing all mixed residue inventory at Rocky Flats by January 1, 1999. Also, the U.S. District Court, Colorado, issued a Judgment and Order on August 13, 1991, that declared Rocky Flats mixed residues to be hazardous materials that must be managed in accordance with the Resource Conservation and Recovery Act. This ruling further ordered that DOE must obtain a permit for the mixed residues without a Resource Conservation and Recovery Act permit. The mixed residues were subsequently incorporated into the existing Rocky Flats Part B Permit for the treatment and storage of mixed and hazardous wastes.

WIPP has specific Resource Conservation and Recovery Act hazardous waste codes that it can accept without requiring the treatment of the waste forms. After stabilization, Rocky Flats mixed wastes will not contain Resource Conservation and Recovery Act wastes outside of the acceptable waste codes for WIPP. WIPP's waste acceptance criteria must be met by each site seeking to ship mixed wastes to WIPP. Each site has developed a WIPP transuranic waste characterization program (including hazardous waste characterization) to meet the waste acceptance criteria.

- **Low-Level Waste**—Low-level waste has typically been packaged and disposed of at either the Nevada Test Site or the Hanford Site. Prior to shipment and acceptance for disposal at these facilities, each waste form must be characterized and shown not to contain Resource Conservation and Recovery Act hazardous constituents.

- **Mixed Low-Level Waste**—A great deal of the solid radioactive waste at Rocky Flats consists of mixed low-level waste. Mixed low-level waste shipments to the Nevada Test Site were suspended in May 1990 when the Resource Conservation and Recovery Act Land Disposal Restriction regulations went into effect. Low-level mixed waste is currently shipped to Envirocare of Utah for disposal. Prior to the acceptance of any waste for disposal at Envirocare of Utah, DOE must fully characterize each waste to prove that hazardous constituents are below treatment standards.

DOE and EPA entered into a Federal Facility Compliance Agreement for Land Disposal Restriction wastes on May 20, 1991. This agreement requires DOE to submit the following: a Comprehensive Treatment and Management Plan addressing treatment proposed for Rocky Flats nonresidue mixed wastes to bring them into compliance with the treatment and storage requirements of the Resource Conservation and Recovery Act; a Waste Minimization Plan identifying process changes proposed to minimize or eliminate wastes; and an Annual Progress Report evaluating Rocky Flats' progress in achieving compliance with the Resource Conservation and Recovery Act Land Disposal Restriction.

Negotiations began in June 1992 for a new Federal Facility Compliance Agreement. This 1993 agreement was entitled the "Settlement Agreement and Compliance Order on Consent No. 93-04-23-01," and it replaced the 1991 Federal Facility Compliance Agreement and the 1989 Agreement in Principle. DOE continues to manage its mixed waste compliance program in accordance with the existing 1993 Settlement Agreement. For example, the Waste Minimization Program Plan, Waste Stream and Residue Identification and Characterization Report, and the Annual Progress Report continue to be updated and submitted on an annual basis. However, because the Federal Facility Compliance Act gives the State primacy in approval of the site treatment plan and issuance of a compliance order, the Colorado Department of Public Health and Environment is now considered the lead regulatory agency in regard to DOE's mixed waste compliance program.

- **Hazardous Waste**—Treatment of hazardous wastes at Rocky Flats is limited to organic liquid wastes. Hazardous wastes are shipped to various Resource Conservation and Recovery Act-permitted commercial vendors for disposal. In 1991, DOE and the Colorado Department of Public Health and Environment agreed on radioactivity limits for waste garage oil. This waste form is now being shipped to a commercial vendor for recycling.

- **Nonhazardous Waste**—DOE and EPA agreed to, and signed on March 25, 1991, a Federal Facility Compliance Agreement for the National Pollutant Discharge Elimination System program. The agreement requires the following actions:

  - Upgrade the sewage treatment plant and change sewer sludge and spray irrigation management practices.
  - Enhance groundwater monitoring for the sewage sludge drying beds.
  - Prepare a compliance plan describing those actions necessary for Rocky Flats to remain in compliance with the NPDES permit.
  - Submit to the EPA a variety of new reports and studies describing the status of compliance.

  The sanitary landfill on Rocky Flats accepts all solid nonhazardous wastes. Liquid nonhazardous waste is treated and released to surface waters.

3.2 SAVANNAH RIVER SITE

The Savannah River Site is one of the Department of Energy's (DOE) primary facilities for research and production of nuclear materials. It is also used for the interim management of radioactive waste. The site occupies 80,130 ha (198,000 ac) in portions of Aiken, Barnwell, and Allendale Counties in South Carolina and is adjacent to the border between South Carolina and Georgia. It is located approximately 19 km (12 mi) south of Aiken, South Carolina, and approximately 40 km (25 mi) southeast of Augusta, Georgia (**Figure 3–9**). The site was built in the early 1950's to produce nuclear materials used to manufacture nuclear weapons. Today, the site includes 16 major production, service, research, and development areas, not all of which are currently in operation.

There are more than 3,000 facilities at the Savannah River Site, including 740 buildings with 511,000 m^2 (5,500,000ft^2) of floor area. Major nuclear facilities at the Savannah River Site include (or have historically included operation of) fuel and target fabrication facilities, nuclear material production reactors, plutonium storage facilities, chemical separations facilities, a tritium processing area, liquid high-level waste tank farms, a waste vitrification facility, and the Savannah River Technology Center. Nuclear materials are processed into forms suitable for continued safe storage, use, or transportation to other DOE sites. In accordance with the Records of Decision for the "F-Canyon Plutonium Solutions Environmental Impact Statement" (60 FR 9824) and the "Interim Management of Nuclear Materials Environmental Impact Statement" (60 FR 65300), plutonium solutions have been stabilized and targets have been dissolved and processed in the F-Canyon.

❒ **DOE Activities**—Current missions at the Savannah River Site are listed in **Table 3–9**. In the past, the Savannah River Site complex produced nuclear materials. The complex consisted of various plutonium storage facilities, five reactors (the C-, K-, L-, P-, and R-reactors, all currently inactive), a fuel and target fabrication plant (currently inactive), two chemical separation plants, a tritium-target processing facility, a heavy water rework facility, and waste management facilities. The K-Reactor (the last operational reactor) has been shut down with no planned provision for restart. The Savannah River Site is still conducting tritium recycling operations for stockpile requirements using retired weapons as the tritium supply source. The separations facilities and the processing facilities are scheduled for use through the year 2003 to complete DOE's commitment to the Defense Nuclear Facilities Safety Board regarding stabilization of site inventories of legacy nuclear materials.

DOE's Office of Environmental Management is pursuing a 30-year plan to treat, store, and dispose of existing wastes; reduce generation of new wastes; clean up inactive waste sites; remediate contaminated groundwater; and dispose of surplus facilities (DOE 1996a).

The Savannah River Technology Center provides technical support to DOE's operations at the Savannah River Site. In this role, it provides process engineering development to reduce costs, waste generation, and radiation exposure. The Savannah River Site has an expanding mission to transfer unique technologies developed at the site to industry. In addition, the Savannah River Site is an active participant in the Strategic Environmental Research and Development Program established to develop technologies to mitigate environmental hazards at Department of Defense and DOE sites.

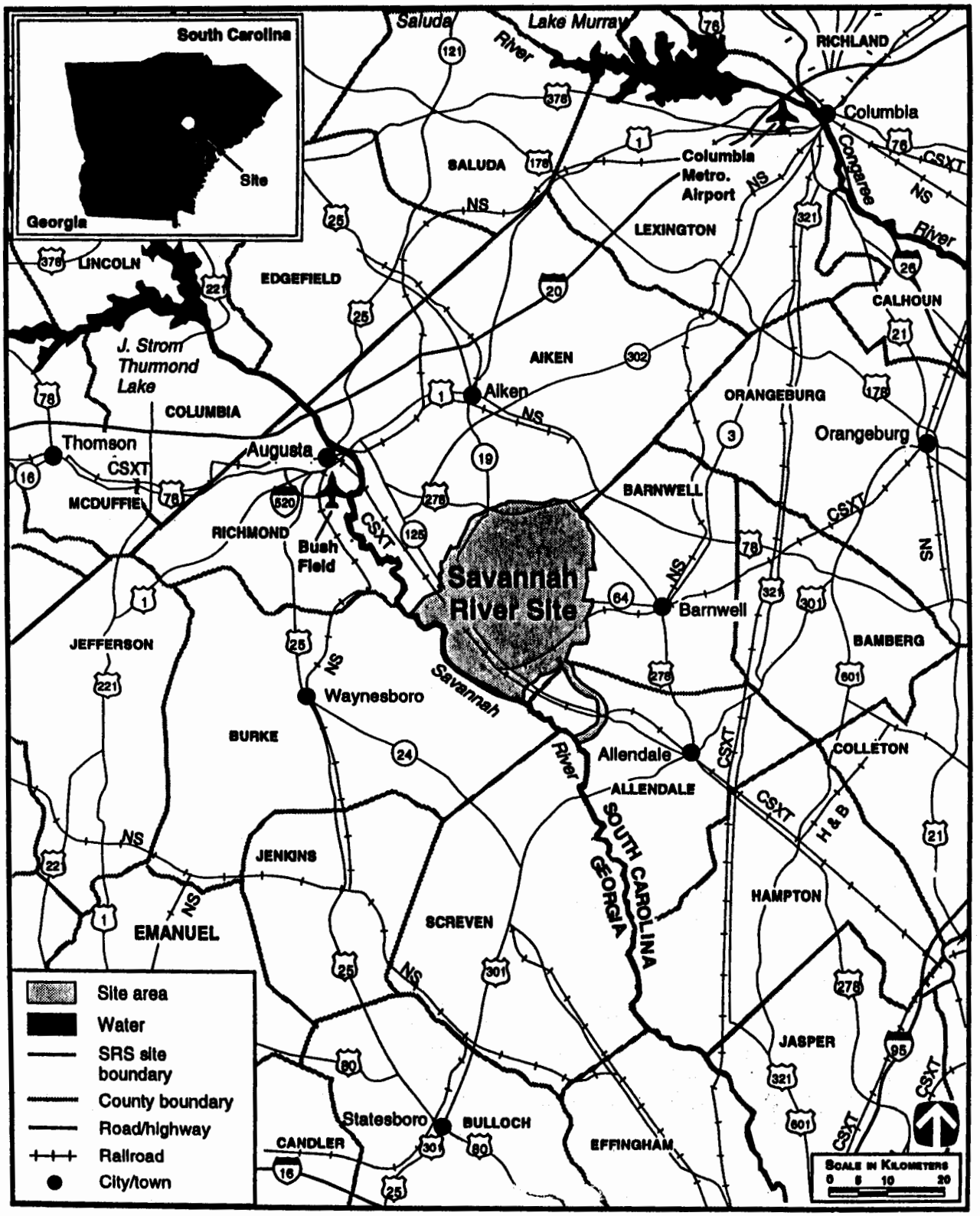


Figure 3–9 Savannah River Site, South Carolina, and Region

Table 3–9 Current Missions at the Savannah River Site

Mission	Description
Plutonium storage	Maintain F-Area plutonium storage facilities
Tritium recycling	Operate H-Area tritium facilities
Stabilize targets, spent nuclear fuels, and other nuclear materials	Operate F- and H-Canyons
Waste management	Operate waste processing facilities
Environmental monitoring and restoration	Operate remediation facilities
Research and development	Savannah River Technology Center technical support of Defense Programs, Environmental Management, and Nuclear Energy programs
Other non-DOE missions	Various, as described below, with the U.S. Forest Service, University of Georgia, and University of South Carolina

Source: WSRC 1995.

- **Non-DOE Activities**—Non-DOE facilities and operations at the Savannah River Site include the Savannah River Forest Station, the Savannah River Ecology Laboratory, and the Institute of Archaeology and Anthropology. The Savannah River Forest Station is an administrative unit of the U.S. Forest Service, which provides timber management, research support, soil and water protection, wildlife management, secondary roads management, and fire management to DOE. The Savannah River Forest Station manages 62,300 ha (154,000 ac), comprising approximately 80 percent of the site area. It has been responsible for reforestation and manages an active timber business. The Savannah River Forest Station assists with the development and updating of sitewide land use and provides continual support with site layout and vegetative management. It also assists in long-term wildlife management and soil rehabilitation projects.

  The Savannah River Ecology Laboratory is operated for DOE by the Institute of Ecology of the University of Georgia. The University has established a center of ecological field research where faculty, staff, and students perform interdisciplinary field research and provide an understanding of the impact of energy technologies on the ecosystems of the southeastern United States. This information is communicated to the scientific community, Government agencies, and the general public.

  The Institute of Archaeology and Anthropology is operated by the University of South Carolina to survey the archaeological resources of the Savannah River Site. These surveys are used by DOE when planning new facility additions or modifications.

  The information in the following subsections is based primarily on the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996a).

3.2.1 Land Resources

- **Land Use**—Land use at the Savannah River Site can be grouped into three major categories: forest/undeveloped, water, and developed facility locations. Forest/undeveloped lands (e.g., open fields and pine or hardwood forests) make up approximately 58,500 ha (144,500 ac) or nearly 73 percent of the total land within the site boundary; water (e.g., wetlands, streams, and lakes) comprises approximately 17,600 ha (43,500 ac) or 22 percent of the site area; and developed facility (e.g., production and support areas, roads, and utility corridors) accounts for approximately 4,000 ha (9,900 ac) or 5 percent of the total land area of the Savannah River Site. Land use bordering the Savannah River Site is primarily forest and agricultural, although there is a substantial amount of open water and nonforested wetland along the Savannah River Valley. Incorporated and industrial areas are the only other significant land uses in the vicinity. A small amount of urban and residential development borders the Savannah River Site; the nearest residences are

located within approximately 60 m (200 ft) of the west, north, and northeast boundaries of the site. Additional information about land resources at the site can be found in the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996a) and the *Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement* (DOE 1995f).

❒ **Visual Resources**—The Savannah River Site landscape is characterized by wetlands and upland hills. The vegetation is composed of bottom land hardwood forests, scrub oak and pine woodlands, and wetland forests. DOE's facilities are scattered throughout the Savannah River Site and are lit brightly at night. The developed areas and utility corridors (transmission lines and aboveground pipelines) of the Savannah River Site are consistent with a Bureau of Land Management Visual Resource Management Class 5 designation (Class 5 designates areas in which cultural activities so dominate the landscape that natural features are not discernible). In other areas of the Savannah River Site, the natural landscape dominates or the natural landscape features are discernible. Additional information about visual resources can be found in the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996a).

3.2.2 Site Infrastructure

❒ **Baseline Characteristics**—The Savannah River Site contains extensive production, service, and research facilities. Not all of these facilities are in operation today. To support current missions and functions, an extensive infrastructure exists, as shown in **Table 3–10**. The Savannah River Site does not have a connection to the local natural gas lines.

Table 3–10 Savannah River Site Baseline Characteristics

Characteristics	*Current Usage*	*Site Availability*
Transportation		
Roads (km)	230	230
Railroads (km)	103	103
Electrical		
Energy consumption (MWh/yr)	420,000	5,200,000
Peak load (MWe)	70	330
Fuel		
Natural gas (m^3/yr)	0	0
Oil (L/yr)*	15,151,355	N/A
Coal (t/yr)	12,000	N/A
Steam (kg/hr)*	81,818	777,273

MWh/yr = megawatt hours per year MWe = megawatts electric m^3/yr = cubic meters per year L/yr = liters per year
t/yr = tons per year kg/hr = kilograms per hour
Source: DOE 1993b.
*Winter usage only.

The subregional electrical power pool area in which the Savannah River Site is located and from which it draws its power is the Virginia-Carolina Subregion, a part of the Southeastern Electric Reliability Council. The Savannah River Site draws most of its electrical power from coal-fired plants and from 17 nuclear-powered generating plants. Characteristics of this power pool are given in **Table 3–11**.

Table 3–11 Virginia–Carolinas Subregional Power Pool Electrical Summary

Characteristics	Energy Production
Type Fuel[a]	
Coal	50%
Nuclear	36%
Hydro/geothermal	2%
Oil/gas	3%
Other[b]	8%

[a] Percentages do not total 100 percent because of rounding.
[b] Includes power from nonutility sources only.
Source: NERC 1993.

3.2.3 Air Quality and Noise

❒ **Meteorology and Climatology**—The Savannah River Site has a temperate climate with mild winters and humid summers. Warm, moist maritime air masses affect the climate throughout the year.

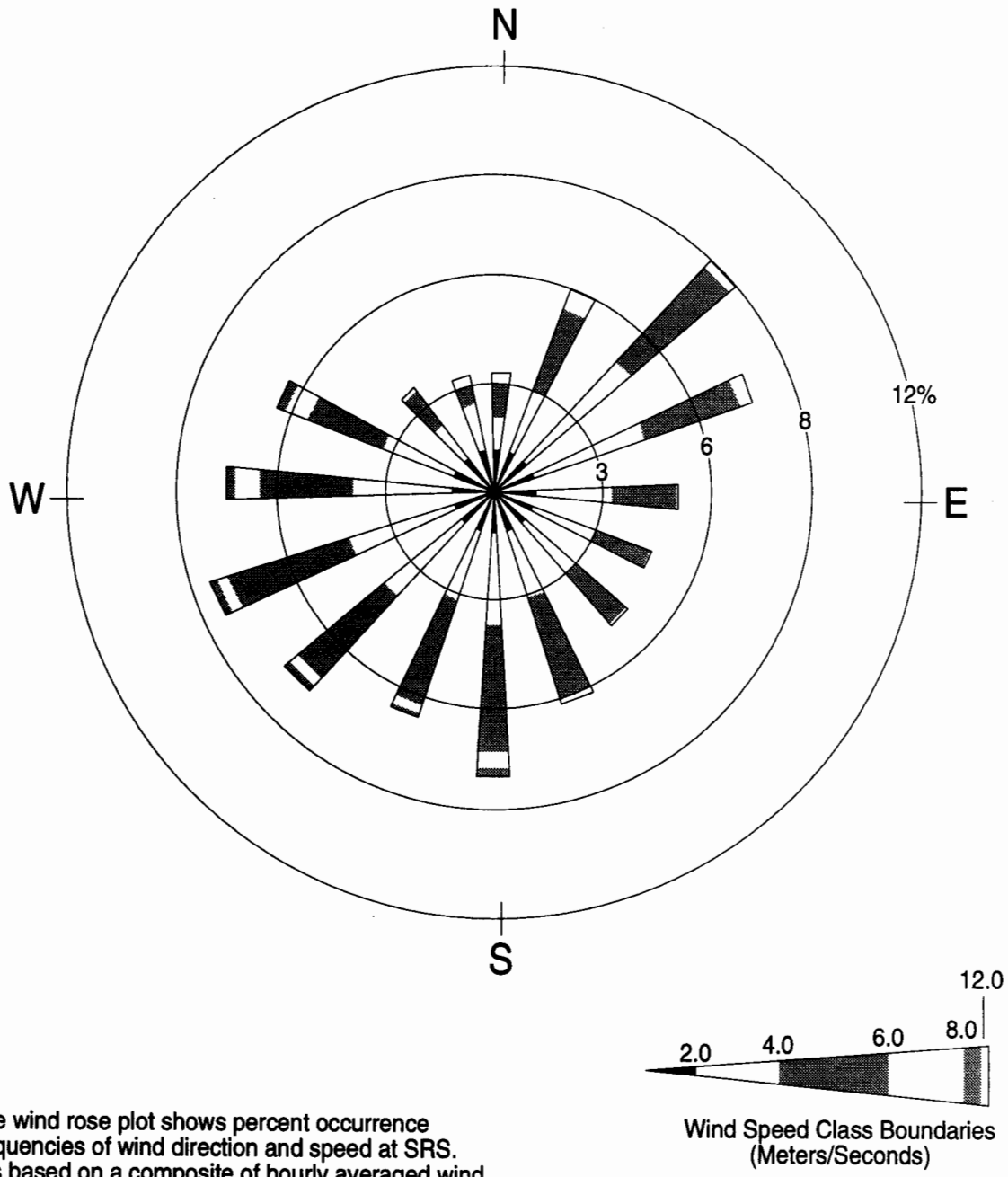
- *Temperature and Humidity*—The annual average temperature at the Savannah River Site is 17.8°C (64°F), and monthly averages range from a low of 7.22°C (45°F) in January to a high of 27.2°C (81°F) in July. Average daily relative humidity ranges from a maximum of 90 percent in the morning to a minimum of 43 percent in the afternoon.

- *Precipitation*—The average annual precipitation at the Savannah River Site is approximately 121.9 cm (48 in) (WSRC 1996). Precipitation distribution is fairly even throughout the year, with the highest precipitation in the summer (36.1 cm [14.2 in]) and the lowest in autumn (22.5 cm [8.8 in]) (Arnett et al. 1993). Snowfall has occurred in the period October through March, with an average annual snowfall of 3.0 cm (1.2 in). Large snowfalls are rare (DOE 1995d).

- *Wind*—**Figure 3–10** shows annual wind direction frequencies and wind speeds for the Savannah River Site from 1987 through 1991. There is no prevailing wind at the Savannah River Site which is typical for the midlands of South Carolina (WSRC 1996). Maximum frequency of 91 percent is from northeast to southwest. The average wind speed for this 5-year period was 3.8 m/s (8.5 mph). Calm winds (less than 2 m/s or 4.5 mph) occurred less than 10 percent of the time during the 5-year period. Seasonally, wind speeds were greatest during the winter, at 4.1 m/s (9.2 mph), and lowest during the summer, at 3.4 m/s (7.6 mph) (Shedrow 1993).

  Winter snowstorms in the Savannah River Site area occasionally bring strong and gusty surface winds with speeds as high as 32 m/s (72 mph). Thunderstorms can generate winds with speeds as high as 18 m/s (40 mph) or even stronger gusts. The fastest wind speed recorded at Augusta between 1950 and 1986 was 37 m/s (83 mph) (DOE 1995d).

❒ **Air Quality**—Savannah River Site's contribution to the baseline air emission concentrations and their applicable standards are included in the data shown in **Table 3–12**. These concentrations are estimates of the highest existing offsite concentrations and represent the highest concentrations to which members of the public could be exposed. These concentrations are in compliance with applicable guidelines and regulations. The Savannah River Site and surrounding counties are in attainment with respect to the National Ambient Air Quality Standards for criteria pollutants (DOE 1996a).



The wind rose plot shows percent occurrence frequencies of wind direction and speed at SRS. It is based on a composite of hourly averaged wind data from the SRS meteorological tower network for the 5-year period 1987-1991. Measurements were taken from 200 feet above ground. Directions indicated are *from* which the wind blows.

Figure 3–10 Wind Rose for the Savannah River Site (1987–1991)

Table 3–12 Comparison of Savannah River Site's Contribution to the Baseline Air Pollutant Concentrations with Most Stringent Applicable Regulations and Guidelines at Savannah River Site, 1990

Pollutant	Averaging Time	Most Stringent Regulation or Guideline[a] ($\mu g/m^3$)	Modeled Baseline Concentration ($\mu g/m^3$)
Criteria Pollutants			
Carbon monoxide	8-hour	10,000[b]	22
	1-hour	40,000[b]	171
Lead	Calendar Quarter	1.5[b]	0.0004
Nitrogen dioxide	Annual	100[b]	5.7
Ozone[c]	1-hour	235[b]	Not Available
Particulate matter less than or equal to 10 microns in diameter[d]	Annual	50[b]	3.0
	24-hour	150[b]	50.6
Sulfur dioxide	Annual	80[b]	14.5
	24-hour	365[b]	196
	3-hour	1,300[b]	823
Mandated by the State of South Carolina			
Total suspended particles	Annual	75[e]	12.6
Gaseous fluorides	30-day	0.8e	0.09
	7-day	1.6[e]	0.39
	24-hour	2.9[e]	1.04
	12-hour	3.7[e]	1.99
Hazardous and Other Toxic Pollutants			
3,3-Dichlorobenzidine	24-hour	0.15[e]	0.0004
Acrolein	24-hour	1.25[e]	0.016
Benzene	24-hour	150.00[e]	31.711
Bis(chloromethyl)ether	24-hour	0.03[e]	0.002
Cadmium oxide	24-hour	0.25[e]	0.021
Chlorine	24-hour	75.00[e]	7.630
Chloroform	24-hour	250.00[e]	4.957
Cobalt	24-hour	0.25[e]	0.206
Formic acid	24-hour	225.00[e]	2.420
Manganese	24-hour	25.00[e]	0.821
Mercury	24-hour	0.25[e]	0.014
Nickel	24-hour	0.50[e]	0.271
Nitric acid	24-hour	125.00[e]	50.960
Parathion	24-hour	0.50[e]	0.007
Phosphoric acid	24-hour	25.00[e]	0.462

[a] The more stringent of the Federal and State standards is presented.
[b] Federal and State standards.
[c] In July 1997, the EPA established a new 8-hour primary ambient standard of 0.08 ppm for ozone that replaces the previous 1-hour standard of 0.12 ppm; see Chapter 5 of this EIS for additional information.
[d] In July 1997, the EPA established new standards for particles with an aerodynamic diameter less than or equal to a nominal 2.5 micrometers; see Chapter 5 of this EIS for additional information.
[e] State standard.
Source: Adapted from DOE 1996a.

❒ **Noise**—The major noise sources at the Savannah River Site are in developed operational areas, including various facilities, equipment, and machines (e.g., cooling towers, transformers, engines, pumps, boilers, steam vents, paging systems, construction and materials-handling equipment, and vehicles). Most major noise sources outside the operational areas are from vehicles and railroad operations. The remote locations of the Savannah River Site operational areas keep existing onsite noise sources from adversely affecting

individuals at offsite locations. Noise limits are established for the workplace to protect workers' hearing in accordance with Occupational Health and Safety Administration standards. Existing Savannah River Site–related noise sources of importance to the public are those associated with road and rail traffic. Additional information about noise sources can be found in the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996a).

3.2.4 Water Resources

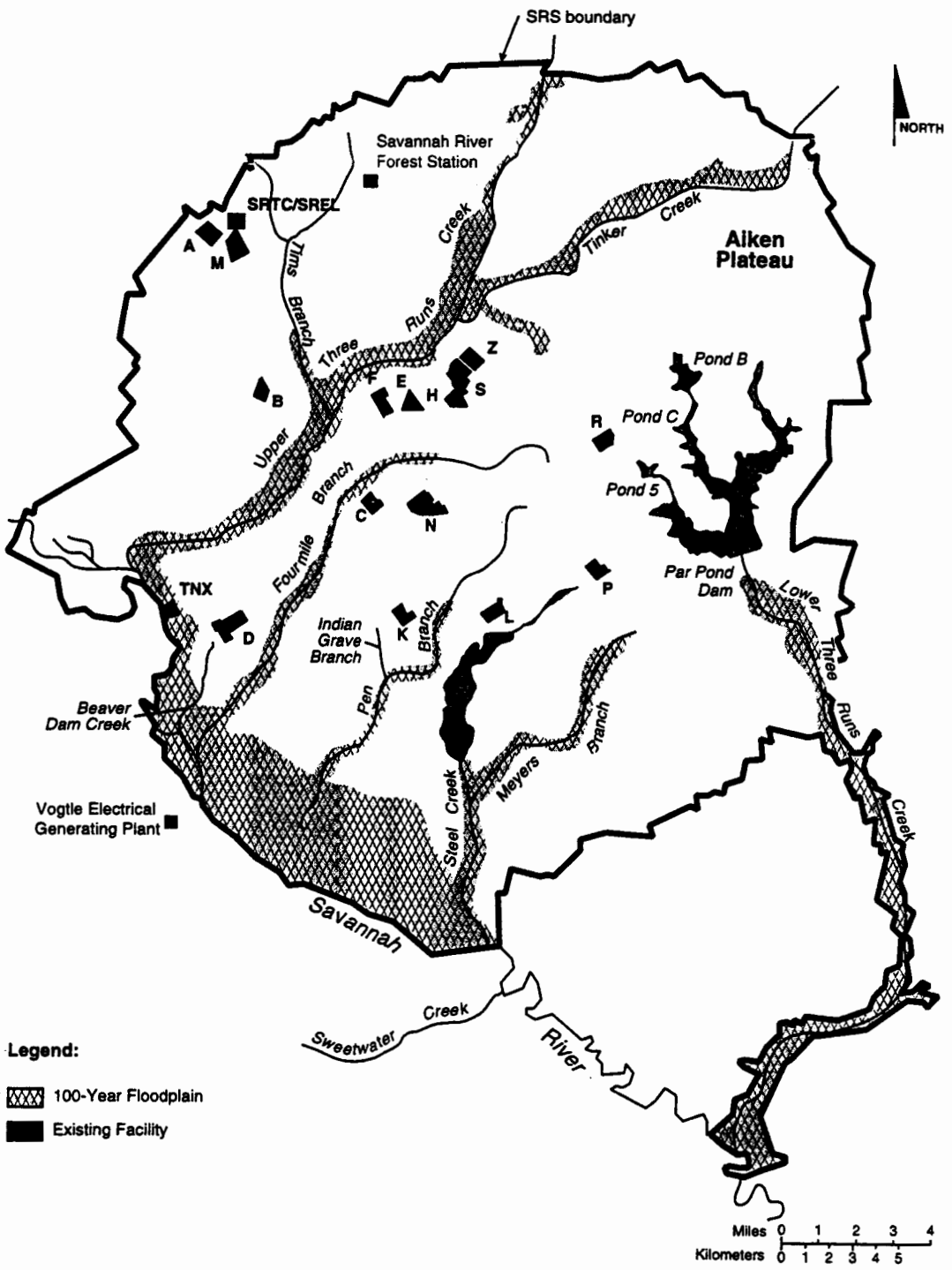
- **Surface Water**—The Savannah River bounds the Savannah River Site on its southwestern border for about 32 km (20 mi), approximately 260 river km (160 river mi) from the Atlantic Ocean. At the Savannah River Site, the Savannah River flow averages about 283 m^3/s (74,760 gal/s). Five principal tributaries to the Savannah River are found on the Savannah River Site: Upper Three Runs Creek, Fourmile Branch, Pen Branch, Steel Creek, and Lower Three Runs Creek (**Figure 3–11**). These tributaries drain almost all of the Savannah River Site. Each of these streams originates on the Aiken Plateau in the Coastal Plain and descends 15 to 60 m (50 to 200 ft) before flowing into the river. The streams, which historically have received varying amounts of discharge from the Savannah River Site operations, are not commercial sources of water.

  The natural flow of the Savannah River Site streams ranges from less than 1 m^3/s (264 gal/s) in smaller streams such as Pen Branch to 6.8 m^3/s (1,795 gal/s) in Upper Three Runs. Three large upstream reservoirs—Hartwell, Richard B. Russell, and Strom Thurmond—minimize the effects of droughts and the impacts of low flow on downstream water quality and fish and wildlife resources in the Savannah River.

  - *Surface Water Quality*—The Savannah River, which forms the boundary between the States of Georgia and South Carolina, supplies potable water to several areas. Upstream of the Savannah River Site, the river supplies domestic and industrial water needs for Augusta, Georgia and North Augusta, South Carolina. Downstream of the Savannah River Site, the river supplies domestic and industrial water needs for Savannah, Georgia and for Beaufort and Jasper Counties in South Carolina. The South Carolina Department of Health and Environmental Control regulates the physical properties and concentrations of chemicals and metals in the Savannah River Site effluent under the National Pollutant Discharge Elimination System and the chemical and biological water quality standards for Savannah River Site waters. On April 24, 1992, South Carolina Department of Health and Environmental Control changed the classification of the Savannah River and the Savannah River Site streams from "Class B waters" to "Freshwaters." The definitions of Class B waters and Freshwaters are the same, but the Freshwaters classification imposes a more stringent set of water quality standards (Arnett et al. 1993). Additional information about surface water quality at the site can be found in the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996a).

- **Groundwater**—At the Savannah River Site, groundwater in the water table (or most shallow) aquifer flows downward to the Congaree Aquifer or discharges to nearby streams that intersect the water table. Depending on the location at the Savannah River Site, the Congaree Aquifer flows downward to the Cretaceous Aquifer or horizontal to Upper Three Runs Creek or the Savannah River. The Cretaceous Aquifer discharges predominantly along the Savannah River and to upper Three Runs Creek (DOE 1996b).

  Most of the rural population in the region draws water from either the Congaree or the water table aquifer. All groundwater at the Savannah River Site is classified by EPA as a Class II water source, meaning it is a current and potential source of drinking water. Groundwater quality ranges from excellent to below EPA drinking water standards for several constituents in the vicinity of some waste sites. For example, the water table aquifer is contaminated with solvents, metals, and low levels of radionuclides at several waste sites and facilities (DOE 1996b).



Note: Letters on the figure refer to historically designated site areas

Figure 3–11 The Savannah River Site, Showing 100-Year Floodplain, Major Stream Systems, and Facilities

Groundwater depth ranges from at or very near the ground surface (near streams) to about 46 m (151 ft). Groundwater usage in support of site operations totaled 13,247 million L/yr (3,500 million gal/yr) in 1993 (DOE 1996b). Additional information about groundwater hydrology and quality at the site can be found in the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996a).

3.2.5 Geology, Soils, and Seismology

The Savannah River Site is located in the Upper Atlantic Coastal Plain physiographic province of western South Carolina, approximately 32 km (20 mi) southeast of the Fall Line, which separates the Piedmont and Coastal Plain provinces. Sands and sandy loams are the primary types of soil. There is no evidence of recent displacement along any fault within the site (DOE 1991).

The Savannah River Site is located within Seismic Zone 2, indicating moderate earthquake damage could occur. Earthquakes capable of producing structural damage to buildings are not likely to occur in the vicinity of the site. Volcanic activity has not been experienced in the area of the site within the last 230 million years (DOE 1996b).

Areas of seismic activity within a 350-km (200-mi) radius of the Savannah River Site include the Charleston, South Carolina, seismic zone on the coastline of South Carolina and the Bowman, South Carolina, seismic zone east of the site. Known seismic activity within 50 km (30 mi) of the site is located primarily to the east and southeast. Several earthquakes of unknown magnitude/intensity occurred in 1897, and about eight earthquakes have been recorded since the 1970's. The majority of the earthquakes recorded since site operations began have been isolated events of low magnitude (m<3), with no dependent foreshocks or aftershocks detected. The most recent earthquake occurred on August 8, 1993. This quake (M=3.2) had an epicenter located about 40 km (25 mi) northeast of the center of the site and about 12 km (9 mi) northeast of Aiken, South Carolina. The event was not associated with any identified seismic source zones, but instead seemed to be characteristic of widely spread events throughout the central Piedmont and Upper Coastal Plain of the State (WSRC 1995). Additional information can be found in Appendix D, Section 3.3.3.2.

3.2.6 Ecology

Detailed information about ecological resources at the Savannah River Site can be found in the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996a) and in the *Savannah River Site Ecology-Environmental Information Document* (WSRC 1994). Federal threatened, endangered, and candidate species that may be found on or in the vicinity of the Savannah River Site include the American peregrine falcon, Arctic peregrine falcon, Bald eagle, Kirtland's warbler, Red-cockaded woodpecker, Wood stork, American alligator, Shortnose sturgeon, and Smooth coneflower.

3.2.7 Cultural and Paleontological Resources

Prehistoric resources at Savannah River Site consist of villages, base camps, limited activity sites, quarries, and workshops. Historic sites include farmsteads, tenant dwellings, mills, plantations and slave quarters, rice farming dikes, dams, cattle pens, ferry locations, towns, churches, schools, cemeteries, commercial building locations, and roads. Approximately 400 historic sites or sites with historic components have been identified within the Savannah River Site. Native American groups with traditional ties to the area include the Apalachee, Cherokee, Chickasaw, Creek, Shawnee, Westo, and Yuchi. Paleontological materials at the Savannah River Site include fossil plants, numerous invertebrate fossils, deposits of giant oysters (*Crassostrea gigantissima*), mollusks, and bryozoa. Additional information about cultural and paleontological resources at the site can be found in the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996a).

3.2.8 Socioeconomics

- **Regional Economy Characteristics**—The Savannah River Site region of influence includes Aiken, Allendale, Bamberg, and Barnwell Counties in South Carolina and Columbia and Richmond Counties in Georgia. Between 1980 and 1990, total employment in the region of influence increased from 139,504 to 199,161, an average annual growth rate of approximately 5 percent. By the year 2000, employment levels should increase 27 percent to approximately 253,000. The unemployment rates for 1980 and 1990 were 7.3 percent and 4.7 percent, respectively (DOE 1995d).

  In Fiscal Year 1992, employment at the Savannah River Site totaled 23,351, with an associated payroll of more than $1.1 billion. In 1990, 75.3 percent of the region of influence labor force lived in Richmond and Aiken Counties, South Carolina (DOE 1995d). The Savannah River Site employed 16,562 people in 1996, accounting for about 7 percent of the regional economic area employment (Section 4.20.4).

- **Population and Housing**—Between 1980 and 1990, population in the region of influence increased 13 percent, from 376,058 to 425,607. More than 88 percent of the 1990 population lived in Aiken (28.4 percent), Columbia (15.5 percent), and Richmond (44.6 percent) Counties. According to 1990 census data, the estimated average number of persons per household in the six-county region was 2.72, and the median age of the population was 31.2 years (DOE 1995d). **Figure 3–12** shows the racial and ethnic composition of minorities residing within an 80-km (50-mi) radius of Savannah River Site at the time of the 1990 census. This 80-km (50-mi) radius defines the region of potential influence for radiological effects evaluated in Chapter 4 of this EIS.

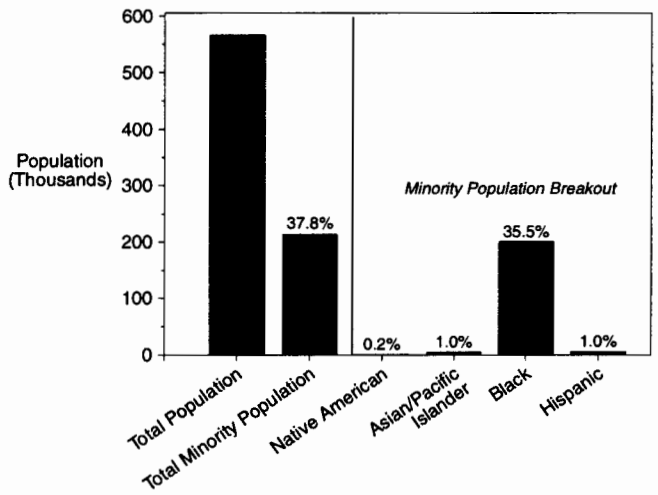
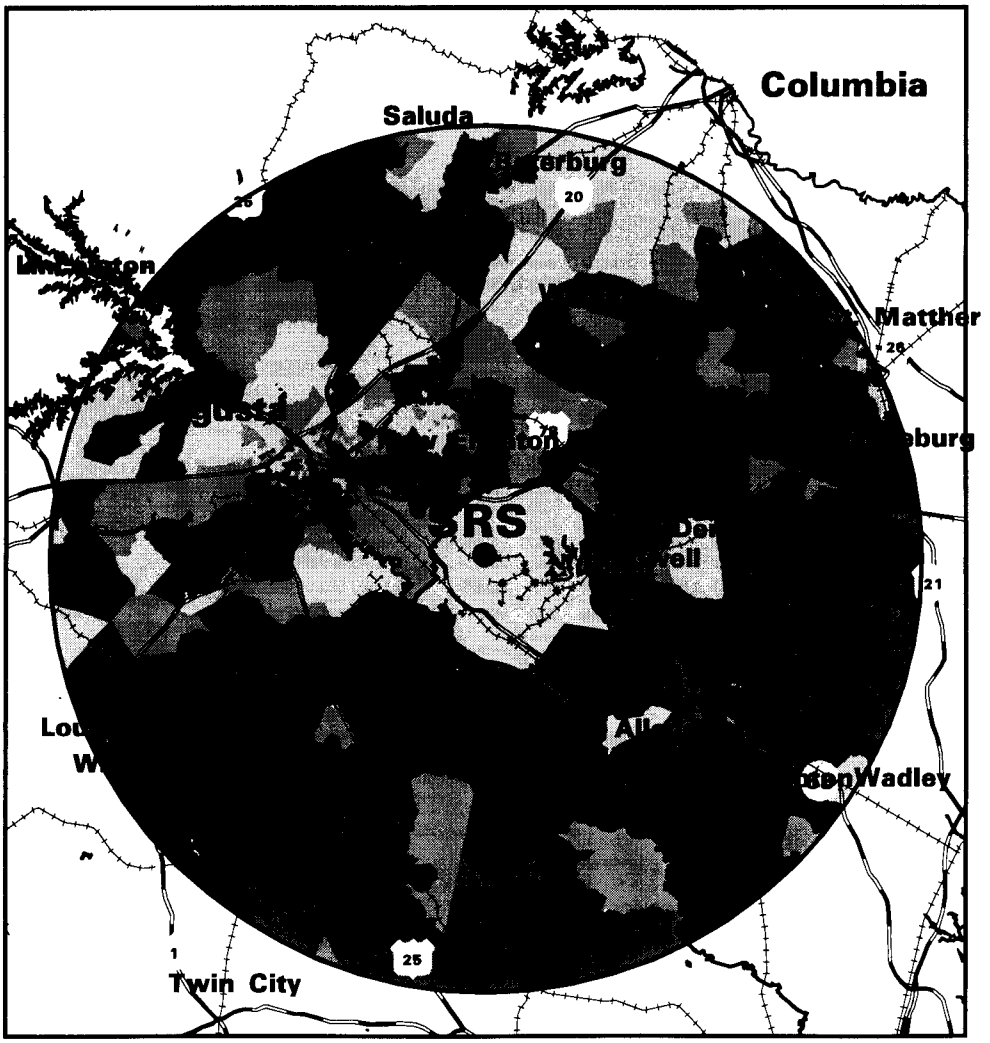


Figure 3–12 Racial and Ethnic Composition of the Minority Population Residing Within 80 km (50 mi) of the Savannah River Site

The minority population as a percentage of total population residing in the region of influence at that time is 13 percent more than the national percentage of minorities (24.2 percent) residing in the continental United States at the time of the 1990 census. Blacks comprised nearly 94 percent of the minority population residing in the region of influence. As illustrated in **Figure 3–13**, the percentage of minority residents equaled or exceeded the national percentage in areas throughout the region of influence.



LEGEND

- Site
- Surface Water Shoreline
- Rail Lines
- State & US Highways

- 0 <= Pm < 12%
- 12% <= Pm < 24%
- 24% <= Pm < 48%
- Pm >= 48%

SUMMARY STATISTICS

WITHIN 80 KM (50 Miles) RADIUS OF THE SITE	
TOTAL POPULATION	613,087
MINORITY POPULATION	233,177
PERCENTAGE	38%

0 5 10 15 20 25 30
miles

Figure 3–13 Distribution of Minority Population Residing Within 80 km (50 mi) of the Savannah River Site

As shown in Table F–3 of Appendix F, at the time of the 1990 census, approximately 42 percent of the 197,937 households residing within the region of influence had a self-reported income less than 80 percent of the median income for the county of residence. These households qualify as low-income households under rules of the U.S. Department of Housing and Urban Development.

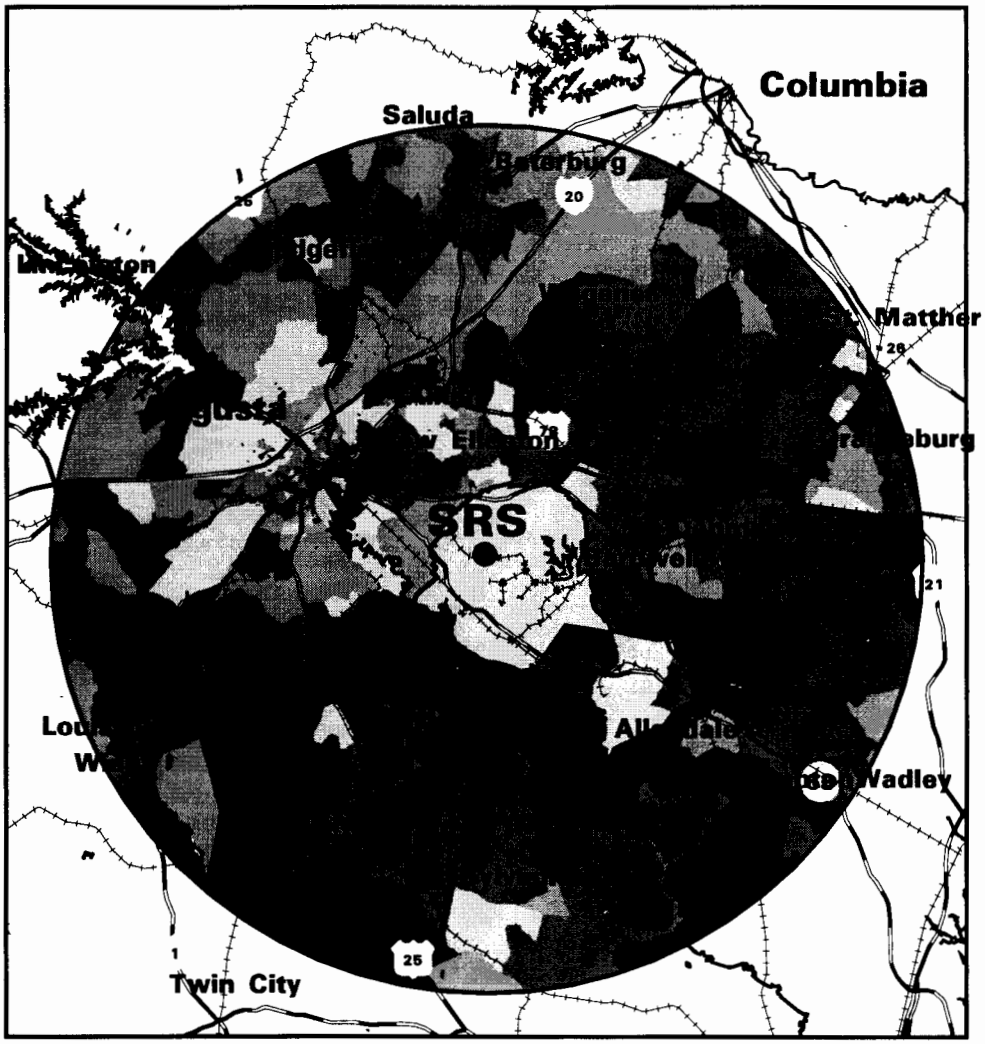
As shown in Table F–4 of Appendix F, approximately 11 percent of the individuals residing within the region of influence had a self-reported income less than the poverty level. As discussed in Appendix F, the poverty level is a function of family size and number of unmarried children in the family under 18 years of age. The national percentage of individuals with income less than the poverty level in 1995 is estimated by the census Bureau to be 13.8 percent. The national percentage of individuals residing in the United States with income below the poverty level was 13.3 percent at the time of the 1990 census. **Figure 3–14** shows the distribution of poverty-level individuals residing within the region of influence.

- **Local Transportation**—The Savannah River Site is surrounded by a system of interstate highways, U.S. highways, State highways, and railroads. The regional transportation networks service the four South Carolina counties (Aiken, Allendale, Bamberg, and Barnwell) and the two Georgia counties (Columbia and Richmond) that generate about 90 percent of the Savannah River Site commuter traffic (DOE 1995f). Two major railroads—CSX Transportation and Norfolk Southern Corporation—also serve the Savannah River Site vicinity. Norfolk Southern serves Augusta and Savannah, Georgia, as well as Columbia and Charleston, South Carolina. CSX serves the same locations and the Savannah River Site.

  Two interstate highways serve the Savannah River Site area. Interstate 20 (I-20) provides a primary east-west corridor and I-520 links I-20 with Augusta, Georgia. U.S. Highways 1 and 25 are principal north-south routes, and U.S. 78 provides east-west connections. Several other highways (U.S. 221, U.S. 301, U.S. 321, and U.S. 601) provide additional transport routes in the region. Several State routes provide direct access to the Savannah River Site. From the northwest and north, access is provided by SC 125 and SC 19, respectively, and SC 125 is open to through traffic. Access to the site is provided from the northeast by SC 39, from the east by SC 64, and from the southeast by SC 125. These are all two-lane roads. The public has access to U.S. 278 and SC 125, but only the Savannah River Site employees are permitted access to the site on the other routes.

  The Savannah River Site transportation infrastructure consists of more than 230 km (143 mi) of primary roads, 1,931 km (1,200 mi) of unpaved secondary roads, and 103 km (64 mi) of railroad track (DOE 1995b). These roads and railroads provide connections among the various Savannah River Site facilities and offsite transportation linkages.

  Two major public highways traverse the Savannah River Site—SC 125 and U.S. 278. SC 125 connects Allendale, South Carolina, to Augusta, Georgia, by crossing the site in a northwest-to-southeast direction. U.S. 278 also connects Augusta and Allendale, but its route generally follows the northern and eastern Savannah River Site boundaries. In general, the primary Savannah River Site roadways are in good condition and are smooth and free from potholes. Typically, wide, firm shoulders border roads that are either straight or have wide gradual turns. Intersections are well marked for both traffic and safety identification, and are sufficiently cleared of trees and brush that might obstruct a driver's view of oncoming traffic. Railings along the side of the roadways offer protection at appropriate locations from dropoffs or other hazards. In general, the roadways are lighted only at gate areas and near major facilities.



LEGEND

- Site
- Surface Water Shoreline
- Rail Lines
- State & US Highways

- 0 <= Pp < 6.5%
- 6.5% <= Pp < 13%
- 13% <= Pp < 26%
- Pp >= 26%

SUMMARY STATISTICS	
WITHIN 80 KM (50 Miles) RADIUS OF THE SITE	
TOTAL POPULATION	613,087
POVERTY LEVEL POPULATION	107,067
PERCENTAGE	17%

0 5 10 15 20 25 30
miles

Figure 3–14 Distribution of Poverty-Level Population Residing Within 80 km (50 mi) of the Savannah River Site

In general, heavy traffic occurs early in the morning and late in the afternoon when workers from surrounding communities commute to and from the Savannah River Site. During working hours, official vehicles and logging trucks constitute most of the traffic. At any time, as many as 60 logging trucks, which can impede traffic, might be operating on the Savannah River Site, with an annual average of about 25 trucks per day. **Table 3–13** provides data on traffic counts for various roads and access points around the Savannah River Site (DOE 1995f).

Table 3–13 Savannah River Site Traffic Counts—Major Roads

Measurement Point	Date	Direction	Day Total	Peak[a]	Peak Time[b]	Average Speed (mph)[c]
Road 2 between Roads C and D	2-23-93	East	3,031	800	1530	47
	4-21-93	West	3,075	864	0630	DNA
Road 4 between Roads E and C	12-9-92	East	1,624	352	1530	DNA
	12-9-92	West	1,553	306	0615	DNA
Road 8 at Pond C	2-23-92	East	634	274	1530	58
	2-23-92	West	662	331	0615	56
Road C between landfill and Road 2	12-16-92	North	6,931	2,435	1530	53
	12-16-92	South	6,873	2,701	0630	58
Road C north of Road 7	1-20-93	North	742	288	0630	53
	1-20-93	South	763	223	1530	54
Road D	9-29-93	North	1,779	218	1500	43
	9-29-93	South	1,813	220	0845	52
Road E at E-Area	8-25-93	North	3,099	669	1530	35
	8-25-93	South	3,054	804	0630	38
Road F at Upper Three Runs Creek	2-2-93	North	3,239	1,438	1530	53
	2-2-93	South	3,192	1,483	0630	51
H-Area Exit	12-2-92	Outbound	2,181	406	1530	12

DNA = Data not available mph = Miles per hour
[a] Number of vehicles in peak hour.
[b] Start of peak hour.
[c] To convert miles per hour to kilometers per hour, multiply by 1.6093.
Source: Swygert (DOE 1995f).

Railroads on the Savannah River Site include both CSX tracks and the Savannah River Site rolling stock and tracks. Two routes of the CSX distribution system run through the Savannah River Site: a line between Florence, South Carolina and Augusta, Georgia, and a line between Yemassee, South Carolina and Augusta. The two lines join on the site near the L-Lake dam. Early in 1989, CSX discontinued service on the line from the Savannah River Site junction to Florence. The 103 km (64 mi) of the Savannah River Site railroad tracks are well maintained. The rails and crosslines are in good condition, and the track lines are clear of vegetation and debris. Significant clear areas border the tracks on both sides. Intersections of railroads and roadways are marked by railroad crossing signs with lights where appropriate. The Savannah River Site rail classification yard is east of P-Reactor. This eight-track facility sorts and redirects railcars. Deliveries of the Savannah River Site shipments occur at two onsite rail stations at the former towns of Ellenton and Dunbarton. From these stations, a Savannah River Site engine moves the railcars to the appropriate receiving facility. The Ellenton station, which is on the main Augusta-Yemassee line, is the preferred delivery point. The Dunbarton station, which is on the discontinued portion of the Augusta-Florence line, receives less use.

3.2.9 Public and Occupational Health and Safety

❒ **Radiation Environment**—Major sources and levels of background radiation exposure to individuals in the vicinity of the Savannah River Site are shown in **Table 3–14**. Annual background radiation doses to individuals are expected to remain constant over time. The total dose to the population changes as the population size changes. Background radiation doses are unrelated to Savannah River Site operations.

Table 3–14 Sources of Radiation Exposure to Individuals in the Vicinity, Unrelated to Savannah River Site Operations

Source	Effective Dose Equivalent (mrem/yr)
Natural Background Radiation[a]	
Cosmic radiation	27
External radiation	28
Internal terrestrial radiation	40
Radon in homes (inhaled)[b]	200
Other Background Radiation[c]	
Diagnostic x-rays and nuclear medicine	53
Weapons test fallout	<1
Air travel	1
Consumer and industrial products	10
Total	360

[a] WSRC 1996.
[b] Value for radon is an average for the United States.
[c] NCRP 1987.

A more detailed presentation of the radiation environment, including background exposures and radiological releases and doses, is presented in the *Savannah River Site Environmental Report* for 1995 (WSRC 1996). The concentrations of radioactivity in various environmental media (including air, water, and soil) in the site region (onsite and offsite) are also presented in this reference.

Releases of radionuclides to the environment from Savannah River Site operations provide another source of radiation exposure to individuals in the vicinity of Savannah River Site. Types and quantities of radionuclides released from Savannah River Site operations in 1995 are listed in the *Savannah River Site Environmental Report* for 1995 (WSRC 1996). Doses to the public resulting from these releases are presented in **Table 3–15**. These doses fall within the radiological limits described in DOE Order 5400.5 and are less than dose levels from background radiation.

The Savannah River Site workers receive the same dose as the general public from background radiation, but also receive an additional dose from working in the Savannah River Site facilities. **Table 3–16** presents the average worker and worker population dose to Savannah River Site workers from operations in 1996. These doses fall within radiological regulatory limits (10 CFR Part 835).

❒ **Chemical Environment**—The background chemical environment important to human health consists of the atmosphere, which may contain hazardous chemicals that can be inhaled; drinking water, which may contain hazardous chemicals that can be ingested; and other environmental media with which people may come in contact (e.g., surface waters during swimming and soil through direct contact or via the food pathway).

Table 3–15 Radiation Doses to the Public from Normal Savannah River Site Operations in 1995 (Committed Effective Dose Equivalent)

Members of the General Public	Atmospheric Releases		Liquid Releases		Total	
	Standard[a]	Actual	Standard[a]	Actual[b]	Standard[a]	Actual
Maximally exposed individual (mrem)	10	0.08	4	0.14	100	0.22
Population within 80 km (50 mi)[c] (person-rem)	None	8.4	None	1.7	None[d]	10.1
Average individual within 80 km (50 mi)[e] (mrem)	None	0.014	None	0.0025	None	0.016

[a] The standards for individuals are given in DOE Order 5400.5. As discussed in that Order, the 10 mrem/yr limit from airborne emissions is required by the Clean Air Act, the 4 mrem/yr limit is required by the Safe Drinking Water Act, and the total dose of 100 mrem/yr is the limit from all pathways combined.

[b] The actual dose value given in the column under liquid releases conservatively includes all water pathways, not just the drinking water pathway. The population dose includes contributions to Savannah River users downstream of the Savannah River Site to the Atlantic Ocean.

[c] In 1995, this population was approximately 620,100. For liquid releases, an additional 65,000 water users in Port Wentworth, Georgia and Beaufort, South Carolina (approximately 160 km [100 mi] downstream), are included in the assessment.

[d] A 100 person-rem value for the population is given in proposed 10 CFR Part 834 (58 FR 16268). If the potential total dose exceeds this value, it is required that the contractor operating the facility notify DOE.

[e] Obtained by dividing the population dose by the number of people living within 80 km (50 mi) of the site for atmospheric releases; for liquid releases, the number of people includes water users who live more than 80 km (50 mi) downstream of the site.

Source: WSRC 1996.

Table 3–16 Radiation Doses to Workers from Normal Savannah River Site Operations in 1996 (Committed Effective Dose Equivalent)

Occupational Personnel	Onsite Releases and Direct Radiation	
	Standard[a]	Actual
Average worker dose (mrem)	None	19
Total worker population dose[b] (person-rem)	None	237

[a] DOE's goal is to keep radiological exposures as low as reasonably achievable. This includes maintaining doses to individual workers so far below the DOE limit of 5,000 mrem/year (10 CFR Part 835) that no dose is expected to exceed the DOE Administrative Control Level of 2,000 mrem/year (DOE/EH-0256T).

[b] The number of badged workers in 1996 was approximately 12,500.

Source: WSRC 1997.

Effective administrative and design controls that decrease hazardous chemical releases to the environment and help achieve compliance with permit requirements (e.g., air emissions and National Pollutant Discharge Elimination System permit requirements) contribute toward minimizing potential health impacts to the public. The effectiveness of these controls is verified through the use of monitoring information and inspection of mitigation measures. Health impacts to the public may occur during normal operations at Savannah River Site via inhalation of air containing hazardous chemicals released to the atmosphere by Savannah River Site operations. Risks to public health from other possible pathways, such as ingestion of contaminated drinking water, or direct exposure, are low relative to the inhalation pathway.

Savannah River Site workers may be exposed to hazardous chemicals during normal operations by inhaling the workplace atmosphere and by direct contact with hazardous materials associated with work assignments. The potential for health impacts varies from facility to facility and from worker to worker, and available information is not sufficient to allow a detailed estimation and summation of these impacts. However, the workers are protected from hazards specific to the workplace through appropriate training, protective equipment, monitoring, and management controls. Savannah River Site workers are also protected by adherence to Occupational Safety and Health Administration and EPA standards that limit workplace atmospheric and drinking water concentrations of potentially hazardous chemicals. Appropriate monitoring that reflects the frequency and amounts of chemicals used in the operational processes ensures that these standards are not exceeded. Additionally, DOE requirements ensure that conditions in the

workplace are as free as possible from recognized hazards that cause or are likely to cause illness or physical harm. Therefore, worker health conditions at the Savannah River Site are expected to be better than required by the standards.

- **Emergency Preparedness**—Each of DOE's sites has established an emergency management program that would be used in the event of an accident. These programs have been developed and maintained to ensure an adequate response to accident conditions. The emergency management programs incorporate activities associated with emergency planning, preparedness, and response. The Emergency Operations Facility at the Savannah River Site provides overall direction and control for onsite responses to emergencies and coordinates with Federal, State, and local agencies and officials on the technical aspects of an emergency.

  The Savannah River Site Emergency Operations Facility consists of the following centers that provide distinct emergency response support functions:

  - *Savannah River Site Operations Center*—The Savannah River Site Operations Center coordinates the initial response to all Savannah River Site emergencies and functions as the heart of the Savannah River Site's emergency response communications network.

  - *Technical Support Center*—The Technical Support Center provides command and control of emergency response activities for the affected facility or operational area.

  - *Emergency Operations Center*—The Emergency Operations Center provides command and control of emergency response activities for Savannah River Site locations outside the affected area.

  - *Security Management Center*—The Security Management Center coordinates activities relating to the security and safeguarding of materials by providing security staff in the affected area and contractor management in the Emergency Operations Center.

  - *Dose Assessment Center*—The Dose Assessment Center assesses the health and environmental consequences of any airborne or aqueous releases of radioactivity or toxic chemicals and recommends onsite and offsite protective actions to other centers.

3.2.10 Waste Management

This section outlines the major environmental regulatory structure and ongoing waste management activities for the Savannah River Site. **Table 3–17** presents an overview of waste management activities at the Savannah River Site for 1993.

DOE is working with Federal and State regulatory authorities to address compliance and cleanup obligations arising from past operations at the Savannah River Site. DOE is engaged in several activities to bring its operations into full regulatory compliance. These activities are set forth in negotiated agreements that contain both schedules for achieving compliance with applicable requirements and financial penalties for nonachievement of agreed-upon milestones.

The EPA has placed the Savannah River Site on the National Priorities List and has identified approximately 150 potential operable units. In accordance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980, DOE entered into a Federal Facility Agreement with the EPA and the State of South Carolina, effective January 15, 1993. The agreement provides cleanup activities at the Savannah River Site under one comprehensive strategy.

Table 3–17 Waste Management Activities at Savannah River Site

Category	1996 Generation (m^3)	Treatment Method	Treatment Capacity (m^3/yr)	Storage Method	Storage Capacity (m^3)	Disposal Method	Disposal Capacity (m^3)
High-Level							
Liquid	2,379	Settle, separate, evaporate	53,700[b]	F- & H-Area Tank Farm	133,000[c]	N/A[d]	N/A
Solid	None	Vitrification[e]	None	Air Cooled Shielded Facility	2,286 canisters[f]	None; high-level waste program in the future	N/A
Transuranic							
Liquid	None	N/A	N/A	N/A	N/A	N/A	N/A
Solid	165	None	None	Pads, buildings	14,600[g]	None; WIPP or alternate facility in the future	None
Low-Level							
Liquid	None	Absorption, evaporation, filtration, neutralization, saltstone	503,000[h]	Ponds, tanks - awaiting processing	N/A	N/A	N/A
Solid	5,779	Compaction	3,980[i]	N/A	N/A	Burial vaults and trenches	2,578,000[j]
Mixed Low-Level							
Liquid	444	Stabilization, adsorption, neutralization, precipitation, filtration, ion exchange, evaporation	511,000[k]	RCRA permit Bldgs. E, 600, 700, M-Area Liquid Effluent Treatment Facility	11,500[l]	None	None
Solid	8	None	N/A	RCRA permit Bldg. 600	1,990[m]	None	None

Category	1996 Generation (m^3)	Treatment Method	Treatment Capacity (m^3/yr)	Storage Method	Storage Capacity (m^3)	Disposal Method	Disposal Capacity (m^3)
Hazardous							
Liquid	None	None	None	DOT containers	Included in solid	Offsite	N/A
Solid	57 (tonnes)	None	None	DOT containers	2,618[n]	Offsite	N/A
Nonhazardous (Sanitary)							
Liquid	None	Filter, settle, strip	1,451,000[o]	Flowing ponds	N/A	Permitted discharge	Varies by each permitted outfall
Solid	2,780 (tonnes)	Compaction	Expandable, as required	N/A	N/A	Landfill (onsite and offsite)	Expandable, as required

DOT = Department of Transportation
Note: N/A = Not applicable.
[a] Some fuel will be processed in the F- and H-Canyons in accordance with the *Final Environmental Impact Statement, Interim Management of Nuclear Materials* (DOE 1995b).
[b] Savannah River Technology Center ion exchange, evaporators.
[c] F- and H-Area Tank Farms.
[d] Treatment removes the high-level constituents (salt and sludge) from the liquids. The salt and sludge are vitrified.
[e] Defense Waste Processing Facility started operation in 1995.
[f] Defense Waste Processing Facility.
[g] Transuranic waste storage pads.
[h] Includes F- and H-Area Effluent Treatment Facility.
[i] Onsite compactors.
[j] Saltstone vaults, E-Area vaults, slit trenches.
[k] Includes F- and H-Area Effluent Treatment Facility, M-Area Effluent Treatment Facility, and Savannah River Technology Center Ion-exchange Treatment.
[l] Hazardous Waste Storage Facility, mixed waste storage buildings, Process Waste Interim Treatment, Defense Waste Processing Facility organic waste storage tank, burial ground storage tank, Savannah River Technology Center mixed waste storage.
[m] Hazardous Waste Storage Facility, mixed waste storage buildings.
[n] Pads and buildings in B-, M-, and N-Areas.
[o] Centralized Sanitary Wastewater Treatment Facility.
Sources: DOE 1996b and DOE 1997a.

The Savannah River Site has an aggressive waste minimization program in progress to improve the operation of existing and planned liquid and solid waste generating, treatment, and storage facilities. An approach to these activities is being developed based on technology and experience from the commercial nuclear industry. This approach has reduced the generation of transuranic waste (48 percent), low-level waste (13 percent), mixed waste (96 percent), and hazardous waste (58 percent) (DOE 1993c). The Savannah River Site generates and manages the following waste categories: high-level, transuranic, low-level, mixed, hazardous, and nonhazardous. A discussion of the waste management operations associated with each of these categories follows.

- **High-Level Waste**—Liquid high-level waste at the Savannah River Site is made up of many waste streams generated during the recovery and purification of transuranic waste products and unburned fissile material from spent reactor fuel elements. These wastes are separated by waste form, radionuclide, and heat content before their transfer to underground storage tanks in the F- and H-Area tank farms. Processes routinely used to treat liquid high-level waste are separation, evaporation, and ion exchange. Evaporation produces a cesium-contaminated condensate. Cesium is removed from the condensate, resulting in a low-level waste stream that is treated in the Effluent Treatment Facility. The remaining high-level waste stream salts are precipitated; some can be decontaminated. The decontaminated salt solution is sent with residues from the Effluent Treatment Facility to the Defense Waste Processing Z-Area Saltstone Facility, where it is mixed with a blend of cement, flyash, and blast furnace slag to form grout. The grout is pumped into disposal vaults where it hardens for permanent disposal as solid low-level waste. The remaining high-level salt and sludge are permanently immobilized as a glass solid cast in stainless steel containers at the Defense Waste Processing Facility Vitrification Plant. The stainless steel containers are decontaminated to the U.S. Department of Transportation standards, welded closed, and temporarily stored onsite for eventual transport to and disposal in a permanent Federal repository. Future high-level waste generation could result from the processing and stabilization of spent fuel for long-term storage as a result of 60 FR 28680 and from remediation or materials recovery activities performed in the F- and H-Canyons

- **Transuranic Waste**—Under the Federal Facilities Compliance Agreement on the Resource Conservation and Recovery Act Land Disposal Restrictions signed by the EPA and DOE on March 13, 1991, the Savannah River Site is required to prepare transuranic waste for shipment. The Savannah River Site will begin discussions with the South Carolina Department of Health and Environmental Control on alternative treatment options in January 1998 if the Secretary of Energy does not decide to operate WIPP by that time. If a delayed opening date for WIPP is determined, DOE will propose modifications to the *Savannah River Site Treatment Plan* for approval by the State of South Carolina. The status of the WIPP readiness schedule will be included in the updates. Certified transuranic waste is stored on transuranic waste storage pads until it can be shipped to an approved transuranic waste disposal facility. Should additional treatment be necessary for disposal, the Savannah River Site would develop the appropriate treatment capability. All transuranic waste currently generated is stored in containers on above-ground pads.

  The Experimental Transuranic Waste Assay and Certification Facility began operations in 1986 to certify newly generated transuranic waste. It since has been shut down. A new transuranic waste characterization and certification facility is planned that would provide extensive containerized waste processing certification capabilities. This facility is needed to prepare and certify transuranic waste for disposal at WIPP. Waste drums containing transuranic waste that can be certified for shipment to WIPP are placed in temporary storage on concrete pads in E-Area. Buried and stored waste containing concentrations of

transuranic waste nuclides between 10 and 100 nanocuries (nCi/g) (referred to as alpha-contaminated low-level waste or alpha waste) is managed in the same way as transuranic waste because its physical and chemical properties are similar and because similar procedures will be used to determine its final disposition. Because all of the transuranic waste placed on the above-ground pads prior to January 1990 is suspected of having hazardous constituents, a Resource Conservation and Recovery Act Part B permit application has been submitted for the transuranic waste storage pads and the Experimental Transuranic Waste Assay Certification Facility. The waste currently is being stored under Resource Conservation and Recovery Act interim status. The transuranic waste expected to be produced as a result of the processing of plutonium residues at the Savannah River Site should not contain any Resource Conservation and Recovery Act constituents (Section 2.1). If residues containing such constituents are processed at Savannah River, Resource Conservation and Recovery Act permit applications would be submitted for the preprocessing storage of residues and postprocessing storage of transuranic wastes.

- **Low-Level Waste**—The bulk of liquid low-level waste is aqueous process waste, including effluent cooling water, decontaminated salt solutions, purge water, water from storage basins for irradiated reactor fuel or target elements, distillate from the evaporation of process waste streams, and surface water runoff from areas where there is a potential for radioactive contamination. Liquids are processed to remove and solidify the radioactive constituents and to release the balance of the liquids to permitted discharge points within standards established by the regulatory permit. Solid low-level waste includes operating plant and laboratory waste, contaminated equipment, reactor and reactor-fuel hardware, spent lithium-aluminum targets, and spent de-ionizer resin from reactor coolant treatment. Solid low-level waste is separated by radiation levels into low and intermediate categories. Solid low-level waste that radiates less than 200 mrem/hr at 5 cm (1.97 in) from the unshielded container is considered low-activity waste. If it radiates greater than 200 mrem/hr at 5 cm (1.97 in), it is considered intermediate-activity waste. Intermediate-activity tritium waste is intermediate-activity waste with greater than 10 Ci of tritium per container. The disposal mode for solid low-level waste is disposal in earthen trenches and concrete vaults. Saltstone generated in the solidification of decontaminated salts extracted from high-level waste is disposed of as low-level waste in separate vaults. Saltstone is the highest volume of solid low-level waste disposed at the Savannah River Site. Disposal facilities are projected to meet solid low-level waste storage requirements and to include low-level waste from offsite DOE facilities for the next 20 years.

- **Mixed Low-Level Waste**—The Federal Facility Compliance Agreement signed by EPA and DOE on March 13, 1991, addresses Savannah River Site compliance with Resource Conservation and Recovery Act Land Disposal Restrictions pertaining to past, ongoing, and future generation of mixed low-level waste (mostly solvents, dioxin, and California list wastes contaminated with tritium). The Savannah River Site is allowed to continue to operate, generate, and store mixed wastes subject to Land Disposal Restrictions; in return, the Savannah River Site will report to the EPA the characterization of all solid waste streams disposed of in land disposal units at the Savannah River Site and has submitted its waste minimization plan to the EPA for review. Schedules for measures to provide compliance through construction of the Consolidated Incineration Facility and the Hazardous Waste and Mixed Waste Storage Facility are included in the Federal Facility Compliance Agreement.

The Consolidated Incineration Facility will treat mixed low-level and hazardous waste. The Hazardous Waste and Mixed Waste Disposal Vaults are scheduled to be available in 2002. Mixed waste currently is placed in interim storage in the E-Area Solid Waste Disposal Facility and in two buildings in G-Area. These Resource Conservation and Recovery Act permitted facilities will be used until completion of the Consolidated Incineration Facility and the Hazardous Waste and Mixed Waste Storage Facility. The Federal Facility Compliance Act of 1992 requires DOE facilities storing mixed waste to develop site-specific treatment plans and to submit the plans for approval. The Federal Facility Compliance Act of 1992 formed the basis for the Savannah River Site Proposed Site Treatment Plan.

- **Hazardous Waste**—Lead, mercury, cadmium, 1,1,1-trichloroethane, leaded oil, trichlorotrifluoroethane, benzene, and paint solvents are typical hazardous wastes generated at the Savannah River Site. All hazardous wastes are stored onsite in U.S. Department of Transportation-approved containers in three Resource Conservation and Recovery Acts permitted hazardous waste storage buildings and on three interim status storage pads in the B- and N-Areas. Most of the waste is shipped offsite to commercial Resource Conservation and Recovery Act permitted treatment and disposal facilities using U.S. Department of Transportation-certified transporters. Eight to nine percent of the hazardous waste (organic liquids, sludge, and debris) will be incinerated in the Consolidated Incineration Facility. Hazardous chemicals are stripped from aqueous liquids collected during ground water monitoring in the M-Area Stripper, and the treated wastewater is discharged in accordance with discharge limits appropriate to National Pollutant Discharge Elimination System permits.

- **Nonhazardous Waste**—In 1994, the centralization and upgrading of the sanitary wastewater collection and treatment systems at Savannah River were completed. The program included the replacement of 14 aging treatment facilities (out of 20) scattered across the site with a new 3,975 m^3/day (1.05 million gal/day) central treatment facility and connection of them with a new 29-km (18-mi) primary sanitary collection system. The collection system intercepts wastewater at points prior to discharge into old sanitary wastewater treatment facilities. The new central treatment facility treats sanitary wastewater by the extended aeration activated sludge process utilizing the oxidation ditch method. The treatment facility separates the wastewater into two forms, clarified effluent and sludge. The liquid effluent is further treated by nonchemical methods of ultraviolet light disinfection to meet National Pollutant Discharge Elimination System discharge limitations. The sludge goes through a composting process to reduce volume and pathogen levels to meet proposed land application criteria (40 CFR Part 503). The remaining existing sanitary wastewater treatment facilities are being upgraded as necessary to meet demands by replacing existing chlorination treatment systems with nonchemical ultraviolet light disinfection systems to meet National Pollutant Discharge Elimination System limitations. Savannah River Site-generated municipal solid waste is sent to a permitted offsite disposal facility. DOE is evaluating a proposal to participate in an interagency effort to establish a regional solid waste management center at the Savannah River Site (DOE 1994c, DOE 1995a).

3.3 Los Alamos National Laboratory

Los Alamos National Laboratory was established in 1943 as a nuclear weapons design laboratory and was formerly known as the Los Alamos Scientific Laboratory. Its facilities are located on approximately 11,300 ha (28,000 ac) approximately 40 km (25 mi) northwest of Santa Fe, New Mexico.

Los Alamos National Laboratory is a multidisciplinary research facility engaged in a variety of programs for DOE and other Government agencies. Its primary mission is the nuclear weapons Stockpile Stewardship and Management Program and related emergency response, arms control, and nonproliferation and environmental activities. Los Alamos National Laboratory conducts research and development activities in the basic sciences, mathematics, and computing with applications to these mission areas and to a broad range of programs, including nonnuclear defense; nuclear and nonnuclear energy; atmospheric, space, and geosciences; bioscience and biotechnology; and the environment. **Table 3–18** illustrates current missions at Los Alamos National Laboratory.

Table 3–18 Current Major Missions at Los Alamos National Laboratory

Mission	*Description*
Nuclear Weapons	Stockpile stewardship; production of nuclear and nonnuclear components; pit surveillance; tritium production research and development
Arms Control and Nonproliferation	Intelligence analysis; technology research and development; treaty verification; fissile material control; counterproliferation analysis
Energy Research, Science and Technology	Neutron science (e.g., at LANSCE); scientific computing; fusion energy; health and environmental research; high energy and nuclear physics; basic energy sciences
Energy Technology	Fossil; nuclear
Environmental	Environmental restoration; waste management and treatment
Non-DOE Missions	Conventional weapons; computing, modeling and simulation

In regard to nuclear weapons, Los Alamos National Laboratory is responsible for the design of the nuclear explosive package in certain U.S. weapons. Los Alamos National Laboratory maintains research, design, development, testing (including nuclear testing), surveillance, assessment, and certification capabilities in support of the Stockpile Stewardship and Management Program. In addition, since the end of the Cold War, Los Alamos National Laboratory conducts the pit surveillance program and some manufacturing of nuclear and nonnuclear components due to termination of the nuclear weapons mission at the Mound, Pinellas, and Rocky Flats Plants.

3.3.1 Land Resources

- **Land Use**—Los Alamos National Laboratory is located in north-central New Mexico, 97 km (60 mi) north-northeast of Albuquerque, 40 km (25 mi) northwest of Santa Fe, and 32 km (20 mi) southwest of Espanola in Los Alamos and Santa Fe Counties. The associated communities of Los Alamos and White Rock are in Los Alamos County. **Figure 3–15** shows the geographical location of Los Alamos National Laboratory. The 11,300-ha (28,000-ac) Los Alamos National Laboratory site and adjacent communities are situated on the Pajarito Plateau, which consists of a series of finger-like mesas separated by deep canyons that run from the Jemez Mountains on the west toward the Rio Grande Valley on the east. Mesa tops range in elevation from approximately 2,400 m (7,800 ft) on the west to about 1,900 m (6,200 ft) on the east (LANL 1994b).

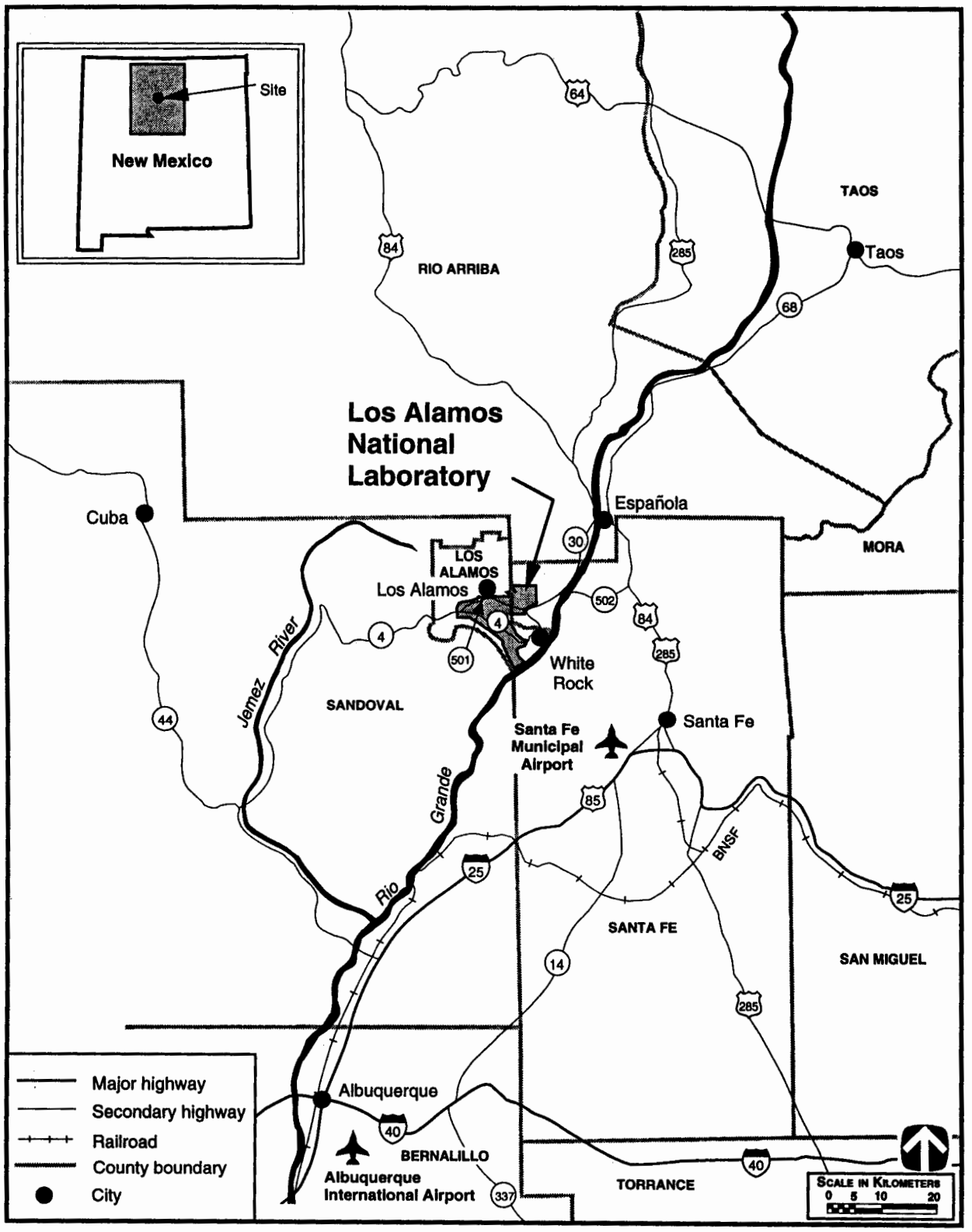


Figure 3–15 Los Alamos National Laboratory, New Mexico and Region

The developed acreage of Los Alamos National Laboratory consists of 49 active technical areas of laboratory facilities and support infrastructure, which accounts for only a small portion of the total land area. Most of Los Alamos National Laboratory is undeveloped to provide security, safety, and expansion possibilities for future mission requirements. There are no agricultural activities present at Los Alamos National Laboratory nor are there any prime farmlands. However, a trailer court with a population of approximately 500 persons is located on a parcel of private property that is surrounded by Los Alamos National Laboratory. This court is located along Route 501 in the northern part of Los Alamos National Laboratory (**Figure 3–16**).

The surrounding land is largely undeveloped with large tracts north, west, and south of the Los Alamos National Laboratory site administered by the U.S. Forest Service (Santa Fe National Forest), the National Park Service (Bandelier National Monument), and Los Alamos County. The San Ildefonso Pueblo borders the Los Alamos National Laboratory site to the east (LANL 1994b). The closest offsite residences to Los Alamos National Laboratory, other than those in the trailer park, are approximately 3 m (10 ft) from the northern boundary.

Additional information about land resources at the site can be found in the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996a).

3.3.2 Site Infrastructure

- **Baseline Characteristics**—Los Alamos National Laboratory contains extensive research and development facilities. To support current missions and functions, an extensive infrastructure exists. Baseline characteristics for this infrastructure are presented in **Table 3–19**.

Table 3–19 Baseline Characteristics for Los Alamos National Laboratory

Characteristics	Current Value
Land	
Area (ha)	11,300
Roads (km)	137
Railroads (km)	0
Electrical	
Energy Consumption (MWh/yr)	381,425
Peak Load (MWe)	87
Fuel	
Natural Gas (m^3/yr)	43,414,560
Liquid (L/yr)	0
Coal (t/yr)	0
Steam (kg/hr)	33,554

MWh/yr = megawatt hours per year MWe = megawatts electric m^3/yr = cubic meters per year L/yr = liters per year
t/yr = tons per year
Source: Adapted from DOE 1996a

Locally, Los Alamos National Laboratory is supplied with electricity by a Los Alamos County/DOE power pool. It also has a 20-megawatts electric gas-fired generating plant in Technical Area 3. Electricity is transmitted to the site and the county over two 115-kilovolt lines, one from Santa Fe (Norton Generating Station) and one from Albuquerque (Reeves Generating Station). These lines enter Los Alamos National Laboratory near Technical Area 5 (Eastern Technical Area substation). Electricity is distributed throughout the site via 13.2-kilovolt lines. The 115-kilovolt system includes a loop that ties substations at Technical Areas 3, 5, and 53 together. This looping ensures a power supply throughout Los Alamos National Laboratory should outages occur in any major line. The total annual power consumption is considerably below the

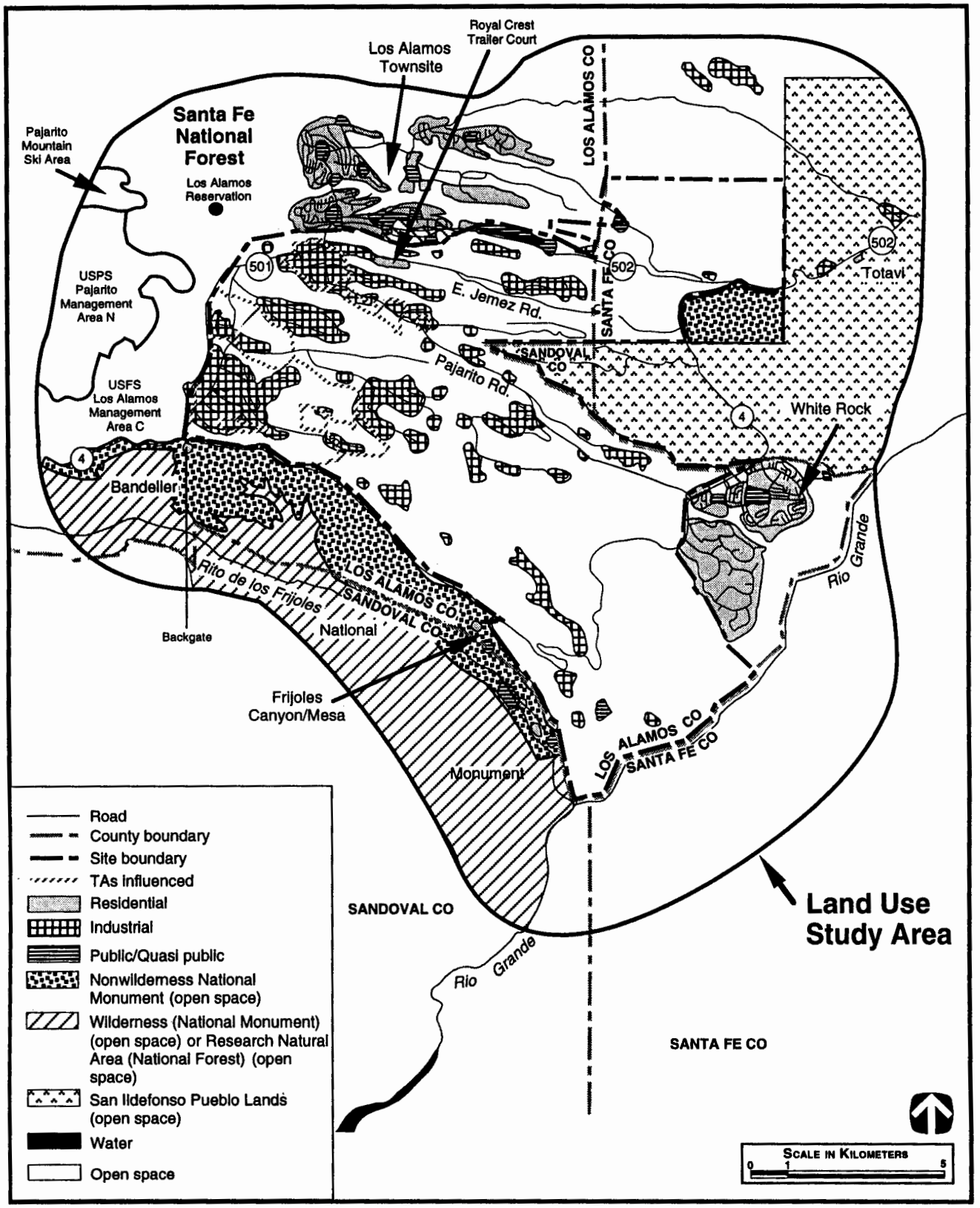


Figure 3–16 Generalized Land Use at Los Alamos National Laboratory and Vicinity

transmission capacity of the system. The subregional electric power pool from which Los Alamos National Laboratory draws its power is the Arizona-New Mexico Power Area. Capabilities of this power pool are summarized in **Table 3–20.**

Table 3–20 Arizona–New Mexico Subregional Power Pool Electrical Summary

Characteristics	Energy Production
Type Fuel[a]	
Coal	57%
Nuclear	24%
Hydro/geothermal	4%
Oil/gas	15%
Other[b]	0.3%

[a] Percentages do not total 100 percent due to rounding.
[b] Includes power from both utility and nonutility sources.
Source: Adapted from DOE 1996a.

3.3.3 Air Quality and Noise

- **Meteorology and Climatology**—Los Alamos has a semiarid, temperate mountain climate. The average annual precipitation is 47.6 cm (18.7 in), but is quite variable from year to year.

  Los Alamos winds are generally light, averaging 2.8 m/s (6.3 mph). Strong winds are most frequent during the spring when peak gusts often exceed 22 m/s (50 mph). The highest recorded wind gust was 34.4 m/s (77 mph). The semiarid climate promotes strong surface heating by day and strong radiative cooling by night. Because the terrain is complex, heating and cooling rates are uneven over the Los Alamos National Laboratory area, which results in local thermally generated winds (LANL 1994b).

  Figure 3–17 shows annual mean windspeed and wind direction frequencies for Los Alamos National Laboratory for 1991. The maximum wind direction frequency is from the west-northwest with a secondary maximum from the west. The mean windspeed from the west-northwest is 3.2 m/s (7.2 mph), whereas the mean windspeed from the west is 3 m/s (6.7 mph). Historical wind data indicate that the prevailing wind directions are from the south through the northwest. The average annual windspeed is 2.8 m/s (6.3 mph) (DOE 1996a).

- **Air Quality**—Los Alamos National Laboratory is located within the New Mexico Intrastate Air Quality Control Region No. 157. None of the areas within Los Alamos National Laboratory and its surrounding counties are designated as nonattainment areas with respect to any of the National Ambient Air Quality Standards (40 CFR Part 81.332). A nonattainment area is an area that has air quality worse than designated by National Ambient Air Quality Standards for one or more criteria pollutants.

  Criteria pollutants—nitrogen dioxide, carbon monoxide, hydrocarbons, particulate matter, and sulfur dioxide—make up approximately 79 percent of the stationary source emissions at Los Alamos National Laboratory. The source of these criteria pollutants is combustion in powerplants, steam plants, asphalt plants, and local space heaters. Toxic and other hazardous pollutants represent the remaining 21 percent of emissions from stationary sources at Los Alamos National Laboratory. These emissions are generated by equipment surface cleaning, coating processes, and acid baths and include gases, vapors, metal dusts, and miscellaneous emissions such as wood dust, hazardous gases, and plastics (LANL 1994b).

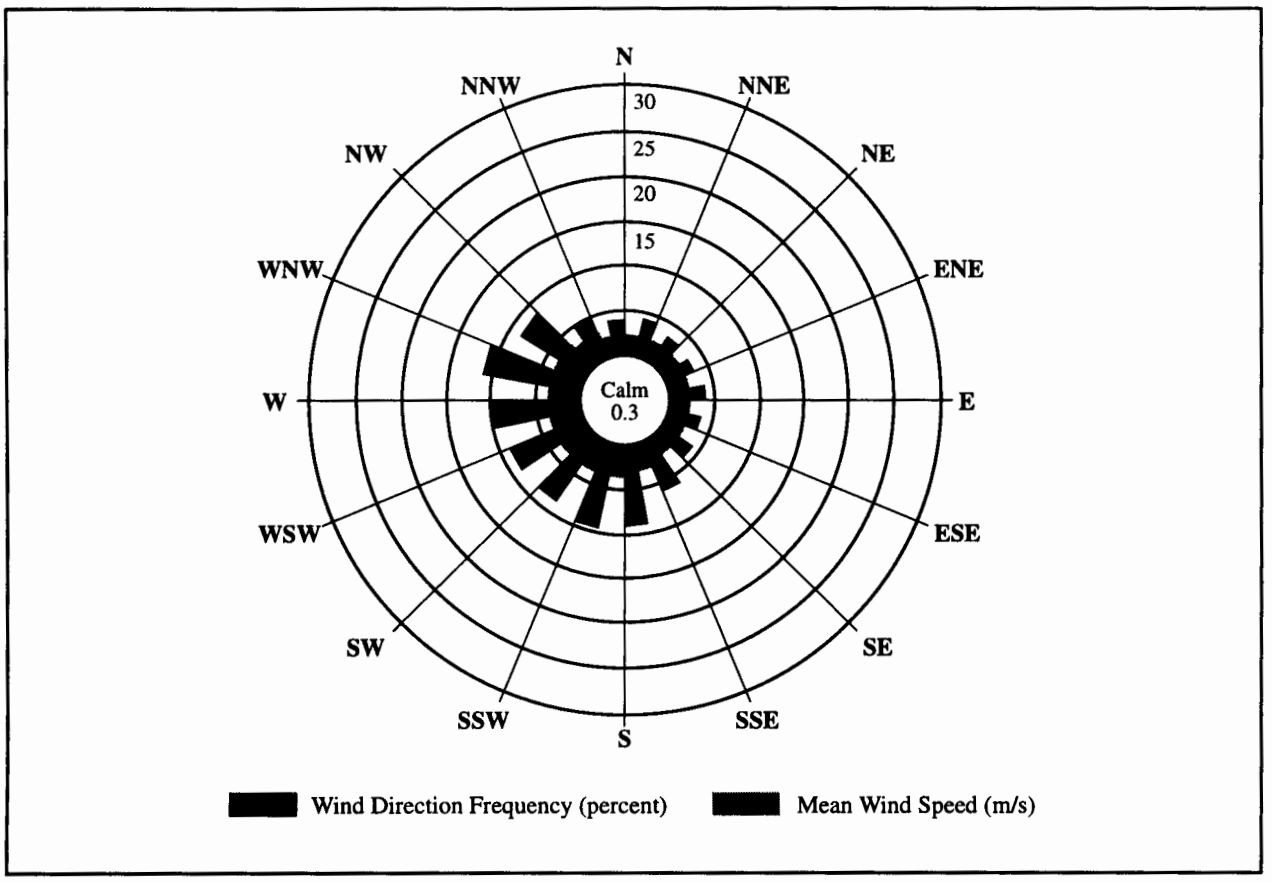


Figure 3–17 Wind Rose for the Los Alamos National Laboratory (1991) (11.5-meter level)

One Prevention of Significant Deterioration Class I Area, the Bandelier National Monument's Wilderness Study Area, borders Los Alamos National Laboratory to the south. To date, Los Alamos National Laboratory has not been subject to Prevention of Significant Deterioration requirements (LANL 1994b).

Concentration limits for hazardous/toxic air pollutants (to be used by the State as one of the criteria in evaluating construction permit applications for a new emission source) have been approved by the New Mexico Environmental Improvement Board. **Table 3–21** presents the baseline ambient air concentrations for criteria pollutants for 1992 and other pollutants of concern for 1990 at Los Alamos National Laboratory. Baseline concentrations are in compliance with applicable guidelines and regulations.

3.3.4 Water Resources

- **Surface Water**—The Rio Grande River is the major surface water feature in north-central New Mexico. All surface water drainage and groundwater discharge from the Pajarito Plateau ultimately arrives at the Rio Grande. The Rio Grande at Otowi, just east of Los Alamos, has a drainage area of 37,037 square kilometers (km^2) (14,300 square miles [mi^2]) in southern Colorado and northern New Mexico (DOE 1995e).

Table 3–21 Comparison of Baseline Air Pollutant Concentrations with Most Stringent Applicable Regulations and Guidelines at Los Alamos National Laboratory, 1990 and 1992

Pollutant	Averaging Time	Most Stringent Regulation or Guideline ($\mu g/m^3$)	Monitored Baseline Concentration ($\mu g/m^3$)
Criteria Pollutants			
Carbon monoxide	8-hour	9,963[a]	115
	1-hour	15,000[b]	630
Lead	Calendar quarter	1.5[b]	[c]
Nitrogen dioxide	Annual	94[a]	3.8
	24-hour	188[a]	[c]
Ozone[d]	1-hour	235[a]	139
Particulate matter[e]	Annual	50[b]	8
	24-hour	150[b]	21
Sulfur dioxide	Annual	52[a]	1.3
	24-hour	262[a]	[c]
	3-hour	1,300[b]	[c]
Mandated by New Mexico			
Asbestos	30-day	0.01[a]	[c]
Beryllium	Calendar quarter	[f]	0.00002
	30-day	0.01[a]	[c]
Heavy metals	30-day	10[a]	[c]
Hydrogen sulfide	1-hour	14[a]	[c]
Nonmethane hydrocarbons	3-hour	100[a]	[c]
Photochemical oxidants	1-hour	118[a]	151
Total reduced sulfur	30-minute	3.9[a]	[c]
Total suspended particulate[e]	Annual	60[a]	8
	30-day	90[a]	<21
	7-day	110[a]	<21
	24-hour	150[a]	21
Hazardous and Other Toxic Pollutants[g]			
1,1,2-Trichloroethane	8-hour	[f]	4.95
2-Butoxyethanol	8-hour	1,200[a]	0.66
Acetic acid	8-hour	250[a]	2.87
Ammonia	8-hour	180[a]	4.27
Chlorine	8-hour	30[a]	0.07
Dichlorodifluoromethane	8-hour	[f]	0.09
Ethylene glycol	8-hour	1,250[a]	0.39
Hexane (N-hexane)	8-hour	1,800[a]	0.41
Hydrogen chloride	8-hour	70[a]	3.41
Hydrogen fluoride	8-hour	25[a]	1.29
Isopropyl alcohol	8-hour	9,800[a]	2.88
Methyl alcohol	8-hour	2,600[a]	3.14
Methyl ethyl ketone	8-hour	5,900[a]	9.95
Methylene chloride	8-hour	3,500[a]	5.90
Nitric acid	8-hour	50[a]	3.53

Pollutant	Averaging Time	Most Stringent Regulation or Guideline ($\mu g/m^3$)	Monitored Baseline Concentration ($\mu g/m^3$)
Hazardous and Other Toxic Compounds[g] (continued)			
Nitrogen oxide	8-hour	300[a]	2.29
Stoddard solvent	8-hour	5,250[a]	1.41
Sulfuric acid	8-hour	10[a]	0.12
Tetrahydrofuran	8-hour	5,900[a]	0.09
Toluene	8-hour	3,750[a]	13.2
Trichloroethylene	8-hour	250[a]	1.12
VM&P Naphtha	8-hour	13,500[a]	3.27
Xylene	8-hour	4,350[a]	9.41

$\mu g/m^3$ = microgram per cubic meter
[a] State standard.
[b] Federal standard.
[c] No monitoring data available; baseline concentrations assumed less than applicable standard.
[d] In July 1997, the EPA established a new 8-hour primary ambient standard of 0.08 ppm for ozone that replaces the previous 1-hour, 0.12 ppm standard (see Chapter 5 of this EIS for additional information).
[e] It is assumed that all particulate matter concentrations are total suspended particulate concentrations. In July 1997, EPA established new standards for particles with an aerodynamic diameter less than or equal to a nominal 2.5 micrometers (see Chapter 5 of this EIS for additional information).
[f] No standard.
[g] Compounds listed are the major pollutants (11.34 kilograms per year or more) of concern.
Source: Adapted from DOE 1996a.

Eleven drainage areas, with a total area of 212 km^2 (82 mi^2) pass through the eastern boundary of Los Alamos National Laboratory. Runoff from heavy thunderstorms and heavy snowmelt reaches the Rio Grande several times a year from some drainages. Los Alamos, Pajarito, and Water Canyons have drainage areas greater than 26 km^2 (10 mi^2). Pueblo Canyon has a drainage area of 21 km^2 (8 mi^2); all others have less than 13 km^2 (5 mi^2). The overall flood risk to Los Alamos National Laboratory is low because nearly all the structures are located on the mesa tops, from which runoff drains rapidly into the deep canyons (DOE 1995e). The hydrological features at Los Alamos National Laboratory are depicted in **Figure 3–18**. No surface water is withdrawn at Los Alamos National Laboratory for either drinking water or facility operations (DOE 1993c).

Existing wastewater generation from Los Alamos National Laboratory is approximately 1,351 million L/yr (357 gal/yr). Permitted effluent discharges at Los Alamos National Laboratory into 10 of the major watersheds from 87 currently active National Pollutant Discharge Elimination System permitted industrial outfalls (Bradford 1996; DOE 1996c).

Surface water quality monitoring results indicate that the overall compliance for sanitary and industrial discharges during 1995 was 100 percent and 98 percent, respectively. Additional information about surface water quality at the site can be found in the publication *Environmental Surveillance at Los Alamos During 1995* (LANL 1996).

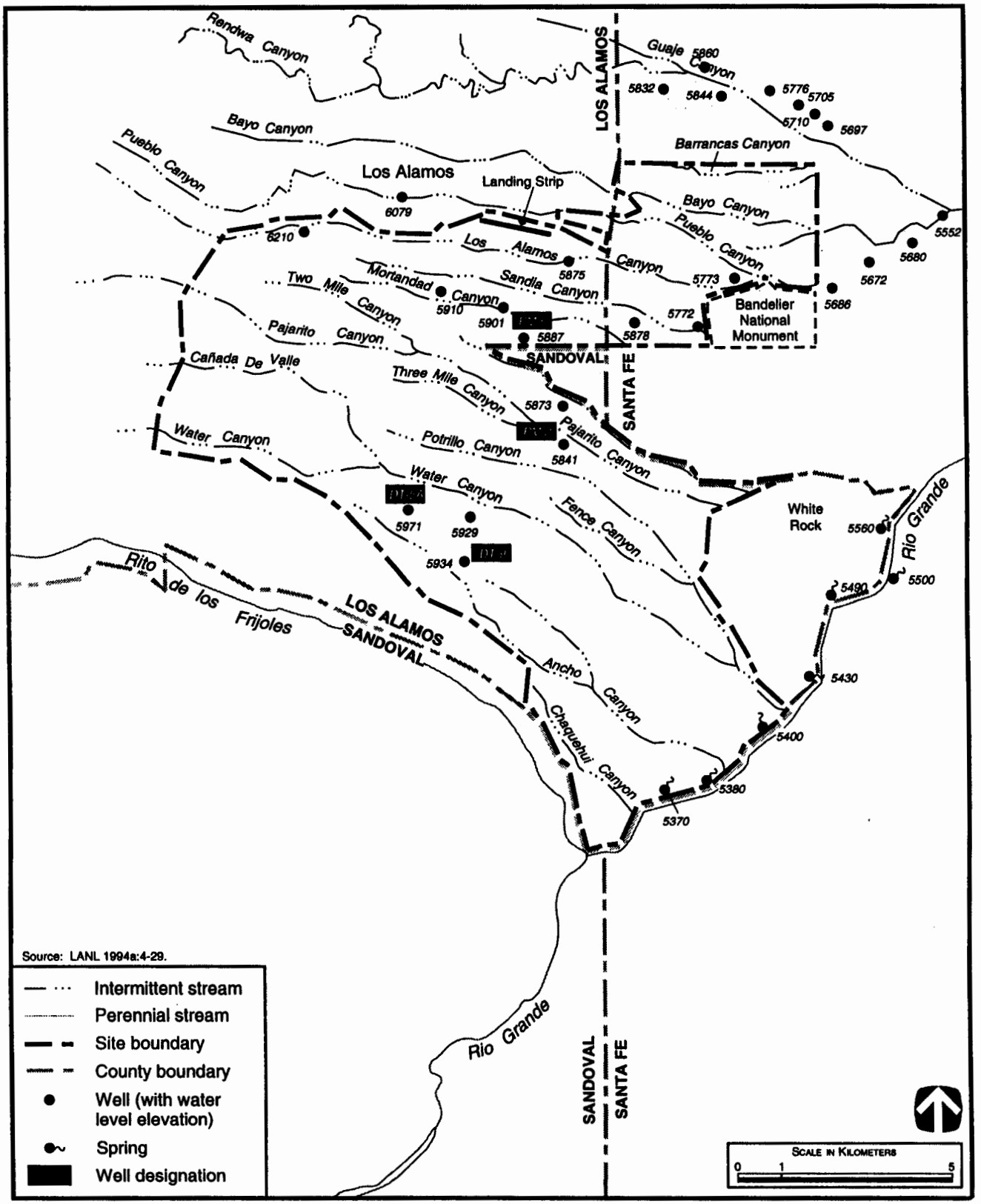


Figure 3–18 Surface Water Features Near Los Alamos National Laboratory

- *Water Rights and Permits*—Water rights in New Mexico fall under the Doctrine of Prior Appropriations. Under this doctrine, the user who first appropriated water for a beneficial use has priority to use the available water supply over a user claiming rights at a later time. All natural water flowing in streams and water courses in New Mexico is considered to be public and subject to appropriation for beneficial use. Beneficial use is the basis, measure, and limit of the right to use water. No water right, therefore, may be granted or claimed for more than the amount that can be beneficially used. DOE owns combined surface and groundwater rights. These rights include the withdrawal of 5,541.3 acre-ft/yr (approximately 6,835 million L/yr) from a variety of wells and surface diversions under licenses RG–485 through RG–488, 1503, 1802, and 1802–B. DOE also owns a contract for 1,200 acre-ft/yr (1,480 million L/yr) of San Juan/Chama Diversion water.

❒ **Groundwater**—Groundwater in the Los Alamos National Laboratory area exists in three modes—in shallow alluvium in canyons, in perched groundwater, and in the main aquifer. The main aquifer consists mostly of clastic sediments within the Santa Fe Group and the Puye Formation. Nearly all groundwater at Los Alamos National Laboratory is obtained from deep wells that produce water from this aquifer. A minor amount of groundwater at Los Alamos National Laboratory is obtained from springs. Most aquifers that lie beneath Los Alamos National Laboratory, with the exception of perched zones, are considered Class II aquifers, having current sources of drinking water and other beneficial uses (DOE 1993c).

The most productive area lies in the central portion of the Pajarito Plateau and includes the Pajarito well field. The average drawdown for these wells is 12 m (39.4 ft). The rate of movement of water in the aquifer is approximately 12 to 29 m (39.4 to 95.1 ft) per year (DOE 1996a).

- *Groundwater Quality*— Most of the wells in the Pajarito Plateau yield fresh water (total dissolved solids less than 500 mg/l), although some wells east of the site have a higher total dissolved solids content (1,000 mg/l or more). The primary, secondary, and radiochemical groundwater quality, as measured from wells and springs in the main aquifer were below DOE's derived concentration guides or the New Mexico standards applicable to a DOE drinking water system (DOE 1993c). All parameters were below the applicable water quality criteria or standard in the main aquifer in 1993. Additional information about groundwater quality at the site can be found in the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996a).

- *Groundwater Availability and Use*—Los Alamos National Laboratory, the nearby communities of Los Alamos and White Rock, and Bandelier National Monument are entirely dependent on groundwater for their water supply. The water supply is primarily obtained from well fields. During 1993, total production from the wells for potable and nonpotable use was 5,519 million L (1,458 million gal). Los Alamos National Laboratory's water system had an average demand equal to about 81 percent of its current allotment of 6,800 million L/yr (1,800 million gal/yr). The site's water system and wells supply the Los Alamos townsite, the White Rock Community, and the Bandelier National Monument facilities.

  Two new wells have been drilled recently at Los Alamos National Laboratory, one of which began pumping in the summer of 1992. The new wells are expected to supplant the now abandoned Los Alamos field. Water is taken from depths of 245 to 550 m (804 to 1,805 ft).

  Over the next 50 years, increases in water use may require one of the following: use of the 1,500 million L/yr (396 million gal/yr) of San Juan-Chama water (releasing the water in exchange for excess pumping) and/or establishment of credit for return flow (DOE 1993c).

3.3.5 Geology, Soils, and Seismology

- **Geology and Soils**—Los Alamos National Laboratory is located on the Pajarito Plateau. The surface of the plateau is dissected by deep, southeast-trending canyons separated by long, narrow mesas. The Pajarito Plateau is capped by the Bandelier Tuff, a geologic unit comprising a massive pumiceous tuff breccia of ash-flow origin and a succession of cliff-forming welded ash flows. The tuff is underlain by sedimentary and volcanic rocks of the Santa Fe Group (DOE 1979).

  The site is underlain by soil types varying in texture from clay and clay loam to gravel. More than 95 percent of the soils are developed on acidic volcanic rocks. Because of the topographic relief of the Pajarito Plateau, rock outcrops occur on more than 50 percent of the site area. The soils are acceptable for standard construction techniques. No soils in Los Alamos County have been designated prime farmland or Soil of Statewide Importance for New Mexico (DOE 1996a).

  Detailed information about site geology and soils can be found in the *Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement* (DOE 1995f).

- **Seismology**—Los Alamos National Laboratory lies within seismic Zone 2. The strongest earthquake in the last 100 years within an 80-km (50-mi) radius was estimated to have a magnitude of 5.5 to 6 and a modified Mercalli intensity of VII. Studies suggest that several faults have produced seismic events with a magnitude of 6.5 to 7.8 in the last 500,000 years. Los Alamos National Laboratory operates a seismic hazards program that monitors seismicity through a seismic network and conducts studies in paleoseismology. Major faults at Los Alamos National Laboratory include the Pajarito, Rendija Canyon, and Guaje Mountain faults (**Figure 3–19**). The Guaje Mountain fault last moved between 4,000 and 6,000 years ago. There is no evidence of movement along the Pajarito fault system during historical times (DOE 1995e). The 100-year earthquake at Los Alamos is regarded as having a magnitude of 5, with an event of magnitude 7 being the maximum credible earthquake (DOE 1979). These values are currently used in design considerations at Los Alamos National Laboratory. Geological concerns associated with the Los Alamos National Laboratory area include potential downslope movements in association with regional seismic activity. Although isolated rockfalls commonly occur from the canyon rims, landslides are an unlikely hazard at Los Alamos because of the dry climate, the deep water table, and the rock characteristics. Although the area has the potential for future volcanic eruptions, the periodicity and structural development of past eruptions indicate a low probability of an eruption occurring within the next 1,000 years (DOE 1979). Additional details can be found in Appendix D, Section 3.3.3.3.

3.3.6 Ecology

Detailed information about ecological resources at the Los Alamos National Laboratory can be found in the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996a). Federal threatened and endangered species that may be found on or in the vicinity of the Los Alamos National Laboratory include the Bald eagle, Mexican spotted owl, Peregrine falcon, Southwestern willow flycatcher, Whooping crane, and Rio Grande silvery minnow (DOE 1996a).

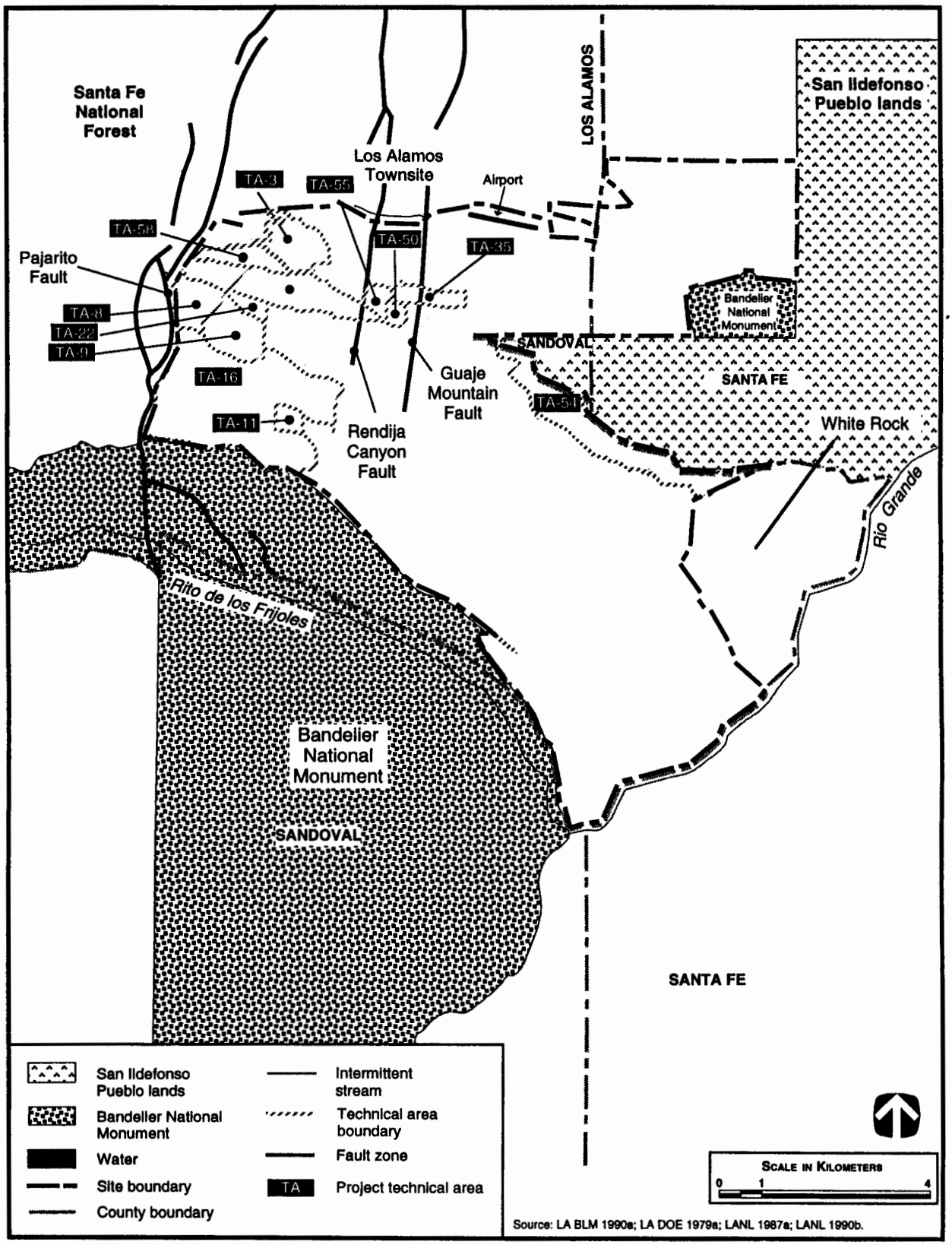


Figure 3–19 Major Fault Systems Near the Los Alamos National Laboratory Region

3.3.7 Cultural and Paleontological Resources

More than 1,300 prehistoric sites and 80 historic resources have been recorded at Los Alamos National Laboratory, and approximately 95 percent of these sites and 90 percent of the resources are considered eligible or potentially eligible for the National Register of Historic Places. Native Americans in the area include the six Tewa-speaking Pueblos of the northern Rio Grande Valley (San Ildefonso, San Juan, Santa Clara, Nambe, Tesuque, and Pojoaque) and the Cochiti and Jemez Pueblos. None of the formations within Los Alamos National Laboratory are known to be fossiliferous. Additional information about cultural and paleontological resources at the site can be found in the publication *Environmetnal Surveillance at Los Alamos During 1995* (LANL 1996).

3.3.8 Socioeconomics

- **Regional Economy**—Between 1980 and 1990, the civilian labor force in the regional economic area increased from 74,759 to 100,257, a 34-percent increase (annual average increase of 3.4 percent). The regional economic area encompasses seven counties around the site located in New Mexico. In 1994, unemployment in the regional economic area was 6.2 percent compared to 6.3 percent for New Mexico. The region's per capita income of $17,689 in 1993 was approximately 8.2 percent higher than New Mexico's per capita income of $16,346. The regional economic area and New Mexico have similar employment patterns. The service sector accounts for the largest share of total employment in both the region (31 percent) and in New Mexico (28 percent). Manufacturing employment accounted for 4 percent of the total regional employment but 6 percent of the total State employment (DOE 1996a).

- **Population and Housing**—Between 1980 and 1992, the population residing within the Los Alamos National Laboratory region of influence grew from 122,241 to 158,249, an increase of 29.5 percent (annual average increase of 2.5 percent). The region of influence is a three-county area (Los Alamos County, Rio Arriba County, and Santa Fe County) in which almost 90 percent of all site employees reside. Within the region of influence, however, Santa Fe County increased by 39.6 percent (annual average increase of 3.3 percent). Population growth in Los Alamos was nearly stagnant during the same period. The unincorporated communities of Los Alamos and White Rock in Los Alamos County are included in the county population and housing analysis (DOE 1996a).

  The number of housing units increased from 46,006 in 1980 to 63,386 units in 1990, an increase of 37.8 percent (annual average increase of 3.8 percent). The 1990 homeowner vacancy rate in the region of influence was 2.3 percent. The rental vacancy rate for the region of influence counties was 7.7 percent. **Figure 3–20** shows the racial and ethnic composition of minorities residing within an 8- km (50-mi) radius of Los Alamos National Laboratory at the time of the 1990 census.

  This 80-km (50-mi) radius defines the region of potential influence for radiological effects evaluated in Chapter 4 of this EIS. The minority population as a percentage of total population (54.2 percent) residing in the region of influence at that time is 30 percent more than the national percentage of minorities (24.2 percent) residing in the continental United States at the time of the 1990 census. Among all of the continental states, the State of New Mexico has the highest percentage minority population (49.6 percent). Hispanics and Native Americans comprised 97 percent of the minority population in the region of influence. As illustrated in **Figure 3–21**, the percentage of minority residents exceeded 25 to 50 percent of the total population, roughly twice the national average, in areas throughout the region of influence.

  Based on the 1990 census, approximately 41 percent of the 77,944 households residing within the region of influence had a self-reported income less than 80 percent of the median income for the county of residence. These households qualify as low-income households under rules of the Department of Housing and Urban Development. As shown in Table F-4 of Appendix F, about 15 percent of the individuals

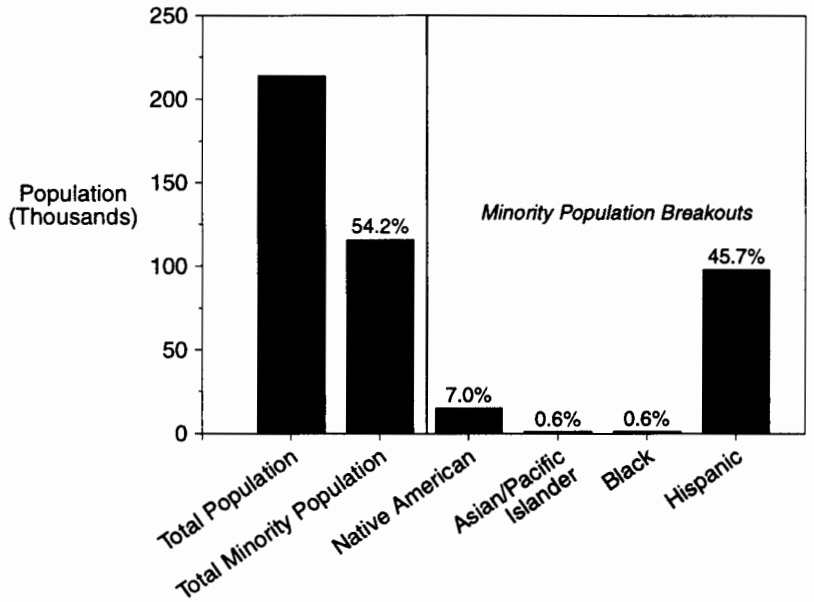


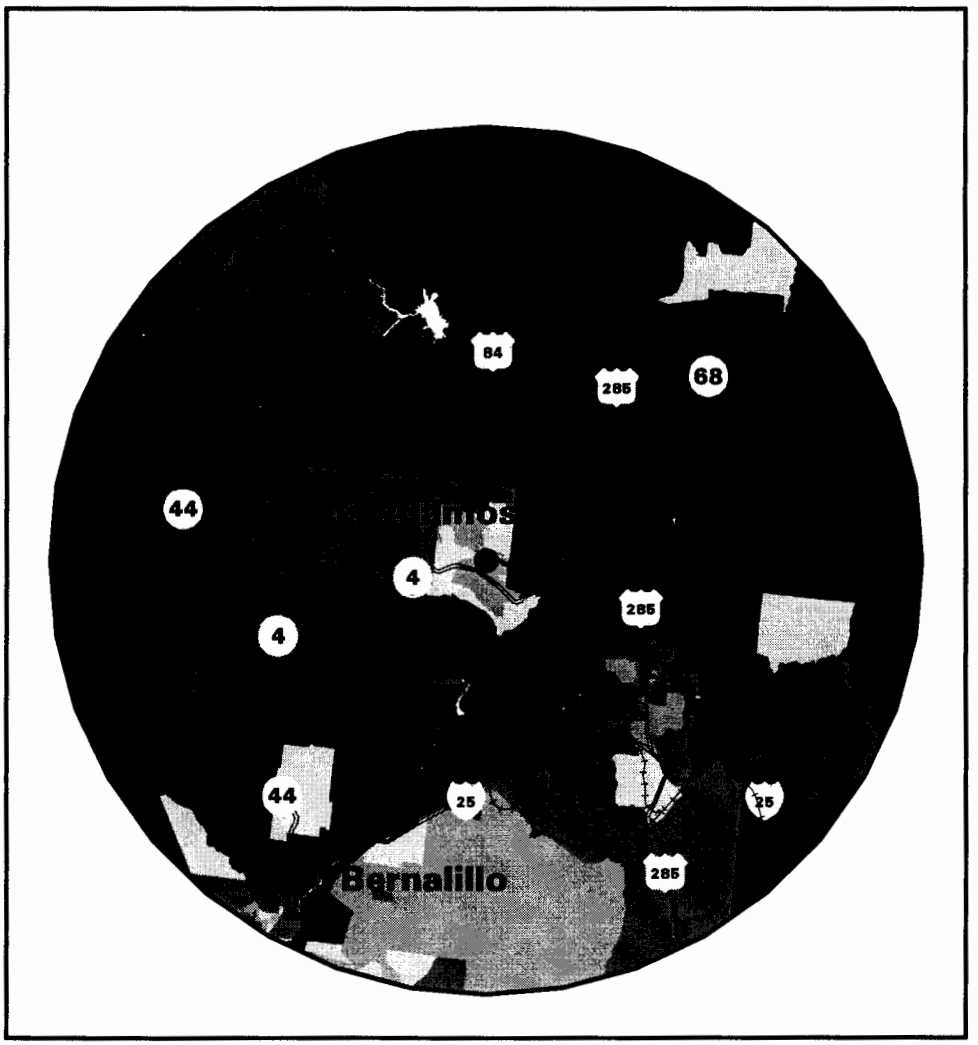
Figure 3–20 Racial and Ethnic Composition of the Minority Population Residing Within 80 km (50 mi) of the Los Alamos National Laboratory

residing within the region of influence had a self-reported income less than the poverty level. As discussed in Appendix F, the poverty level is a function of family size and number of unmarried children in the family under 18 years of age. The national percentage of individuals with income less than the poverty-level in 1995 is estimated by the Census Bureau to be 13.8 percent. The national percentage of individuals residing in the continental United States with income below the poverty-level was 13.3 percent at the time of the 1990 census. **Figure 3–22** shows the distribution of poverty-level individuals residing within the region of influence. As shown in the figure, there are areas throughout the region of influence in which the percentage of residents with income below the poverty-level was a factor of two or more larger than the national average.

3.3.9 Public and Occupational Health and Safety

❒ **Radiation Environment**—Major sources of background radiation exposure to individuals in the vicinity of Los Alamos National Laboratory are shown in **Table 3–22**. Annual doses to individuals from background radiation are expected to remain constant over time. Total dose to the population changes as the population size changes. Background radiation doses are unrelated to Los Alamos National Laboratory operations.

Releases of radionuclides to the environment from Los Alamos National Laboratory operations provide another source of radiation exposure to individuals in the vicinity of Los Alamos National Laboratory. The radionuclides and quantities released from Los Alamos National Laboratory operations in 1995 are listed in *Environmental Surveillance at Los Alamos During 1995* (LANL 1996). Doses to the public resulting from these releases and direct radiation are presented in **Table 3–23.** These doses fall within regulatory limits given in DOE Order 5400.5 and are small in comparison to background radiation.



LEGEND

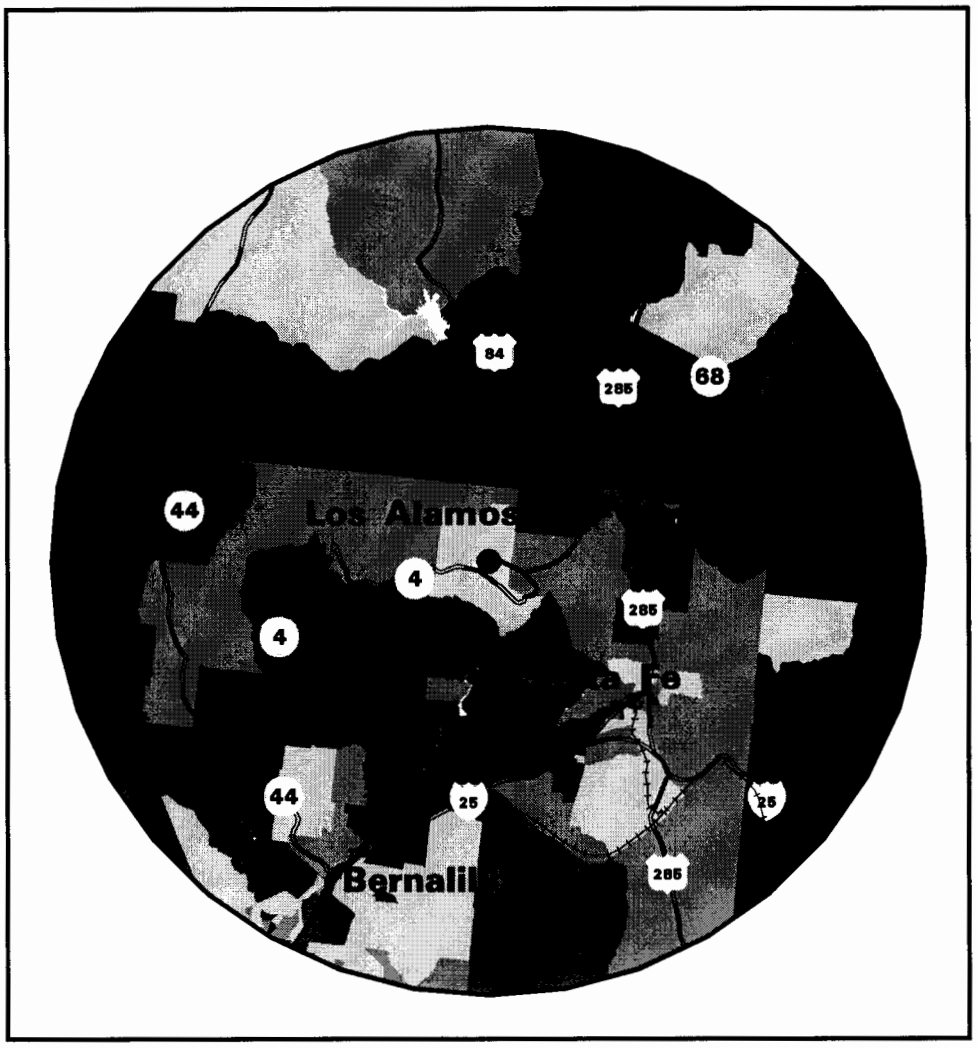
- Site
- Surface Water Shoreline
- Rail Lines
- State & US Highways

- 0 <= Pm < 12%
- 12% <= Pm < 24%
- 24% <= Pm < 48%
- Pm >= 48%

SUMMARY STATISTICS	
WITHIN 80 KM (50 MILES) RADIUS OF THE SITE	
TOTAL POPULATION	214,290
MINORITY POPULATION	116,091
PERCENTAGE	54%

0 5 10 15 20 25 30
miles

Figure 3–21 Distribution of Minority Population Residing Within 80 km (50 mi) of Los Alamos National Laboratory



LEGEND

- Site
- Surface Water Shoreline
- Rail Lines
- State & US Highways

- 0 <= Pp < 6.5%
- 6.5% <= Pp < 13%
- 13% <= Pp < 26%
- Pp >= 26%

SUMMARY STATISTICS	
WITHIN 80 KM (50 MILES) RADIUS OF THE SITE	
TOTAL POPULATION	214,290
POVERTY-LEVEL POPULATION	31,542
PERCENTAGE	15%

0 5 10 15 20 25 30
miles

Figure 3–22 Distribution of Low-Income Population Residing Within 80 km (50 mi) of Los Alamos National Laboratory

Table 3–22 Sources of Radiation Exposure to Individuals in the Vicinity, Unrelated to Los Alamos National Laboratory Operations

Source	Committed Effective Dose Equivalent (mrem/yr)
Natural Background Radiation[a]	
Cosmic and external terrestrial radiation	109
Internal terrestrial radiation	40
Radon in homes (inhaled)[b]	200
Other Background Radiation [a,c]	
Diagnostic x-rays and nuclear medicine	53
Weapons test fallout	<1
Air travel	1
Consumer and industrial products	10
Total	414

[a] LANL 1996 (Chapter 3).
[b] Value for Radon is an average for the United States.
[c] NCRP 1987.

Table 3–23 Doses to the General Public from Normal Operations at Los Alamos National Laboratory, 1995 (Committed Effective Dose Equivalent)

Members of the General Public	Atmospheric Releases		Liquid Releases		Total	
	Standard[a]	Actual	Standard[a]	Actual	Standard[a]	Actual
Maximally exposed individual (mrem)	10	5.1	4	0.58	100	5.7
Population within 80 km (50 mi)[b] (person-rem)	None	3.2	None	~0[c]	None[d]	3.2
Average individual within 80 km (50 mi)[e] (mrem)	None	0.013	None	~0[c]	None	0.013

[a] The standards for individuals are given in DOE Order 5400.5. As discussed in that Order, the 10 mrem/yr limit for airborne emissions is required by the Clean Air Act. The 4 mrem/yr limit is required by the Safe Drinking Water Act, and the total dose of 100 mrem/yr is the limit from all pathways combined.
[b] In 1995, this population was approximately 241,000.
[c] Although the maximally exposed individual receives a dose, no population groups are exposed to any liquid pathways.
[d] A 100 person-rem value for the population is found in proposed 10 CFR Part 834 (58 FR 16268). If the potential total dose exceeds this value, it is required that the contractor operating the facility notify DOE.
[e] Obtained by dividing the population dose by the number of people living within 80 km (50 mi) of the site.
Source: LANL 1996 (Chapter 3).

Workers at Los Alamos National Laboratory receive the same dose as the general public from background radiation, but also receive an additional dose from working in the facilities. **Table 3–24** includes the average, maximum, and total occupational doses to Los Alamos National Laboratory workers from operations during the period of 1991 through 1995.

A more detailed presentation of the radiation environment, including background exposures and radiological releases and doses, is presented in *Environmental Surveillance at Los Alamos During 1995* (LANL 1996). In addition, the concentrations of radioactivity in various environmental media (e.g., air, water, and soil) in the onsite and offsite regions are presented in the same reference.

Table 3–24 Annual Doses to Onsite Workers from Normal Operations at Los Alamos National Laboratory, Period 1991–1995

Occupational Personnel	Onsite Releases and Direct Radiation	
	Standard [a]	Actual [b]
Average Worker (mrem)	None	16
Maximally exposed worker (mrem)	5,000	2,000
Total workers (person-rem)	None	165

[a] 10 CFR Part 835. DOE's goal is to maintain radiological exposure as low as reasonably achievable. This includes maintaining doses to individual workers so far below the DOE limit of 5,000 mrem/year that no dose is expected to exceed the DOE Administrative Control Level of 2,000 mrem/year (DOE/EH-0256T).
[b] DOE 1997d. The annual doses are averaged over the 5-year period.

❒ **Chemical Environment**—The background chemical environment important to human health consists of the atmosphere, which may contain hazardous chemicals that can be inhaled; drinking water, which may contain hazardous chemicals that can be ingested; and other environmental media with which people may come in contact (e.g., soil through direct contact or via the food pathway). The baseline data for assessing potential health impacts from the chemical environment are those presented in Section 3.3.3 on air quality and Section 3.3.4 on surface and groundwater quality.

Adverse impacts to the public are minimized through administrative and design controls to decrease hazardous chemical releases to the environment and to achieve compliance with permit requirements. The effectiveness of these controls is verified through the use of monitoring information and inspection of mitigation measures. Health impacts to the public may occur during normal operations at Los Alamos National Laboratory via inhalation of air containing hazardous chemicals released to the atmosphere. Risks to public health from ingestion of contaminated drinking water or direct exposure are also potential concerns.

Baseline air emission concentrations for hazardous air pollutants and their applicable standards were presented earlier in Section 3.3.3. These concentrations are estimates of the highest existing offsite concentrations and represent the highest concentrations to which members of the public could be exposed.

Exposure pathways to Los Alamos National Laboratory workers during normal operations may include inhaling air in the workplace atmosphere, drinking water, and possible other contact with hazardous materials associated with work assignments. The potential for health impacts varies from facility to facility and from worker to worker, and available information is not sufficient to allow a numerical estimation and summation of these impacts. However, workers are protected from hazards specific to the workplace through appropriate training, protective equipment, monitoring, and management controls. Los Alamos National Laboratory workers are also protected by adherence to Occupational Safety and Health Administration and EPA occupational standards that limit workplace atmospheric and drinking water concentrations of potentially hazardous chemicals. Appropriate monitoring, which reflects the frequency and amounts of chemicals utilized in the operation processes, ensures that these standards are not exceeded. Additionally, DOE requirements ensure that conditions in the workplace are as free as possible from recognized hazards that cause or are likely to cause illness or physical harm.

❒ **Emergency Preparedness**—Each of DOE's sites have established an emergency management program that would be activated in the event of an accident. These programs have been developed and maintained

to ensure adequate response for most accident conditions. Emergency management programs incorporate activities associated with emergency planning, preparedness, and response. The Los Alamos National Laboratory Emergency Preparedness Plan is designed to minimize or mitigate the impact of any emergency upon the health and safety of employees and the public.

3.3.10 Waste Management

Table 3–25 presents a summary of waste management activities at Los Alamos National Laboratory. DOE cooperates with Federal and State regulatory authorities to address compliance and cleanup obligations arising from its past operation of Los Alamos National Laboratory. Several activities are now conducted to bring its current operations into full regulatory compliance. These activities are set forth in permits and negotiated agreements that contain schedules for achieving compliance with applicable requirements and financial penalties for nonachievement of agreed upon milestones. These agreements have been reviewed to assure the proposed actions are allowable under the terms of these agreements.

Los Alamos National Laboratory is not listed on the National Priorities List. As a function of obtaining a Resource Conservation and Recovery Act permit, however, the Hazardous and Solid Waste Amendments of 1984 mandate that permits include provisions for corrective actions to clean up contamination in areas designated as solid waste management units. By the end of 1995, over 60 of the approximately 2,100 potential release sites identified had been remediated, no further action was proposed for 575 sites, and 1,100 sites were slated for investigation or cleanup; for the remaining sites, action is still pending. Cleanup activities are expected to be completed by 2010 (LANL 1996).

Through its research activities, Los Alamos National Laboratory manages a small quantity of the following five broad waste categories: transuranic waste, low-level, mixed, hazardous, and nonhazardous wastes:

- **Transuranic Waste**—In 1993, Los Alamos National Laboratory generated approximately 54 m^3 (70 yd^3) of transuranic waste (LANL 1994a). The Plutonium Facility (Technical Area 55) is the principal generator of liquid transuranic waste at Los Alamos National Laboratory. Principal sources include process acidic and caustic wastewaters, evaporator distillates from the nitrate recovery area, cooling water from glove boxes, and wet vacuum seal water. Sludges that remain after treatment through filtration and residual evaporator bottoms are loaded into 208-L (55-gal) drums, solidified, and transported to Area G for storage. Liquid wastes remaining after filtration are transferred from Technical Area 55 to the Radioactive Liquid Waste Treatment Facility (Technical Area 50) by gravity drain in double-wall pipelines. After treatment at Technical Area 50 involving sedimentation, clarification, and flocculation, the residual radioactive sludge is loaded into drums, solidified, and transported to Area G for storage. Most of Los Alamos National Laboratory's transuranic waste is currently stored on four asphalt pads. Transuranic wastes are currently being stored, until they can be shipped to the Waste Isolation Pilot Plant (WIPP) if that facility can demonstrate compliance with the requirements of 40 CFR Part 191 and 40 CFR Part 268, or to another transuranic waste disposal facility should WIPP prove unsatisfactory.

Table 3–25 Waste Management Activities at Los Alamos National Laboratory

Category	*1996 Generation (m^3)*	*Treatment Method*	*Treatment Capacity (m^3/yr)*	*Storage Method*	*Storage Capacity (m^3)*	*Disposal Method*	*Disposal Capacity (m^3)*
Transuranic Liquid	None	Pretreatment at TA-50: neutralization, clariflocculation, filtration, precipitate, cement mixing	48,800	N/A	N/A	N/A	N/A
Solid	77	Volume reduction	1,080	Storage pads at TA-54, modified LLW burial pits and shafts	24,355	None: Federal repository in the future	None
Mixed Transuranic Liquid	None	See Transuranic	Included in transuranic	N/A	N/A	N/A	N/A
Solid	4	See transuranic	Included in transuranic	N/A	Included in transuranic	See transuranic	None
Low-Level Waste Liquid	11	Chemical treatment and ion-exchange, solidification; and volume reduction (vial crusher)	45 m^3/hour	Chemical and Ion-Exchange Plant at TA-50 and the Chemical Plant at TA-21	663	Treated effluent is discharged to the environment. Residual sludge is solidified and disposed of at TA-54, Area G, as solid LLW	None
Solid	521	Compaction	76	TA-54 in Area G	Variable	Currently solid LLW goes to TA-54, Area G for burial. Continued construction at Area G under evaluation in sitewide EIS	Estimated available capacity is 25,000 m^3

Category	1996 Generation (m^3)	Treatment Method	Treatment Capacity (m^3/yr)	Storage Method	Storage Capacity (m^3)	Disposal Method	Disposal Capacity (m^3)
Mixed Low-Level Waste Liquid	2	Neutralization, precipitation, oxidation, thermal treatment; solidification; volume reduction; liquid scintillation cocktail vials	Capabilities under development per site treatment plan	RCRA-permitted buildings (not built yet) and interim status container storage areas	583	N/A	None
Solid	5	None	Capabilities under development per site treatment plan	RCRA-permitted Bldgs. (not built yet) and interim status container storage areas	583	Capabilities under development as per Site Treatment Plan for Mixed Wastes	None
Hazardous Waste Liquid	None	Thermal treatment, treatment tanks, neutralization, precipitation, and evaporation	Varies depending on the waste stream	Thermal treatment TAs-14,-15,-16,-36, and -39 and storage and treatment TA-54, Area L	1,864	Offsite	N/A
Solid	89 (tonnes)	Thermal treatment and flashpad	Varies depending on the waste stream	See above	See above	Offsite	N/A
Nonhazardous (Sanitary) Liquid	None	Filtration, settling, and stripping	1,060,063	N/A	N/A	Permitted discharge sanitary tile fields	2,271 m^3/day
Solid	2,057 (tonnes)	None	None	N/A	N/A	Offsite county landfill and onsite landfill Area J	N/A

TA = Technical Area N/A = not applicable LLW = low-level waste RCRA = Resource Conservation and Recovery Act
Source: Adapted from DOE 1996a DOE 1997a and DOE 1997d.

Should additional treatment be necessary for disposal at WIPP, Los Alamos National Laboratory would develop the appropriate treatment to meet WIPP waste acceptance criteria and package the wastes in accordance with DOE, Nuclear Regulatory Commission, and U.S. Department of Transportation requirements for transport to WIPP for disposal. Los Alamos National Laboratory is presently upgrading transuranic waste storage facilities to comply with Resource Conservation and Recovery Act requirements under the terms of a consent order with the State of New Mexico.

Los Alamos National Laboratory generates mixed transuranic wastes. Newly generated mixed transuranic wastes are identified, characterized, and stored in compliance with the Resource Conservation and Recovery Act. In 1993, Los Alamos National Laboratory generated approximately 255 m^3 (334 yd^3) of mixed transuranic wastes. The Federal Facility Compliance Act of 1992 requires DOE to provide specific information to the EPA and the State of New Mexico on Los Alamos National Laboratory's mixed transuranic waste streams, treatment facilities, and technology development activities. This waste category covers a broad range of physical matrix categories for Los Alamos National Laboratory. The Federal Facility Compliance Order for the Site Treatment Plan requires treatment of all mixed wastes not in compliance with the land disposal provisions of the Resource Conservation and Recovery Act. This compliance order is the implementation of the Federal Facility Compliance Act at Los Alamos National Laboratory. WIPP waste acceptance criteria specifies limiting parameters for waste containers, waste form, waste packaging, accompanying data, and miscellaneous packaging and Resource Conservation and Recovery Act requirements. It is anticipated that some technology required for additional treatment of transuranic waste to attain additional treatment standards can be adapted from the technologies that must be brought online for mixed low-level waste. If DOE is successful in obtaining a no-migration petition for the disposal of mixed transuranic wastes at WIPP, adherence with treatment standards under the land disposal restrictions would not be required.

- **Low-Level Waste**—Both liquid and solid low-level waste are generated and managed by Los Alamos National Laboratory. In 1993, Los Alamos National Laboratory generated approximately 21,400 m^3 (5,653,000 gal) of liquid and 2,693 m^3 (3,523 yd^3) of solid low-level waste. Liquid low-level waste is generated from many areas throughout Los Alamos National Laboratory: there are two wastewater treatment facilities used for treatment of aqueous low-level waste, one of which utilizes ion-exchange technology. As part of a new radioactive liquid waste treatment facility project, a facility for the solidification and subsequent volume reduction of the radioactive liquid waste treatment plant sludge containing plutonium, americium, and other radionuclides is proposed but not funded at Los Alamos National Laboratory.

  Solid low-level waste is generated from many areas throughout Los Alamos National Laboratory. Solid low-level waste such as paper, plastic, glassware, and rags are separated into compactible and noncompactible materials by the waste generators. Compactible bales are banded, wrapped and sealed in plastic and moved to Area G for disposal in landfill pits located at Technical Area 54 (Figure 3-16). Low-level waste noncompactible items, such as large equipment and much of the decontamination and decommissioning waste, generally are not packaged but delivered to the burial site in covered or enclosed vehicles. Continued construction at Area G is dependent on decisions made in conjunction with the Los Alamos National Laboratory site-wide EIS being prepared by Los Alamos National Laboratory.

- **Mixed Low-Level Waste**—In 1993, Los Alamos National Laboratory generated approximately 45 m^3 (59 yd^3) of mixed low-level waste (LANL 1994b). Mixed low-level waste includes solvents, pyrophoric substances, spray cans, scintillation vials, uranium-contaminated lithium hydride, miscellaneous reagent chemicals, vacuum pump oil contaminated with mercury, gas cylinders, and other contaminated material. It is stored at Technical Area-54 Areas L and G. Currently, Los Alamos National Laboratory does not dispose of mixed low-level waste. In accordance with the Federal Facility Compliance Act of 1992, Los Alamos National Laboratory has developed a site treatment plan which covers management of all mixed

waste at Los Alamos National Laboratory. The State of New Mexico Environment Department issued a Compliance Order in the Site Treatment Plan for Mixed Waste in October 1995. The compliance order addresses land disposal restricted mixed waste. For mixed waste with identified treatment technologies, the plan provides a schedule for submitting permit applications, entering into contracts, initiating construction, conducting systems testing, starting operations, and processing mixed wastes. For mixed waste without an identified treatment technology, the plan includes a schedule for identifying and developing technologies, identifying the funding requirements for research and development, submitting treatability study notifications, and submitting research and development permit applications.

Mixed waste treatment skids are being designed to treat onsite hazardous and mixed waste streams that are not amenable to offsite treatment. Examples of the waste streams potentially amenable to skid treatment are reactive metals, plating wastes, acids, bases, ignitable liquids, spent solvents, and decontamination debris. Not all of the technologies to be included have been chosen. The mixed waste treatment skids would be housed in an existing Los Alamos National Laboratory structure. An environmental restoration high-energy plasma technology is being tested as a technique for total destruction of mixed low-level waste that has been treated to land disposal restrictions standards. This technique will allow Los Alamos National Laboratory to stay in compliance with the Federal Facility Compliance Act of 1992.

- **Hazardous Waste**—Los Alamos National Laboratory received a permit for treatment, storage, and disposal of hazardous waste under the Resource Conservation and Recovery Act in November 1989 and for the Hazardous and Solid Waste Amendments of 1984 provisions from the EPA on March 8, 1990. All hazardous waste treatment and storage facilities at Los Alamos National Laboratory are either fully permitted or are operating under interim status, while other waste management facilities are being developed.

  Los Alamos National Laboratory produces a wide variety of hazardous wastes. In 1993, Los Alamos National Laboratory generated approximately 84 metric tons (93 tons) of Resource Conservation and Recovery Act-regulated, 460 metric tons (507 tons) of State-regulated, and 124 metric tons (137 tons) of solid hazardous wastes (LANL 1994b). Small volumes of almost all wastes listed under 40 CFR Part 261 are generated as a result of a wide variety of ongoing research. High explosive waste is generated during the processing and testing of various high explosive materials. All high explosive hazardous waste and potentially contaminated high explosive waste is picked up from the generating facility and treated by open detonation, open burning, or incineration at Technical Areas 14, 15, 16, 36, and 39. Ash residue is then treated and, when its hazardous characteristic can be removed and it is determined that this residue does not contain radioactive constituents, it is disposed of onsite in the landfill, Technical Area 54, Area J. The high explosive wastewater is treated by gravity settlement in a sump and discharged from outfalls permitted under the National Pollutant Discharge Elimination System. Los Alamos National Laboratory is developing a high explosive wastewater treatment facility that will collect and treat these wastewaters with stepped filtration.

  Los Alamos National Laboratory does not landfill Resource Conservation and Recovery Act hazardous waste onsite, but contracts with certified transporters to deliver hazardous waste to commercial offsite Resource Conservation and Recovery Act-permitted treatment, storage, and disposal facilities. Before waste is sent offsite, the potential treatment or disposal facility is inspected by Los Alamos National Laboratory personnel. Operating records and permits are also reviewed. Los Alamos National Laboratory has an EPA Letter of Authorization allowing disposal of solid polychlorinated biphenyl-contaminated articles at the Technical Area 54, Area G landfill. Other polychlorinated biphenyl waste and liquid polychlorinated biphenyl-contaminated articles are sent offsite to Toxic Substances Control Act-regulated disposal facilities. Asbestos mixed waste is buried at Technical Area 54, Area G. Asbestos waste is shipped offsite to an approved disposal site in accordance with Toxic Substances Control Act and National

Emission Standards for Hazardous Air Pollutants regulations. Infectious wastes are managed according to State of New Mexico regulations.

- **Nonhazardous Waste**—In 1993, Los Alamos National Laboratory generated 8,180 metric tons (9,017 tons) of solid sanitary wastes. Solid sanitary wastes are generated routinely and include general facility refuse such as paper, cardboard, glass, wood, plastic, scrap, metal containers, dirt, and rubble. Solid sanitary wastes are segregated and recycled whenever possible. Trash is accumulated onsite in dumpsters, which are emptied on a regular basis by a commercial waste disposal firm and taken to the county sanitary landfill. The Los Alamos County landfill is located on property owned by DOE and is operated under a special-use permit. Approximately one-third of the solid sanitary waste disposed of at the county landfill originates from Los Alamos National Laboratory. The Area J special waste landfill, which is operated by and under the administrative control of Los Alamos National Laboratory, receives only administratively controlled solid sanitary waste. Solid sanitary waste will be managed and disposed of at the Los Alamos County Landfill until about the year 2012, when it is estimated that the existing sanitary landfill may reach the end of its useful life. At that time, either a new landfill will have to be constructed or provisions made for offsite disposal.

  Los Alamos National Laboratory generates approximately 693,000 m^3 (183,000,000 gal) of liquid sanitary waste (DOE 1993c). A new sanitary wastewater treatment plant and collection system to replace 7 existing wastewater treatment facilities and 30 existing septic tanks have been completed. The new treatment plant enables reuse of the treated wastewater for nondrinking water uses such as cooling and irrigation. The plant and collection system is designed to meet the requirements of Los Alamos National Laboratory's existing Federal Facility Compliance Agreement and is expected to meet all of Los Alamos National Laboratory's needs for the next 20 years.

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Chapter 4

Environmental Consequences

4. ENVIRONMENTAL CONSEQUENCES

4.1 OVERVIEW OF ENVIRONMENTAL IMPACTS

4.1.1 Presentation of the Environmental Impacts

Fifteen categories and subcategories of plutonium residues and scrub alloy are analyzed in this Environmental Impact Statement (EIS), and the material in each can be processed with various technologies. The use of some of the processing technologies would require transporting residues from the Rocky Flats Environmental Technology Site (Rocky Flats) to another U.S. Department of Energy (DOE) site. Combinations of material category or subcategory and processing option as described in Chapter 2 are analyzed. For each combination of material category or subcategory and processing option, DOE generated a set of impacts, including the amounts of products and wastes, radiological health and safety impacts, and hazardous chemical impacts.

In this EIS, each processing option for each material category or subcategory was analyzed independently. Therefore, each set of impacts can be compared to other sets of impacts within the same material category. This analytical approach allows decision makers and the public to understand the impacts of each processing option for each category and subcategory independently. The impacts of each processing option for the 15 material categories and subcategories are presented and compared to each other in Sections 4.2 through 4.11.

The first processing option listed under each material category in Sections 4.2 through 4.11 is the no action processing option. To calculate the total impacts of processing all the plutonium residues and scrub alloy under the No Action Alternative, DOE summed the impacts that would result from all the no action processing options. The total environmental impacts of the No Action Alternative are presented in Section 4.20.

The Preferred Management Approach is a set of specific processing options for every material category. To calculate the total impacts of processing all the plutonium residues and scrub alloy under the Preferred Management Approach, DOE summed the impacts that would result from all the preferred processing options. For those residue types which DOE has not identified a preferred processing option, the impacts are shown as ranges. The total environmental impacts of the Preferred Management Approach are presented in Section 4.21.

The No Action Alternative and Preferred Management Approach are only two of the strategic management approaches. The environmental impacts of eight strategic management approaches are compared to each other in Section 4.22.

In addition, DOE has summed the lowest and highest potential impacts at each site from the processing options to obtain the range of potential impacts at each site. These impacts are presented in Section 4.23. Similarly, transportation from Rocky Flats to other sites for processing would generate impacts, and the range of these impacts is presented in Section 4.24. Cumulative impacts are discussed in Section 4.25.

The focus of the impacts is on the public and occupational health and safety associated with the various plutonium residue and scrub alloy management activities. The impacts associated with incident-free operation and during postulated accidents are presented and discussed in this chapter. Supplemental information and supporting data are given in Appendices B through F. Additional impacts and topics covered in Chapter 4 include the following:

- Air Quality
- Water Quality
- Post-processing Transportation
- Disposal/Disposition Activities
- Environmental Justice
- Costs
- Socioeconomics
- Materials, Utilities, and Energy
- Cumulative Impacts
- Short-term versus Long-term Resource Commitments
- Irreversible and Irretrievable Resource Commitments.

Several kinds of impacts are not discussed in Chapter 4 because they will not occur, they will be extremely small, and/or they are covered by other analyses:

❒ **Proliferation Risk**—As discussed in Chapter 1, any plutonium separated from the residues or scrub alloy would be stored pending disposition in compliance with decisions to be made after completion of the Surplus Plutonium Disposition EIS (DOE 1997e). In accordance with existing DOE policy, this plutonium would not be used for nuclear explosive purposes (DOE 1994e). No increase in proliferation risk would occur as a result of these actions.

❒ **Land**—The management of plutonium residues and scrub alloy would not require the construction of new facilities at Rocky Flats, the Savannah River Site, or Los Alamos National Laboratory, so no impacts on land resources would be expected at these sites. In the event of a major accident, some radioactive material could be deposited on the land downwind of the accident site. Analysis of this impact is covered in site-specific and facility-specific environmental and safety documentation.

❒ **Intrasite Transportation**—The incident-free impacts of intrasite transportation are limited to radiation exposure to workers loading and unloading trucks and are included in the overall worker dose values presented for each process. The accident risks are bounded by the site accident risk analysis. Strict site safety procedures and short travel distances limit the impacts to workers.

❒ **Noise**—Noise impacts at the proposed sites should be minor and limited to noises generated during operations because new facility construction would not be required. No offsite noise impacts are expected for this same reason.

❒ **Ecological Resources**—Because no new construction would be required for DOE's management of plutonium residues and scrub alloy, there would be no clearing of vegetation. Thus, there would be no negative impacts from construction on terrestrial or aquatic plants or animals.

Scientific evidence indicates that chronic radiation doses below 0.1 rad per day do not harm animal or plant populations (IAEA 1992). This is equivalent to 100 mrem per day for direct radiation and about 2,000 mrem per day for ingestion of plutonium. Compliance with DOE Order 5400.5 to limit the exposure of the most exposed member of the public to 100 mrem per year (i.e., about 0.3 mrem per day) makes it highly probable that dose rates to plants and animals in the same area would be less than 0.1 rad per day. Therefore, no radiological damage to plant and animal populations would be expected as the result of the plutonium residue and scrub alloy management activities.

Chemicals emitted to the environment during routine processing activities are listed in Table D-151 for Rocky Flats and Table D-153 for Savannah River. In addition, Tables D-152 and D-154 provide the rates

for such emissions, and Table 4-53 contains modeled onsite air concentrations for some of the chemicals emitted. Most of these chemicals should not impact plants or animals because either the amounts emitted are very low or the chemicals have little potential for causing negative effects. However, at high enough concentrations the strong acids (e.g., nitric acid, hydrochloric acid), carbon tetrachloride, volatile organic compounds, and the gaseous fluorides have the potential to cause negative impacts in certain environments (e.g., water bodies).

Consultation with the U.S. Fish and Wildlife Service has been initiated to comply with Section 7 of the Endangered Species Act. Before the final EIS is issued, DOE will seek concurrence from the U.S. Fish and Wildlife Service of the preliminary conclusion that management of residues and scrub alloy would not affect endangered, threatened, proposed, or candidate species or proposed or designated critical habitats. Consultation letters and any other documents prepared to comply with Section 7 will be included in an appendix to the final EIS.

Thus, for the reasons discussed above, no adverse impacts to ecological resources would be expected to occur due to DOE's management of plutonium residues and scrub alloy.

- **Cultural and Paleontological Resources**—No cultural or paleontological resources would be disturbed because new facility construction would not be required at any of the proposed sites.

4.1.2 Products and Wastes

- **Generation**—All the processing options in this EIS would change plutonium residues or scrub alloy into other forms. Plutonium residues and scrub alloy are the input—products and wastes are the outputs. The products and wastes are better suited for storage, transportation, and disposal or other disposition than the existing plutonium residues and scrub alloy. The products and wastes fall into several distinct categories:

  - **Stabilized residues** would be generated from the no action processing options. As the term is used in this EIS, stabilized residues contain plutonium concentrations in excess of the safeguards termination limits. Thus, stabilized residues are not acceptable for disposal at the Waste Isolation Pilot Plant (WIPP) unless a variance from the safeguards termination limits can be obtained. DOE has already approved a variance for several specific stabilized residues containing very low concentrations of plutonium. These stabilized residues will be acceptable for disposal in WIPP.

  - **Transuranic waste** would be generated from all plutonium residues and scrub alloy under all the processing options. This waste would be disposed of in WIPP.

  - **High-level waste** would be generated only at the Savannah River Site. The final form would be solid glass inside stainless steel canisters. This waste would be stored at the Savannah River Site until a geologic repository is ready to receive it.

  - **Separated plutonium** from the residues and/or scrub alloy would be in either a metal or oxide form. The separated plutonium would be stored in secure facilities along with the much larger quantities of plutonium already in storage until decisions can be made about its disposition.

  - **Low-level waste** would be generated from all plutonium residues and scrub alloy under all the processing options. This waste would be disposed of in existing facilities using routine procedures.

  - **Saltstone** would be generated only at the Savannah River Site. Saltstone is a form of concrete containing low levels of radioactivity and would be disposed of onsite.

- **Waste Minimization**—DOE would incorporate the best available practices into all the processing options at all three sites in order to generate the smallest possible amounts of wastes, and to comply with DOE's waste minimization and pollution prevention goals.

  In 1996, Rocky Flats, through its commitment to waste minimization, was able to reduce waste generation by an estimated total of 980 cubic meters (34,600 cubic feet) at an estimated cost savings of $66,000. Rocky Flats reduced radioactive waste generation in 1996 by 10 percent compared to 1993 baseline levels, whereas, mixed waste generation was reduced by 90 percent and hazardous waste generation was reduced by 32 percent. Eight percent of sanitary waste was recycled in 1996, and 74 percent of the materials purchased under the affirmative procurement process were U.S. Environmental Protection Agency- (EPA-) designated recycled products (DOE 1997b).

  The Savannah River Site conducted pollution prevention projects in 1996 that reduced waste generation by an estimated 8,400 cubic meters (296,600 cubic feet) at a cost savings of $17.4 million. Radioactive waste generation in 1996 was reduced by 63 percent compared to 1993 baseline levels. Hazardous waste generation was reduced by 12 percent, and sanitary waste generation was reduced by 58 percent compared to baseline levels. Thirty-one percent of sanitary waste was recycled in 1996, and 36 percent of the materials purchased under the affirmative procurement process were EPA-designated recycled products (DOE 1997b).

  In 1996, the Los Alamos National Laboratory conducted pollution prevention projects that reduced radioactive waste generation by 70 percent compared to 1993 baseline levels. Mixed waste generation was reduced by 42 percent, hazardous waste generation was reduced by 71 percent, and sanitary waste was reduced by 26 percent over baseline levels (SAIC 1997a).

4.1.3 General Radiological and Chemical Health Consequences

The methodologies used to evaluate potential radiological and chemical health effects are described in Appendix D. This section provides information about the development and interpretation of the health risk estimates.

- **Radiological**—The effect of radiation on people depends upon the kind of radiation exposure (alpha, beta, and neutron particles and gamma and x-rays) and the total amount of tissue exposed to radiation. The amount of radiant energy imparted to tissue from exposure to ionizing radiation is referred to as absorbed dose. The sum of the absorbed dose to each tissue, when multiplied by certain quality and weighting factors that take into account radiation quality and different sensitivities of these various tissues, is referred to as effective dose equivalent.

  An individual may be exposed to radiation from outside the body, or from inside the body because radioactive materials may enter the body by ingestion or inhalation. External dose is different from internal dose in that it is delivered only during the actual time of exposure. An internal dose, however, continues to be delivered as long as the radioactive source is in the body (although both radioactive decay and elimination of the radionuclide by ordinary metabolic processes decrease the dose rate with the passage of time). The dose from internal exposure is calculated over 50 years following the initial exposure.

  The regulatory annual radiation dose limits to the maximally exposed member of the public from total operations at a DOE site are 10 mrem from atmospheric pathways, 4 mrem from the drinking water pathway, and 100 mrem from all pathways combined (DOE Order 5400.5 and 40 Code of Federal Regulations (CFR) Part 61, Subpart H). The potential doses associated with the normal processing and storage of plutonium residues and scrub alloy are very small factions of these values, and total site doses will remain well within these DOE limits. For comparison, it is estimated that the average individual in

the United States receives a dose of approximately 350 mrem per year from all radiation sources combined, including natural and medical sources.

The maximally exposed individual worker doses listed in this chapter assume that an individual worker receives the maximum annual dose allowed under current DOE regulations and guidance, instead of being based on the total amount of residue in this category. Maximally exposed individual worker doses will be kept below the DOE Standard of 5,000 mrem per year (10 CFR Part 835). Furthermore, as low as reasonably achievable principles will be exercised to maintain individual worker doses below the DOE Administrative Control Level of 2,000 mrem per year (DOE 1994a). Each DOE site also maintains its own Administrative Control Level; for the sake of consistency, however, DOE used the 2,000 mrem per year level throughout this EIS. Transportation workers (i.e., drivers) will be held to an annual limit of 100 mrem per year because they are not certified radiation workers. All worker doses are routinely monitored; if any individual worker's dose approaches the annual limit, he or she would be rotated into another job.

The collective or "population" dose to an exposed population is calculated by summing the estimated doses received by each member of the exposed population. The total population dose received by the exposed population is measured in person-rem. For example, if 1,000 people each received a dose of 0.001 rem, the population dose would be 1.0 person-rem (1,000 persons × 0.001 rem = 1.0 person-rem). The same population dose (1.0 person-rem) would result if 500 people each received a dose of 0.002 rem (500 persons × 0.002 rem = 1 person-rem).

Radiation can cause a variety of adverse health effects in people. A large dose of radiation can cause prompt death. At low doses of radiation, the most important adverse health effect for depicting the consequences of environmental and occupational radiation exposures (which are typically low doses) is the potential inducement of cancers that may lead to death in later years. This effect is referred to as latent cancer fatalities because the cancer may take years to develop and for death to occur.

In addition to latent cancer fatalities, other health effects could result from environmental and occupational exposures to radiation. These effects include nonfatal cancers among the exposed population and genetic effects in subsequent generations. **Table 4–1** shows the dose-to-effect factors for these potential effects as well as for latent cancer fatalities. For simplicity, this EIS presents estimated effects of radiation only in terms of latent cancer fatalities. Nonfatal cancers and genetic effects are less probable consequences of radiation exposure.

Table 4–1 Risk of Latent Cancer Fatalities and Other Health Effects from Exposure to One Rem of Radiation [a]

Population [b]	*Latent Cancer Fatalities*	*Nonfatal Cancers*	*Genetic Effects*	*Total Detriment*
Workers	0.0004	0.00008	0.00008	0.00056
Public	0.0005	0.0001	0.00013	0.00073

[a] When applied to an individual, units are lifetime probability of latent cancer fatalities per rem of radiation dose. When applied to a population of individuals, units are excess number of cancers per person-rem of radiation dose. Genetic effects as used here apply to populations, not individuals.

[b] The difference between the worker risk and the general public risk is attributable to the fact that the general population includes more individuals in the more sensitive age group of less than 18 years of age.

The factors used in this EIS to relate a dose to its effect is 0.0004 latent cancer fatalities per person-rem for workers and 0.0005 latent cancer fatalities per person-rem for individuals among the general population (DOE 1995c). The latter factor is slightly higher because some individuals in the public, such as infants and children, are more sensitive to radiation than workers. These factors are based on the *1990 Recommendations of the International Commission on Radiological Protection* (ICRP 1991), and are consistent with those used by the U.S. Nuclear Regulatory Commission in its rulemaking *Standards for*

Protection Against Radiation (NRC 1991). The factors apply where the dose to an individual is less than 20 rem and the dose rate is less than 10 rem per hour. At higher doses and dose rates, the factors used to relate radiation doses to latent cancer fatalities are doubled. At much higher doses, prompt effects, rather than latent cancer fatalities, may be the primary concern.

These concepts may be applied to estimate the effects of exposing a population to radiation. For example, if 100,000 people were each exposed only to natural background radiation (0.3 rem per year), 15 latent cancer fatalities per year would be expected (100,000 persons × 0.3 rem per year × 0.0005 latent cancer fatalities per person-rem = 15 latent cancer fatalities per year).

Sometimes, calculations of the number of latent cancer fatalities associated with radiation exposure do not yield whole numbers and, especially in environmental applications, may yield numbers less than 1.0. For example, if 100,000 people were each exposed to a total dose of only 1 mrem (0.001 rem), the population dose would be 100 person-rem, and the corresponding estimated number of latent cancer fatalities would be 0.05 (100,000 persons × 0.001 rem × 0.0005 latent cancer fatalities per person-rem = 0.05 latent cancer fatalities).

The *average* number of deaths that would result if the same exposure situation were applied to many different groups of 100,000 people is 0.05. In most groups, nobody (zero people) would incur a latent fatal cancer from the one mrem dose each member would have received. In a small fraction of the groups, one latent fatal cancer would result; in exceptionally few groups, two or more latent fatal cancers would occur. The average number of deaths over all the groups would be 0.05 latent fatal cancers (just as the average of 0,0,0, and 1 is 1/4, or 0.25). The most likely outcome is zero latent cancer fatalities.

These same concepts apply to estimating the effects of radiation exposure on a single individual. Consider the effects, for example, of exposure to natural background radiation over a lifetime. The "number of latent cancer fatalities" corresponding to a single individual's exposure to 0.3 rem per year over a (presumed) 72-year lifetime is:

1 person × 0.3 rem per year × 72 years × 0.0005 latent cancer fatalities per person-rem = 0.011 latent cancer fatalities or slightly more than one chance in 100 of a latent cancer fatality.

Again, this should be interpreted in a statistical sense; that is, the estimated effect of natural background radiation exposure on the exposed individual would produce a 1.1 percent chance that the individual would incur a latent fatal cancer. Alternatively, this method estimates that about 1 person in 91 would die of cancers induced by natural background radiation.

The estimates of health effects from radiation doses used in this EIS are based on the linear no-threshold theory of radiation carcinogenesis, which postulates that all radiation doses, even those close to zero, are harmful. A recent examination of low radiation studies has reported that no statistically significant low-dose radiation study was found to support the linear no-threshold theory (Polycove 1997). This finding is supported by the National Council of Radiation Protection and Measurements in a report on collective dose that states ". . . essentially no human data can be said to prove or even to provide direct support for the concept of collective dose with its implicit uncertainties of nonthreshold, linearity and dose-rate independence with respect to risk" (NCRP 1995). Accordingly, calculations of health impacts based on the linear no-threshold theory may overstate the actual impacts of low radiation doses and should be viewed as an upper bound on the potential health effects.

- **Chemical**—The potential impacts of exposure to hazardous chemicals released to the atmosphere as a result of the processing of plutonium residues and scrub alloy were evaluated for the incident-free operation of processing facilities at Rocky Flats and at the Savannah River Site. No hazardous chemicals are

expected to be released from the proposed processing at Los Alamos National Laboratory. The receptors considered in these evaluations include the offsite population in the vicinity of the sites and noninvolved workers located onsite at Rocky Flats and the Savannah River Site. Impacts were also evaluated for the maximally exposed individual member of the offsite and worker populations. The health effect endpoints evaluated in this analysis include excess incidences of latent cancers and a spectrum of chemical-specific noncancer health effects. The maximally exposed individual is located in the region with the highest estimated concentration. At Rocky Flats, the maximum concentration for the noninvolved worker is estimated to occur at a distance of 170 meters (m) (560 feet [ft]) south-southeast of Building 371. The maximum modeled offsite concentration occurred on the facility boundary 1.6 kilometers (km) (1.0 mile [mi]) northwest of the stack location. At the Savannah River Site, the maximum modeled onsite concentration occurred at a distance of 820 m (2,690 ft) west-southwest of the stack location. The maximum modeled offsite concentration occurred just outside the site boundary, at a distance of 10 km (6.2 mi) west-southwest of the stack location (SAIC 1997c).

Appendix D, Section D.4 describes the methods, assumptions, and source terms used in evaluating the health impacts of exposures to hazardous chemicals. Of the parameters used in the intake algorithm presented in Appendix D, the values for contaminant concentrations in air (in milligrams per cubic meters [mg/m^3]) were estimated by the ISC3 model and exposure duration values (years) were estimated by the sites as part of the process source terms. The averaging time (period over which exposure is averaged) values were 70 years for carcinogens and 6.6 years and 9 years for exposure of workers and the offsite public, respectively, to noncarcinogens. The following standard exposure assessment values (EPA 1989a) were used for the other parameters:

Parameter	*Worker Exposure*	*Offsite Population Exposure*
IR (inhalation rate)	1.25 m^3/hour	0.83 m^3/hour
ET (exposure time)	8 hours/day	24 hours/day
EF (exposure frequency)	260 days/year	365 days/year
BW (body weight)	70 kg (154 lb)	70 kg (154 lb)

Not all of the chemicals potentially released from the proposed action processing at Rocky Flats and the Savannah River Site that are listed in Appendix D were used to estimate health risks. Some of the chemicals are inert (e.g., argon) and some are innocuous in ambient air (e.g., calcium, calcium oxide, water vapor, and carbon dioxide). The toxicity of some of the chemicals is not well characterized (e.g., tributyl phosphate and n-dodecane), and some are addressed as air pollutants in Section 4.12 (e.g., volatile organic compounds, NO_x). Of the chemicals potentially released in the processing of plutonium residues and scrub alloy, only the following hazardous chemicals have Reference Concentration (RfC) values or cancer inhalation unit risk factors available in EPA's Integrated Risk Information System (EPA 1989b, 1991a, 1991b, 1995a, 1995b):

Chemical	*Cancer Inhalation Unit Risk Factor*	*Reference Concentration*	*Reference Dose*
Carbon tetrachloride	0.000015 per $\mu g/m^3$	Not available	0.0007 mg/kg-day
Hydrochloric acid	Not available	0.02 mg/m^3	0.0057 mg/kg-day
Phosphoric acid	Not available	0.01 mg/m^3	0.0029 mg/kg-day
Ammonium nitrate (as ammonia)	Not available	0.1 mg/m^3	0.029 mg/kg-day
Hydrogen fluoride/ calcium fluoride (as soluble fluoride)	Not available	Not available	0.06 mg/kg-day

The potential health risks resulting from exposure to hazardous chemicals released as a result of accidents at processing facilities were not quantitatively evaluated for any of the processing options considered in this EIS. The impacts of chemical exposures from relevant facility accidents at Building 371 at Rocky Flats and at the F- and H-Area separation facilities of the Savannah River Site have been evaluated in other investigations, such as the *Rocky Flats Cumulative Impacts Document* (DOE 1997a), *the Rocky Flats Environmental Technology Site, Basis for Interim Operation, Building 371/374 Complex* (KHC 1997) and the Savannah River Site *Final Environmental Impact Statement, Interim Management of Nuclear Materials* (DOE 1995b). These investigations concluded that the consequences for the most exposed member of the offsite population and onsite noninvolved workers would be low and could be mitigated by emergency response actions. Workers involved in the facility processes may experience serious injury or fatalities as a result of their proximity to the release sources. The impacts of chemical releases as a result of accidents at the proposed plutonium residue and scrub alloy processing facilities at Building 371 at Rocky Flats and the F-Area at Savannah River Site are addressed and estimated in these other investigations. Because chemical inventories for the H-Area separation facilities of the Savannah River Site are similar to those estimated for the F-Area, potential impacts also are expected to be similar.

At the Los Alamos National Laboratory, no hazardous chemicals would be used in the distillation of pyrochemical salts, and only relatively small amounts of hydrochloric acid would be used in the water leach processing of direct oxide reduction pyrochemical salts. Therefore, the potential impacts of hazardous chemical exposures from facility accidents at this site were not quantitatively evaluated in this EIS.

4.1.4 Risks

Another concept important to the presentation of results in this EIS is the concept of risk. Risks are most important when presenting accident analysis results. The chance that an accident might occur during the conduct of an operation is called the probability of occurrence. An event that is certain to occur has a probability of 1.0 (as in a 100 percent certainty). If an accident is expected to happen once every 50 years, the frequency of occurrence is 0.02 per year (1 occurrence every 50 years = 0.02 occurrences per year). A frequency estimate can be converted to a probability statement. If the frequency of an accident is 0.02 per year, the probability of the accident occurring in a 10-year program is 0.2 (10 years × 0.02 occurrences per year).

Once the frequency (occurrences per year) and the consequences (for radiation effects, measured in terms of the number of latent cancer fatalities caused by the radiation exposure) of an accident are known, the risk can be determined. The risk per year is the product of the annual frequency of occurrence times the number of latent cancer fatalities. This annual risk expresses the expected number of latent cancer fatalities per year, taking account of both the annual chance that an accident might occur and the estimated consequence if it does occur.

For example, if the frequency of an accident were 0.2 occurrences per year and the number of latent cancer fatalities resulting from the accident were 0.05, the risk would be 0.01 latent cancer fatalities per year (0.2 occurrences per year × 0.05 latent cancer fatalities per occurrence = 0.01 latent cancer fatalities per year). Another way to express this risk (0.01 latent cancer fatalities per year) is to note that if the operation subject to the accident continued for 100 years, one latent cancer fatality would be likely to occur because of accidents during that period. This is equivalent to 1 chance in 100 that a single latent cancer fatality would be caused by the accident source for each year of operation. This risk can be related to the risk of death from other accidental causes for comparison. As an example, the risk of dying from a motor vehicle accident is about 1 chance in 80. Similarly, the risk of death for the average American from fire is approximately 1 chance in 500, and from death from accidental poisoning, the risk is about 1 chance in 1,000 (NNPP 1993).

The accident risks presented in this EIS do not always agree with the accident risks presented in site-specific safety documentation (e.g., Los Alamos National Laboratory Safety Analysis Reports, Rocky Flats Cumulative Impacts Document, etc.). The differences in the results may be attributed to differences in one or more of the following:

- Computer codes used for analysis
- Analysis data bases (e.g., population, weather, agriculture, etc.)
- Accident scenarios
- Analysis ground rules and assumptions
- Materials at risk
- Source terms released to the environment
- Source term isotopic breakdowns
- Accident frequencies
- Process durations.

4.1.5 Comparison of Health and Safety Risks with Common Risks to the Public

This section compares the increased risks to the public associated with the management of plutonium residues and scrub alloy to those of common activities, such as smoking, flying, receiving a medical x-ray, and so forth.

❒ **Risks in this EIS**—Succeeding sections in Chapter 4 evaluate the risks from radiological and nonradiological incident-free operations and accidents for all materials and processing options.

The highest increase in the incident-free population risk to the general public living near any of the DOE management sites involved in these alternatives would be 0.00019 latent cancer fatalities, as shown in Table 4–76 in Section 4.23. This risk occurs at the Savannah River Site.

The highest increase in the accident population risk to the general public living near any of the DOE management sites would be 0.50 latent cancer fatalities, as shown in Table 4–74 in Section 4.23. This risk occurs at the Rocky Flats site.

The highest increase in the population risk to the general public along the transportation routes due to radiation exposure during ground transport would be 0.011 latent cancer fatalities (Table 4–82 in Section 4.24), if the maximum number of shipments is assumed (208 from Rocky Flats to the Savannah River Site).

Nonradiological fatalities are also unlikely. The highest increases in the risk of nonradiological fatalities to the public is through a traffic accident involving a truck transporting plutonium residues or scrub alloy. Assuming the same number of shipments (208 to the Savannah River Site), the increase in the population risk to the general public along the transportation routes would be 0.021 fatalities (Table 4–83 in Section 4.24).

❒ **Common Radiological Risks—Table 4–2** presents several typical sources of exposure to radiation from everyday life (DOE 1993b). The average person in the United States receives about 300 mrem each year from natural sources of radiation and about another 50 mrem from manmade sources of radiation. The largest dose listed in Table 4–2 is the 200 mrem per year from exposure to naturally-occurring radon gas. This is much higher than the dose any member of the general public would receive as the result of activities associated with the management of plutonium residues and scrub alloy.

Table 4–2 Typical Sources of Radiation, Average Individual Exposures, and Average Individual Risks

Source	Dose Rate (mrem/yr)	Risk (Latent Cancer Fatalities/yr)
Radon	200	0.0001
Internal	39	0.000020
Diagnostic x-rays	39	0.000020
Soil, rocks	28	0.000014
Cosmic rays	27	0.000014
Nuclear medicine	14	0.000007
Nuclear fuel cycle	less than 1	less than 5×10^{-7}
Fallout	less than 0.01	less than 5×10^{-9}

There are also large variations in radiation dose to which people are routinely exposed. For example, people who live at high altitudes receive more radiation dose than people who live at sea level. People who live or work in brick, granite, or marble buildings receive more radiation dose than people who live or work in wooden structures. People who live in well-insulated houses receive more radiation dose from trapped radon gas than people who live in well-ventilated houses. Taking all the various factors into account, the annual U.S. dose from background radiation can easily range from 100 mrem for people who live in well-ventilated wooden houses on sandy soil at sea level to about 1,000 mrem for people who live in well-insulated houses in the Denver area (de Planque 1994). Thus, in addition to the average annual radiation dose, routine variations in annual radiation dose are also much larger than the dose any member of the general public would be likely to receive under any of the alternatives.

- **Risks from Common Activities**—Every activity carries some risk. **Table 4–3** shows activities estimated to increase an individual's chance of death in any year by one in one million (Slovic 1986). Most of these voluntary activities would not be considered unusually risky actions, and they can be compared to the risks presented in this chapter for perspective.

Table 4–3 Risks Estimated To Increase Chance of Death in any Year by One Chance in a Million

Activity	Cause of Death
Smoking 1.4 cigarettes	Cancer; heart disease
Living 2 days in New York or Boston	Air pollution
Traveling 16 km (10 mi) by bicycle	Accident
Flying 1,600 km (1,000 mi) by jet	Accident
Living 2 months in Denver on vacation from New York	Cancer caused by cosmic radiation
One chest x-ray	Cancer caused by radiation

4.1.6 Estimated Radiation Dose Rate Near the Plutonium Transportation Containers

The regulatory external radiation dose limit for ground transport is 10 mrem per hour at 2 m (6.6 ft) from the vehicle (49 CFR 173.441). Historical data from actual plutonium residue and scrub alloy handling experience during transportation have shown dose rates below this regulatory limit. Dose rates at 2 m (6.6 ft) from the Type 9975 and Type 6M containers have typically been between 0.15 and 0.6 mrem per hour, depending on the age and type of residue. Because Safe Secure Trailers carry up to 30 Type 9975 or 38 Type 6M containers, dose rates around the vehicle could be higher than around a single container, but must be kept lower than the regulatory limit.

To be conservative, the analyses in this chapter use the regulatory limit of 10 mrem per hour at 2 m (6.6 ft) from the side of the transport vehicle. This conservative value was used in the calculations of incident-free doses to members of the public traveling along the highway and to ground transport workers. For radiation workers handling containers at the DOE sites, the dose rate close to the shipping containers was estimated by the conservative methodology presented in Appendix D.

4.1.7 Plutonium and Americium Toxicity

The adverse health effects experienced following exposure to plutonium result predominantly from its radiological toxicity rather than its chemical toxicity. Plutonium is not readily absorbed from the gastrointestinal tract following ingestion or through the intact skin following dermal exposure; inhalation is the most common route of human exposure. Once inhaled, the rate of clearance from the lungs is influenced by particle size, specific isotope, and chemical form. Following inhalation exposure, plutonium partitions to the lungs, liver, and bone. The radiotoxicity of plutonium results from its emission of ionizing radiation, primarily in the form of alpha particles, although low-energy gamma radiation and low-energy neutrons are also released. In studies with laboratory animals, exposure to high radiation doses of plutonium isotopes has resulted in decreases in lifespans, diseases of the respiratory tract, and cancer (ATSDR 1990, DOE 1997f). Plutonium residues and scrub alloy contain a number of different isotopes of plutonium.

In addition to plutonium isotopes, scrub alloy and some plutonium residues contain substantial amounts of americium-241, which is formed by the decay of plutonium-241. Americium-241 is radiotoxic because it produces high gamma radiation doses and also emits alpha particles and neutrons. Like plutonium, the radiotoxicity of americium is of much greater concern than its chemical toxicity (DOE 1997f).

4.1.8 WIPP Waste Acceptance Criteria

As noted in Section 4.1.2, processing the plutonium residues would produce transuranic wastes which would require disposal at WIPP. Analysis in the EIS assumes that the transuranic wastes would be transported in the safest, cost-effective manner, which would be TRUPACT II shipping containers. Each TRUPACT II is assumed to contain approximately 2,800 fissile gram equivalents of radioactive material (primarily plutonium and americium). The Nuclear Regulatory Commission (NRC 1997) certified the 2,800 fissile gram equivalents load for the TRUPACT II in February 1997. The WIPP Supplemental EIS (DOE 1997h) analyzed the impacts of transporting the Rocky Flats wastes utilizing the 2,800-fissile-gram-equivalent TRUPACT II loading. The WIPP planning basis waste acceptance criteria, however, have not been revised to allow this loading. The WIPP waste acceptance criteria currently would permit only 325 fissile gram equivalents of radioactive material to enter WIPP in a TRUPACT II. If this lower TRUPACT II loading limit must be applied, the number of shipments required to transport wastes from nonseparation processing facilities to WIPP would increase substantially.

4.2 Impacts of Managing Ash Residues

The inventory of ash residues assessed in this EIS weighs 20,060 kg (44,224 lb) including 1,164 kg (2,566 lb) of plutonium. This inventory is stored in 1,281 drums (with approximately 6,400 internal metal containers) and 531 other small individual containers. As discussed in Chapter 2, the ash residues are divided into four subcategories. The subcategories of ash residues are listed in **Table 4–4**, along with the inventory data for each one.

Table 4–4 Ash Residues

Ash Subcategories	Residue Mass (kg) [a]	Plutonium Mass (kg) [a]	Number of Drums	Number of Other Individual Containers
Incinerator Ash (including firebrick fines)	14,056	909.8	1,016	54
Sand, Slag, and Crucible	3,062	128.9	138	214
Inorganic Ash	2,043	50.9	46	237
Graphite Fines	899	74.0	81	26

[a] To convert to pounds, multiply by 2.2.

Each subcategory has the same basic processing option under the No Action Alternative: to cement the residue. Each subcategory has the same two processing options under the Process without Plutonium Separation Alternative: to calcine and vitrify the residue or to calcine and blend down the residue. The options within the Process with Plutonium Separation Alternative are more complicated: the incinerator ash subcategory has two options, the sand, slag, and crucible subcategory has one option, the graphite fines subcategory has one option, and there are no options for the inorganic ash subcategory. The preferred processing option for incinerator ash, inorganic ash, and graphite fines is vitrification at Rocky Flats. The preferred processing option for sand, slag, and crucible residues is preprocess at Rocky Flats and Purex at the Savannah River Site.

One of the residues in the incinerator ash subcategory is not included in one of the incinerator ash processing options. The firebrick fines residue (Item Description Code [IDC] 378) are not proposed to be processed by the ash fusion and Purex process since the feasibility of it being processed this way has not been established. This residue has a mass of 26 kg (57 lb), including 10.8 kg (23 lb) of plutonium. If DOE decides to implement this processing option for the incinerator ash residues, then the firebrick fines residue would have to be managed under one of the other four processing options. The residue mass of 26 kg (57 lb) represents less than 0.2 percent of the total residue mass in this subcategory, so DOE performed the impact calculations as if the firebrick fines were included along with the rest of the incinerator ash residues in this option. This assumption is reasonable because the inventory of firebrick fines is very small compared to the total amount of residue in this subcategory.

This section presents the environmental impacts of managing the entire inventory of ash residues under each of the processing options. The results in this section were used in the calculation of the total impacts of the No Action Alternative and the Preferred Management Approach which are presented in Sections 4.20 and 4.21, respectively, and of the rest of the management approaches which are presented in Section 4.22.

4.2.1 Products and Wastes

Under every processing option for ash residues, DOE would generate transuranic waste and would prepare this waste for disposal in WIPP. Every option would also result in low-level waste, which would be disposed of routinely using existing procedures at each site. A small portion of the low-level waste generated at Rocky Flats could possibly be low-level mixed waste, but this waste would also be disposed of routinely using existing procedures. The No Action Alternative would result in stabilized residues that would have to remain in storage indefinitely. In the processing options under the Process without Plutonium Separation Alternative, DOE would generate transuranic waste directly from the residue. The stabilized residues and transuranic waste would be placed in pipe components inside 210-liter (L) (55-gallon [gal]) drums as shown in Figure 2-13 in Chapter 2.

High-level waste and saltstone would be generated only at the Savannah River Site if the residues were shipped to that site for plutonium separation. The final form of the high-level waste would be glass poured into

stainless steel canisters, which would be stored at the Savannah River Site until a geologic repository is ready to receive them. Saltstone is a cement form of low-level waste that is generated as a byproduct of the Savannah River Site tank farm operations and is routinely disposed of onsite in concrete vaults. If plutonium is separated at the Savannah River Site, it would be stored securely onsite until a decision is made on its disposition. No increase in proliferation risk would result and this plutonium would not be used for nuclear explosive purposes. The americium from residues sent to the Savannah River Site would go into the high-level waste.

The solid plutonium-bearing products and wastes that would be generated from ash residues under each of the options are presented in **Table 4–5**. The shaded areas of Table 4–5 indicate types of solid products and wastes that would not be generated under the various processing options. The products and wastes from the preferred processing options are presented in bold type.

- **Incinerator Ash and Firebrick Fines**—The largest amount of transuranic waste (6,430 drums) would be generated in the calcine and blend down option, but the vitrify option would generate almost as much (5,428 drums). These two options would generate much more transuranic waste than the other options, which would generate no more than 1,310 drums. The quantities of high-level waste, low-level waste, and saltstone are low under all the options and the sites would manage these wastes using routine procedures. The maximum amount of plutonium that could be separated from incinerator ash residues is 901 kg (1,986 lb).

- **Sand, Slag, and Crucible Residues**—The largest amount of transuranic waste (1,402 drums) would be generated in the calcine and blend down option, but the vitrify option would generate almost as much (1,183 drums). These two options would generate much more transuranic waste than the other options, which would generate fewer than 300 drums. The quantities of high-level waste, low-level waste, and saltstone are low under all the options and the sites would manage these wastes using routine procedures. The maximum amount of plutonium that could be separated from sand, slag, and crucible residues is 128 kg (282 lb).

- **Inorganic Ash**—The largest amount of transuranic waste (917 drums) would be generated in the calcine and blend down option, but the vitrify option would generate almost as much (772 drums). The no action option would generate much less transuranic waste, but would also generate almost 700 drums of stabilized residues. The quantities of low-level waste are low under all the options and the site would manage this waste using routine procedures. No plutonium would be separated from inorganic ash residues under any processing option.

- **Graphite Fines**—The largest amount of transuranic waste (414 drums) would be generated in the calcine and blend down option, but the vitrify option would generate almost as much (350 drums). These two options would generate much more transuranic waste than the other options, which would generate no more than 87 drums. The quantities of high-level waste, low-level waste, and saltstone are low under all the options and the sites would manage these wastes using routine procedures. The maximum amount of plutonium that could be separated from graphite fines residues is 73 kg (160 lb).

4.2.2 Public and Occupational Health and Safety Impacts

This section describes the radiological and hazardous chemical impacts that could result from the alternatives associated with the management of ash residues. These impacts are presented for incident-free operation and postulated accident scenarios. The detailed site and transportation analyses are presented in Appendices D and E, respectively.

Table 4–5 Products and Wastes from Ash Residues

	Stabilized Residues (Drums)	*Transuranic Waste (Drums)*	*High-Level Waste (Canisters of Glass)*	*Separated Plutonium (kg)* [a]	*Low-Level Waste (Drums)*	*Saltstone (cubic yards)*
Incinerator Ash and Firebrick Fines						
Alternative 1 (No Action)						
Calcine and Cement at Rocky Flats	4,800	1,310			2,860	
Alternative 2 (without Plutonium Separation)						
Vitrify at Rocky Flats		**5,428**			**1,187**	
Calcine and Blend Down at Rocky Flats		6,430			1,187	
Alternative 3 (with Plutonium Separation)						
Preprocess at Rocky Flats		593	–	–	1,187	–
Purex at Savannah River Site		150	4	890	394	1,766
Preprocess at Rocky Flats		593	–	–	1,187	–
MEO/Purex at Savannah River Site		253	26	901	373	876
Sand, Slag, and Crucible Residues						
Alternative 1 (No Action)						
Calcine and Cement at Rocky Flats	1,046	286			607	
Alternative 2 (without Plutonium Separation)						
Vitrify at Rocky Flats		1,183			242	
Calcine and Blend Down at Rocky Flats		1,402			242	
Alternative 3 (with Plutonium Separation)						
Preprocess at Rocky Flats		**130**	–	–	**242**	–
Purex at Savannah River Site		**12**	**4**	**128**	**58**	**466**
Inorganic Ash						
Alternative 1 (No Action)						
Calcine and Cement at Rocky Flats	698	173			395	
Alternative 2 (without Plutonium Separation)						
Vitrify at Rocky Flats		**772**			**152**	
Calcine and Blend Down at Rocky Flats		917			152	
Graphite Fines						
Alternative 1 (No Action)						
Cement at Rocky Flats	307	87			186	
Alternative 2 (without Plutonium Separation)						
Vitrify at Rocky Flats		**350**			**79**	
Calcine and Blend Down at Rocky Flats		414			79	
Alternative 3 (with Plutonium Separation)						
Preprocess at Rocky Flats		41	–	–	79	–
MEO/Purex at Savannah River Site		16	2	73	24	56

MEO = mediated electrochemical oxidation.
[a] To convert to pounds, multiply by 2.2.
Notes: Shaded areas indicate the types of solid products and waste that would not be generated. Products and wastes from the preferred processing option are presented in bold type. The storage capacities at each site are adequate to store the products and wastes listed in this table.

The round-trip highway distance from Rocky Flats to the Savannah River Site is 5,233 km (3,250 mi). If DOE decides to ship the incinerator ash to the Savannah River Site for Purex processing or mediated electrochemical oxidation/Purex processing, then the number of shipments would be 116 or 86, respectively, and the total round-trip shipping distances would be 607,000 km (377,000 mi) or 450,000 km (280,000 mi), respectively. Shipping the sand, slag, and crucible would require 26 shipments, and the total round-trip shipping distance would be 136,000 km (84,000 mi). Similarly, shipping the graphite fines to the Savannah River Site would require 7 shipments, and the total round-trip shipping distance would be 37,000 km (23,000 mi).

No construction of new facilities is required for any of the alternatives at Rocky Flats but DOE may need to modify certain existing facilities. For some activities performed at the Savannah River Site, DOE may need to perform decontamination and decommissioning and also modify existing facilities. Mitigation measures during these activities would ensure that only very limited radiological and chemical releases occur. However, workers would be exposed to contaminated materials. Such exposures would be limited to assure that doses are maintained as low as reasonably achievable.

4.2.2.1 Incident-Free Operations

❒ **Radiological Impacts**

- *Incinerator Ash and Firebrick Fines*—The radiological impacts to the public and the workers associated with incident-free operations of each processing option for incinerator ash and firebrick fines are presented in **Table 4–6**. The impacts due to the preferred processing option are presented in bold type. The impacts are those which are anticipated to occur as a result of process operations and transportation over whatever time period is necessary to process the entire inventory of these residues. The length of time necessary to process these residues will depend on which option DOE decides to implement. Impacts associated with subsequent incident-free storage of stabilized residues, separated plutonium, and waste would be much smaller than from processing or transportation.

  The highest estimated public maximally exposed individual dose in Table 4–6 is 11 mrem, which could occur only during transportation. This is a boundary estimate of the dose to a maximally exposed individual. It probably exceeds actual potential exposure by a factor of 5. This hypothetical individual's latent cancer fatality risk would be increased by less than one in one hundred thousand. The public maximally exposed individual risks near the sites would be much lower under all of the options. The highest total of the public population radiation doses listed in Table 4–6 would occur if DOE decides to implement the option to perform Purex processing at the Savannah River Site. The sum of these doses is approximately 11.6 person-rem, which would cause far less than one additional latent cancer fatality among the population living near both sites and traveling along the truck route. The population living near the truck route would receive a much smaller radiation dose. Estimates of population exposure to transportation are based on very conservative assumptions designed to overestimate potential risk. See Section E.8 of Appendix E for a discussion of uncertainties and conservatism in the EIS assessment of transportation risk.

  The highest involved worker population radiation dose would be 394 person-rem, which would occur if DOE decides to implement the option to perform Purex processing at the Savannah River Site. This dose would cause 0.16 additional latent cancer fatalities among the workers directly involved in the operation. Onsite workers who are not involved with the actual processing of the residues are designated as "noninvolved workers." The impacts to these workers would be expected to be much smaller than the impacts to the involved workers.

Table 4–6 Radiological Impacts Due to Incident-Free Management of Ash Residues

	Offsite Public Maximally Exposed Individual		*Offsite Public Population*		*Maximally Exposed Individual Involved Worker*		*Involved Worker Population*	
	Dose (mrem)	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*	*Dose (mrem per year)*	*Probability of a Latent Cancer Fatality per year*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*
Incinerator Ash and Firebrick Fines								
Alternative 1 (No Action)								
Calcine and Cement at Rocky Flats	0.00024	1.2×10^{-10}	0.0051	2.6×10^{-6}	2,000	0.0008	320	0.13
Alternative 2 (without Plutonium Separation)								
Vitrify at Rocky Flats	**0.000034**	**1.7×10^{-11}**	**0.0014**	**7.0×10^{-7}**	**2,000**	**0.0008**	**179**	**0.072**
Calcine and Blend Down at Rocky Flats	0.00019	9.5×10^{-11}	0.0040	2.0×10^{-6}	2,000	0.0008	229	0.092
Alternative 3 (with Plutonium Separation)								
Preprocess at Rocky Flats	0.000057	2.8×10^{-11}	0.0023	1.2×10^{-6}	2,000	0.0008	145	0.058
Transport to Savannah River Site	11	5.5×10^{-6}	11.4	0.0057	100	0.00004	18	0.0072
Purex at Savannah River Site [a]	0.0015	7.5×10^{-10}	0.17	0.000085	2,000	0.0008	231	0.092
Preprocess at Rocky Flats	0.000056	2.8×10^{-11}	0.0023	1.2×10^{-6}	2,000	0.0008	108	0.043
Transport to Savannah River Site	11	5.5×10^{-6}	8.5	0.0042	100	0.00004	13.3	0.0053
MEO/Purex at Savannah River Site [a]	0.00079	4.0×10^{-10}	0.088	0.000044	2,000	0.0008	152	0.061
Sand, Slag, and Crucible Residues								
Alternative 1 (No Action)								
Calcine and Cement at Rocky Flats	0.000035	1.8×10^{-11}	0.00073	3.6×10^{-7}	2,000	0.0008	45	0.018
Alternative 2 (without Plutonium Separation)								
Vitrify at Rocky Flats	4.6×10^{-6}	2.3×10^{-12}	0.00019	9.5×10^{-8}	2,000	0.0008	25	0.010
Calcine and Blend Down at Rocky Flats	2.7×10^{-5}	1.3×10^{-11}	0.00058	2.9×10^{-7}	2,000	0.0008	151	0.060
Alternative 3 (with Plutonium Separation)								
Preprocess at Rocky Flats	**2.7×10^{-6}**	**1.4×10^{-12}**	**0.00011**	**5.5×10^{-8}**	**2,000**	**0.0008**	**27**	**0.011**
Transport to Savannah River Site	**11**	**5.5×10^{-6}**	**2.57**	**0.0013**	**100**	**0.00004**	**4**	**0.0016**
Purex at Savannah River Site [a]	**0.00013**	**6.5×10^{-11}**	**0.014**	**7.0×10^{-6}**	**2,000**	**0.0008**	**17**	**0.0068**
Inorganic Ash								
Alternative 1 (No Action)								
Calcine and Cement at Rocky Flats	0.000013	6.5×10^{-12}	0.00029	1.4×10^{-7}	2,000	0.0008	18	0.0072
Alternative 2 (without Plutonium Separation)								
Vitrify at Rocky Flats	**1.8×10^{-6}**	**9.0×10^{-13}**	**0.000076**	**3.8×10^{-8}**	**2,000**	**0.0008**	**9.8**	**0.0039**
Calcine and Blend Down at Rocky Flats	1.0×10^{-5}	5.2×10^{-12}	0.00023	1.1×10^{-7}	2,000	0.0008	60	0.024

	Offsite Public Maximally Exposed Individual		*Offsite Public Population*		*Maximally Exposed Individual Involved Worker*		*Involved Worker Population*	
	Dose (mrem)	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*	*Dose (mrem per year)*	*Probability of a Latent Cancer Fatality per year*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*
Graphite Fines								
Alternative 1 (No Action)								
Cement at Rocky Flats	0.000020	1.0×10^{-11}	0.00042	2.1×10^{-7}	2,000	0.0008	26	0.010
Alternative 2 (without Plutonium Separation)								
Vitrify at Rocky Flats	**2.7×10^{-6}**	**1.4×10^{-12}**	**0.00011**	**5.5×10^{-8}**	**2,000**	**0.0008**	**15**	**0.0060**
Calcine and Blend Down at Rocky Flats	1.1×10^{-5}	5.2×10^{-12}	0.00023	1.1×10^{-7}	2,000	0.0008	18	0.0072
Alternative 3 (with Plutonium Separation)								
Preprocess at Rocky Flats	4.7×10^{-6}	2.4×10^{-12}	0.00019	9.5×10^{-8}	2,000	0.0008	8.8	0.0035
Transport to Savannah River Site	11	5.5×10^{-6}	0.69	0.00035	100	0.00004	1.1	0.00044
MEO/Purex at Savannah River Site [a, b]	0.000064	3.2×10^{-11}	0.0071	3.6×10^{-6}	2,000	0.0008	1.2	0.0048

MEO = mediated electrochemical oxidation

[a] Impacts to the public and workers are presented for F-Canyon operations. It has been determined that H-Canyon operations result in lower impacts to these groups.

[b] If H-Canyon were used, an additional 60 person-rem (with an associated 0.024 latent cancer fatalities) would be received by workers involved with decontamination and decommissioning of highly contaminated equipment prior to installation of two new dissolvers for mediated electrochemical oxidation operations. This 60 person-rem worker population dose when added to the H-Canyon operational worker population dose would be less than the worker population dose associated with F-Canyon mediated electrochemical oxidation operations.

Note: The impacts from the preferred processing option are presented in bold type.

- *Sand, Slag, and Crucible Residues*—The radiological impacts to the public and the workers associated with incident-free operations of each option for sand, slag, and crucible residues are presented in Table 4–6. The impacts are those which are anticipated to occur as a result of process operations and transportation over whatever time period is necessary to process the entire inventory of these residues. The length of time necessary to process these residues will depend on which option DOE decides to implement. Impacts associated with subsequent incident-free storage of stabilized residues, separated plutonium, and waste would be much smaller than from processing or transportation.

  The highest estimated public maximally exposed individual dose in Table 4–6 is 11 mrem, which could occur only during transportation. This hypothetical individual's latent cancer fatality risk would be increased by less than one in one hundred thousand. The public maximally exposed individual risks near the sites would be much lower under all of the options. The highest total of the public population radiation doses listed in Table 4–6 would occur if DOE decides to implement the option to perform Purex processing at the Savannah River Site. The sum of these doses is approximately 2.6 person-rem, which would cause far less than one additional latent cancer fatality among the population living near both sites and traveling along the truck route. The population living near the truck route would receive a much smaller radiation dose.

  The highest involved worker population radiation dose would be 151 person-rem, which would occur if DOE decides to implement the option to calcine and blend down at Rocky Flats. This dose would cause 0.060 additional latent cancer fatalities among the workers directly involved in the operation. Onsite workers who are not involved with the actual processing of the residues are designated as "noninvolved workers." The impacts to these workers would be expected to be much smaller than the impacts to the involved workers.

- *Inorganic Ash*—The radiological impacts to the public and the workers associated with incident-free operations of each option for inorganic ash are presented in Table 4–6. The impacts are those which are anticipated to occur as a result of process operations over whatever time period is necessary to process the entire inventory of these residues. The length of time necessary to process these residues will depend on which option DOE decides to implement. Impacts associated with subsequent incident-free storage of stabilized residues, separated plutonium, and waste would be much smaller than from processing.

  The highest estimated public maximally exposed individual dose in Table 4–6 is 0.000013 mrem, which would occur during the option to calcine and cement at Rocky Flats. This hypothetical individual's latent cancer fatality risk would be increased by less than one in one-hundred billion. The highest public population radiation dose listed in Table 4–6 would also occur if DOE decides to implement the option to calcine and cement at Rocky Flats. This dose is 0.00029 person-rem, which would cause far less than one additional latent cancer fatality among the population living near Rocky Flats.

  The highest involved worker population radiation dose would be 60 person-rem, which would occur if DOE decides to implement the option to calcine and blend down at Rocky Flats. This dose would cause 0.024 additional latent cancer fatalities among the workers directly involved in the operation. Onsite workers who are not involved with the actual processing of the residues are designated as "noninvolved workers." The impacts to these workers would be expected to be much smaller than the impacts to the involved workers.

- *Graphite Fines*—The radiological impacts to the public and the workers associated with incident-free operations of each option for graphite fines are presented in Table 4–6. The impacts are those which are anticipated to occur as a result of process operations and transportation over whatever time period is necessary to process the entire inventory of these residues. The length of time necessary to process these residues will depend on which option DOE decides to implement. Impacts associated with subsequent

incident-free storage of stabilized residues, separated plutonium, and waste would be much smaller than from processing or transportation. Cumulative impacts are provided in Section 4.25.

The highest estimated public maximally exposed individual dose in Table 4–6 is 11 mrem, which could occur only during transportation. This hypothetical individual's latent cancer fatality risk would be increased by less than one in one hundred thousand. The public maximally exposed individual risks near the sites would be much lower under all of the options. The highest total of the public population radiation doses listed in Table 4–6 would occur if DOE decides to implement the option to perform mediated electrochemical oxidation/Purex processing at the Savannah River Site. The sum of these doses is approximately 0.70 person-rem, which would cause far less than one additional latent cancer fatality among the population living near both sites and traveling along the truck route. The population living near the truck route would receive a much smaller radiation dose.

The highest involved worker population radiation dose would be 26 person-rem, which would occur if DOE decides to implement the option to cement at Rocky Flats. This dose would cause 0.010 additional latent cancer fatalities among the workers directly involved in the operation. Onsite workers who are not involved with the actual processing of the residues are designated as "noninvolved workers." The impacts to these workers would be expected to be much smaller than the impacts to the involved workers.

❒ Hazardous Chemical Impacts

- *Incinerator Ash and Firebrick Fines*—The impacts of exposure to hazardous chemicals from the processing and storage of incinerator ash and firebrick fines at Rocky Flats were not evaluated because hazardous chemicals are not expected to be released from the proposed operations at this site.

  The processing of incinerator ash, firebrick fines, and soot at the Savannah River Site involves releases of only noncarcinogenic hazardous chemicals. The noncancer health risks for the Purex process and mediated electrochemical oxidation process are the summary of releases of phosphoric acid, ammonia nitrate, and fluorides. The estimated offsite population and noninvolved worker Hazard Index values presented in **Table 4–7** are less than one, which suggests that noncancer health effects are not expected. The Hazard Index, which is an estimate of total potential noncancer toxicity, is computed by summing the ratios of the potential intakes of hazardous chemicals to their chemical-specific toxicity threshold levels (i.e., Reference Concentrations and Reference Doses; see Appendix D, Section D.4). Hazard Index values of 1 or more suggest the potential for adverse noncancer health effects following long-term exposure. The results for the preferred processing option are presented in bold type.

- *Sand, Slag, and Crucible Residues*—The processing of sand, slag, and crucible residues at Rocky Flats would not involve airborne releases of hazardous chemicals.

  No carcinogenic chemicals would be released from the Purex process at the Savannah River Site. Noncancer health risks resulting from releases of phosphoric acid, ammonia nitrate, and fluorides would be low. Phosphoric acid is a corrosive irritant to the eyes, skin and mucous membranes and a respiratory tract irritant following inhalation exposure (Lewis 1991, EPA 1995a).

- *Inorganic Ash*—The processing of inorganic ash residues at Rocky Flats would not involve airborne releases of hazardous chemicals.

- *Graphite Fines*—The processing of graphite fines residues at Rocky Flats would not involve airborne releases of hazardous chemicals.

  No carcinogenic chemicals are released from the mediated electrochemical oxidation process at the Savannah River Site. Noncancer health risks resulting from releases of phosphoric acid would be low.

Table 4–7 Chemical Impacts Due to Incident-Free Management of Ash Residues

	Offsite Public Maximally Exposed Individual		*Offsite Public Population*	*Maximally Exposed Individual Involved Worker*		*Involved Worker Population*
	Probability of Cancer Incidence	*Hazard Index*	*Number of Cancer Incidences or Fatalities* [a]	*Probability of Cancer Incidence*	*Hazard Index*	*Number of Cancer Incidences or Fatalities* [a]
Incinerator Ash and Firebrick Fines						
Alternative 1 (No Action)						
Calcine and Cement at Rocky Flats [b]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 2 (without Plutonium Separation)						
Vitrify at Rocky Flats [b]	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**
Calcine and Blend Down at Rocky Flats [b]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 3 (with Plutonium Separation)						
Preprocess at Rocky Flats [b]	N/E	N/E	N/E	N/E	N/E	N/E
Transport to Savannah River Site	N/A	N/A	0.0015 [c]	N/A	N/A	(c)
Purex at Savannah River Site [d, e]	N/E	0.06	N/E	N/E	0.8	N/E
Preprocess at Rocky Flats [b]	N/E	N/E	N/E	N/E	N/E	N/E
Transport to Savannah River Site	N/A	N/A	0.0011 [c]	N/A	N/A	(c)
MEO/Purex at Savannah River Site [d, e]	N/E	0.06	N/E	N/E	0.9	N/E
Sand, Slag, and Crucible Residues						
Alternative 1 (No Action)						
Calcine and Cement at Rocky Flats [b]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 2 (without Plutonium Separation)						
Vitrify at Rocky Flats [b]	N/E	N/E	N/E	N/E	N/E	N/E
Calcine and Blend Down at Rocky Flats [b]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 3 (with Plutonium Separation)						
Preprocess at Rocky Flats [b]	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**
Transport to Savannah River Site	**N/A**	**N/A**	**0.00034 [c]**	**N/A**	**N/A**	**(c)**
Purex at Savannah River Site [d, e]	**N/E**	**0.02**	**N/E**	**N/E**	**0.3**	**N/E**
Inorganic Ash						
Alternative 1 (No Action)						
Calcine and Cement at Rocky Flats [b]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 2 (without Plutonium Separation)						
Vitrify at Rocky Flats [b]	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**
Calcine and Blend Down at Rocky Flats [b]	N/E	N/E	N/E	N/E	N/E	N/E

	Offsite Public Maximally Exposed Individual		Offsite Public Population	Maximally Exposed Individual Involved Worker		Involved Worker Population
	Probability of Cancer Incidence	Hazard Index	Number of Cancer Incidences or Fatalities [a]	Probability of Cancer Incidence	Hazard Index	Number of Cancer Incidences or Fatalities [a]
Graphite Fines						
Alternative 1 (No Action)						
Cement at Rocky Flats [b]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 2 (without Plutonium Separation)						
Vitrify at Rocky Flats [b]	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**
Calcine and Blend Down at Rocky Flats [b]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 3 (with Plutonium Separation)						
Preprocess at Rocky Flats [b]	N/E	N/E	N/E	N/E	N/E	N/E
Transport to Savannah River Site	N/A	N/A	0.00009 [c]	N/A	N/A	(c)
MEO/Purex at Savannah River Site [d, e]	N/E	0.007	N/E	N/E	0.1	N/E

MEO = mediated electrochemical oxidation. N/A = Not applicable. The maximally exposed individual is undefined for vehicle emissions. N/E = No emissions.

[a] Cancer incidences and fatalities are calculated for process emissions and transportation emissions, respectively.

[b] No hazardous chemicals are released from this process; therefore, no associated health risks exist.

[c] Cancer fatalities due to vehicle emissions into the air. This impact is listed only once under public population because the vehicle emissions affect the public and worker populations collectively; however, the risk to the public dominates. See Appendix E, Section E.4 for additional details.

[d] Impacts are presented for F-Canyon operations. H-Canyon operations are expected to result in similar or lower impacts.

[e] No carcinogenic chemicals are released from the process; therefore, only noncancer health risks are evaluated.

Note: The results for the preferred processing option are presented in bold type.

4.2.2.2 Accidents

The potential radiological impacts to the public and the noninvolved onsite workers due to accidents with ash residues are summarized and presented in this section. The detailed analysis of onsite accidents, with the associated assumptions, is presented in Appendix D, Section D.3. The detailed analysis considered a wide spectrum of potential accident scenarios, including fire, explosion, spill, criticality, earthquake, and aircraft crash. The accident scenarios with the highest consequences and risks were selected and carried forward to this section for the purpose of consequence and risk comparison. A composite of the risks due to major onsite accident scenarios in each spectrum (including the nonbounding accidents) was also computed and used for comparisons. The composite risk estimates are accurate enough for the purpose of comparing processing options against each other. The composite risk estimates are accurate enough for the purpose of comparing processing options against each other. The detailed analysis of transportation accidents, with the associated assumptions, is presented in Appendix E, Sections E.5 and E.6.

The accident frequencies and process durations of the selected accidents are presented in **Table 4–8**. The impacts due to the preferred processing option are presented in bold type. The onsite accident frequencies are given on a per year basis because many accidents, such as earthquakes, are commonly expressed this way. The duration of each process is given in years. The actual probability of occurrence of each onsite accident can be obtained by multiplying the accident frequency by the option's duration. In this way, the calculated probabilities are based on the total amount of residue in this category rather than a standard unit of time. The results for the preferred processing option are presented in bold type.

The calculation of accident probability is slightly different for traffic accident fatalities. The frequency of traffic accidents is given in terms of the number of fatal accidents per round trip shipment from Rocky Flats to the Savannah River Site. The process duration for traffic accidents is given as the number of round trip shipments. Thus, the actual probability of a fatal traffic accident can be obtained by multiplying the frequency (fatal accidents per round-trip shipment) times the duration (number of round-trip shipments).

The consequences for the public and a noninvolved onsite worker are also presented in Table 4–8 for each of the four classes of ash residue. Five processing options are under consideration for the incinerator ash and firebrick fines residue; four processing options are under consideration for the sand, slag, and crucible residue; three processing options are under consideration for the inorganic ash residue; and four processing options are under consideration for the graphite fines residue.

The risks associated with each accident are calculated by multiplying the probability times the consequences. The risks to the public and an onsite worker are presented in **Table 4–9**, for each processing option for the four subcategories of ash residue. The risk associated with the highest risk accident and a composite risk associated with all major accidents are both presented. The risks associated with the preferred processing option are presented in bold type.

The public maximally exposed individual is a hypothetical individual who resides at the site boundary in the downwind direction. The public population is defined as the residential population within a radius of 80 km (50 mi). A noninvolved onsite worker is defined as an individual worker who is located 100 m (328 ft) or more downwind from the release point when an accidental release of radioactive material occurs.

Table 4–8 Accident Frequencies, Process Durations, and Consequences for Accidents with Ash Residues

	Accident Scenario	Accident Frequency (per year)	Process Duration (years)	Offsite Public Maximally Exposed Individual Consequences		Offsite Public Population Consequences		Noninvolved Onsite Worker Consequences	
				Dose (mrem)	Probability of a Latent Cancer Fatality	Dose (person-rem)	Number of Latent Cancer or Traffic Fatalities	Dose (mrem)	Probability of a Latent Cancer Fatality
Incinerator Ash and Firebrick Fines									
Alternative 1 (No Action)									
Calcine and Cement at Rocky Flats	Earthquake (Bldg. 371)	0.000094	3.00	833	0.00042	11,600	5.8	9,720	0.0039
	Earthquake (Bldg. 707) [a]	0.0018	3.00	556	0.00028	11,600	5.8	9,720	0.0039
Alternative 2 (without Plutonium Separation)									
Vitrify at Rocky Flats	**Explosion (Bldg. 707) [b]**	**0.00005**	**2.18**	**480**	**0.00024**	**10,000**	**5.0**	**8,400**	**0.0034**
	Earthquake (Bldg. 707) [c]	**0.0018**	**2.18**	**457**	**0.00023**	**9520**	**4.8**	**8,000**	**0.0032**
Calcine & Blend Down at Rocky Flats	Earthquake (Bldg. 707)	0.0018	2.50	667	0.00033	13,900	7.0	11,700	0.0047
	Earthquake (Bldg. 371) [d]	0.000094	2.50	1,000	0.00050	13,900	7.0	11,700	0.0047
Alternative 3 (with Plutonium Separation)									
Preprocess at Rocky Flats	Earthquake (Bldg. 707)	0.0018	1.41	1,170	0.00059	24,300	12	20,400	0.016
Transport to Savannah River Site	Traffic Fatality	0.00010 per shipment	116 shipments	N/A	N/A	N/A	1.0 [e]	N/A	(f)
Purex at Savannah River Site	Earthquake (H-Canyon) [g]	0.000182	15.83	74	0.000037	3,330	1.7	23,600	0.019
Preprocess at Rocky Flats	Earthquake (Bldg. 707)	0.0018	1.03	1,620	0.00081	33,800	17	28,400	0.023
Transport to Savannah River Site	Traffic Fatality	0.00010 per shipment	86 shipments	N/A	N/A	N/A	1.0 [e]	N/A	(f)
MEO/Purex at Savannah River Site	Earthquake (H-Canyon)	0.000182	2.16	62	0.000031	2,800	1.4	19,900	0.0080
Sand, Slag, and Crucible Residues									
Alternative 1 (No Action)									
Calcine and Cement at Rocky Flats	Earthquake (Bldg. 371)	0.000094	0.42	833	0.00042	11,600	5.8	9,720	0.0039
	Earthquake (Bldg. 707) [a]	0.0018	0.42	556	0.00028	11,600	5.8	9,720	0.0039
Alternative 2 (without Plutonium Separation)									
Vitrify at Rocky Flats	Explosion (Bldg. 707) [b]	0.00005	0.31	480	0.00024	10,000	5.0	8,400	0.0034
	Earthquake (Bldg. 707) [c]	0.0018	0.31	457	0.00023	9520	4.8	8,000	0.0032
Calcine & Blend Down at Rocky Flats	Earthquake (Bldg. 707)	0.0018	0.35	667	0.00033	13,900	7.0	11,700	0.0047
	Earthquake (Bldg. 371) [d]	0.000094	0.35	1,000	0.00050	13,900	7.0	11,700	0.0047
Alternative 3 (with Plutonium Separation)									
Preprocess at Rocky Flats	**Earthquake (Bldg. 707)**	**0.0018**	**0.31**	**768**	**0.00038**	**16,000**	**8.0**	**13,400**	**0.0054**
Transport to Savannah River Site	**Traffic Fatality**	**0.00010 per shipment**	**26 shipments**	**N/A**	**N/A**	**N/A**	**1.0 [e]**	**N/A**	**(f)**
Purex at Savannah River Site	**Earthquake (H-Canyon) [g]**	**0.000182**	**1.58**	**74**	**0.000037**	**3,330**	**1.7**	**23,600**	**0.019**

	Accident Scenario	Accident Frequency (per year)	Process Duration (years)	Offsite Public Maximally Exposed Individual Consequences		Offsite Public Population Consequences		Noninvolved Onsite Worker Consequences	
				Dose (mrem)	Probability of a Latent Cancer Fatality	Dose (person-rem)	Number of Latent Cancer or Traffic Fatalities	Dose (mrem)	Probability of a Latent Cancer Fatality
Inorganic Ash									
Alternative 1 (No Action)									
Calcine & Cement at Rocky Flats	Earthquake (Bldg. 371)	0.000094	0.17	833	0.00042	11,600	5.8	9,720	0.0039
	Earthquake (Bldg. 707) [a]	0.0018	0.17	556	0.00028	11,600	5.8	9,720	0.0039
Alternative 2 (without Plutonium Separation)									
Vitrify at Rocky Flats	**Explosion (Bldg. 707) [b]**	**0.00005**	**0.12**	**480**	**0.00024**	**10,000**	**5.0**	**8,400**	**0.0034**
	Earthquake (Bldg. 707) [c]	**0.0018**	**0.12**	**457**	**0.00023**	**9520**	**4.8**	**8,000**	**0.0032**
Calcine & Blend Down at Rocky Flats	Earthquake (Bldg. 707)	0.0018	0.14	667	0.00033	13,900	7.0	11,700	0.0047
	Earthquake (Bldg. 371) [d]	0.000094	0.14	1,000	0.00050	13,900	7.0	11,700	0.0047
Graphite Fines									
Alternative 1 (No Action)									
Cement at Rocky Flats	Earthquake (Bldg. 371)	0.000094	0.24	833	0.00042	11,600	5.8	9,720	0.0039
	Earthquake (Bldg. 707) [a]	0.0018	0.24	556	0.00028	11,600	5.8	9,720	0.0039
Alternative 2 (without Plutonium Separation)									
Vitrify at Rocky Flats	**Explosion (Bldg. 707) [b]**	**0.00005**	**0.18**	**480**	**0.00024**	**10,000**	**5.0**	**8,400**	**0.0034**
	Earthquake (Bldg. 707) [c]	**0.0018**	**0.18**	**457**	**0.00023**	**9520**	**4.8**	**8,000**	**0.0032**
Calcine & Blend Down at Rocky Flats	Earthquake (Bldg. 707)	0.0018	0.20	667	0.00033	13,900	7.0	11,700	0.0047
	Earthquake (Bldg. 371) [d]	0.000094	0.20	1,000	0.00050	13,900	7.0	11,700	0.0047
Alternative 3 (with Plutonium Separation)									
Preprocess at Rocky Flats	Earthquake (Bldg. 707)	0.0018	0.31	1,620	0.00081	33,800	17	28,400	0.023
Transport to Savannah River Site	Traffic Fatality	0.00010 per shipment	7 shipments	N/A	N/A	N/A	1.0 [e]	N/A	(f)
MEO/Purex at Savannah River Site	Earthquake (H-Canyon)	0.000182	0.17	62	0.000031	2,800	1.4	19,900	0.0080

MEO = mediated electrochemical oxidation N/A =not applicable

[a] Building 707 is designated as an alternate location for the Calcine and Cement process at Rocky Flats.

[b] Highest consequence accident for this processing option.

[c] Highest risk accident for this processing option.

[d] Building 371 is designated as an alternate location for the Calcine and Blend Down process at Rocky Flats.

[e] This fatality is due to the mechanical impact of the accident, not cancer due to radiation. The radiological consequences of a radioactive release on the highway are impossible to list as a single number because the accident could occur at any point along the route and meteorological conditions and population distributions vary greatly along the route.

[f] The consequence of a high-speed traffic accident would be at least one fatality among the transportation workers due to trauma.

[g] HB-Line operates 12.5 percent of the time. Dose estimates assumed the HB-Line was operating at the time of the accident.

Note: The impacts and results for the preferred processing option are presented in bold type.

Table 4–9 Risks Due to Accidents with Ash Residues

	Accident Scenario	Offsite Public Maximally Exposed Individual Risk (Probability of a Latent Cancer Fatality)	Offsite Public Population Risk (Number of Latent Cancer or Traffic Fatalities)	Noninvolved Onsite Worker Risk (Probability of a Latent Cancer Fatality)
Incinerator Ash and Firebrick Fines				
Alternative 1 (No Action)				
Calcine and Cement at Rocky Flats	Earthquake (Bldg. 371)	1.2×10^{-7}	0.0016	1.1×10^{-6}
	Composite (Bldg. 371)	1.7×10^{-7}	0.0024	1.6×10^{-6}
	Earthquake (Bldg. 707) [a]	1.5×10^{-6}	0.031	0.000021
	Composite (Bldg. 707) [a]	1.6×10^{-6}	0.033	0.000022
Alternative 2 (without Plutonium Separation)				
Vitrify at Rocky Flats	**Earthquake (Bldg. 707)**	**9.0×10^{-7}**	**0.019**	**0.000013**
	Composite	**9.5×10^{-7}**	**0.020**	**0.000013**
Calcine and Blend Down at Rocky Flats	Earthquake (Bldg. 707)	1.5×10^{-6}	0.031	0.000021
	Composite (Bldg. 707)	1.6×10^{-6}	0.033	0.000022
	Earthquake (Bldg. 371) [b]	1.2×10^{-7}	0.0016	1.1×10^{-6}
	Composite (Bldg. 371) [b]	1.7×10^{-7}	0.0024	1.6×10^{-6}
Alternative 3 (with Plutonium Separation)				
Preprocess at Rocky Flats	Earthquake (Bldg. 707)	1.5×10^{-6}	0.031	0.000042
	Composite	1.5×10^{-6}	0.032	0.000042
Transport to Savannah River Site	Traffic Fatality	N/A	0.012 [c]	N/A
	Radioactive Release	N/A	0.000020	N/A
Purex at Savannah River Site	Earthquake (H-Canyon) [d]	3.6×10^{-8}	0.0016	0.000011
	Composite [d]	6.6×10^{-8}	0.0031	0.000018
Preprocess at Rocky Flats	Earthquake (Bldg. 707)	1.5×10^{-6}	0.031	0.000042
	Composite	1.5×10^{-6}	0.032	0.000043
Transport to Savannah River Site	Traffic Fatality	N/A	0.0088 [c]	N/A
	Radioactive Release	N/A	0.000020	N/A
MEO/Purex at Savannah River Site	Earthquake (H-Canyon)	1.2×10^{-8}	0.00055	3.1×10^{-6}
	Composite	2.0×10^{-8}	0.00094	3.2×10^{-6}
Sand, Slag, and Crucible Residues				
Alternative 1 (No Action)				
Calcine and Cement at Rocky Flats	Earthquake (Bldg. 371)	1.7×10^{-8}	0.00023	1.5×10^{-7}
	Composite (Bldg. 371)	2.4×10^{-8}	0.00034	2.3×10^{-7}
	Earthquake (Bldg. 707) [a]	2.1×10^{-7}	0.0044	2.9×10^{-6}
	Composite (Bldg. 707) [a]	2.2×10^{-7}	0.0046	3.1×10^{-6}

	Accident Scenario	Offsite Public Maximally Exposed Individual Risk (Probability of a Latent Cancer Fatality)	Offsite Public Population Risk (Number of Latent Cancer or Traffic Fatalities)	Noninvolved Onsite Worker Risk (Probability of a Latent Cancer Fatality)
Sand, Slag, and Crucible Residues (continued)				
Alternative 2 (without Plutonium Separation)				
Vitrify at Rocky Flats	Earthquake (Bldg. 707)	1.3×10^{-7}	0.0027	1.8×10^{-6}
	Composite	1.4×10^{-7}	0.0028	1.9×10^{-6}
Calcine and Blend Down at Rocky Flats	Earthquake (Bldg. 707)	2.1×10^{-7}	0.0044	2.9×10^{-6}
	Composite (Bldg. 707)	2.2×10^{-7}	0.0046	3.1×10^{-6}
	Earthquake (Bldg. 371) [b]	1.6×10^{-8}	0.00023	1.5×10^{-7}
	Composite (Bldg. 371) [b]	2.4×10^{-8}	0.00033	2.2×10^{-7}
Alternative 3 (with Plutonium Separation)				
Preprocess at Rocky Flats	**Earthquake (Bldg. 707)**	**2.1×10^{-7}**	**0.0045**	**3.0×10^{-6}**
	Composite	**2.2×10^{-7}**	**0.0047**	**3.1×10^{-6}**
Transport to Savannah River Site	**Traffic Fatality**	**N/A**	**0.0027 [c]**	**N/A**
	Radioactive Release	**N/A**	**2.9×10^{-7}**	**N/A**
Purex at Savannah River Site	**Earthquake (H-Canyon) [d]**	**3.5×10^{-9}**	**0.00016**	**1.8×10^{-6}**
	Composite [d]	**6.6×10^{-9}**	**0.00030**	**1.8×10^{-6}**
Inorganic Ash				
Alternative 1 (No Action)				
Calcine and Cement at Rocky Flats	Earthquake (Bldg. 371)	6.7×10^{-9}	0.000093	6.2×10^{-8}
	Composite (Bldg. 371)	9.8×10^{-9}	0.00014	9.2×10^{-8}
	Earthquake (Bldg. 707) [a]	8.5×10^{-8}	0.0018	1.2×10^{-6}
	Composite (Bldg. 707) [a]	8.9×10^{-8}	0.0019	1.3×10^{-6}
Alternative 2 (without Plutonium Separation)				
Vitrify at Rocky Flats	**Earthquake (Bldg. 707)**	**4.9×10^{-8}**	**0.0010**	**6.9×10^{-7}**
	Composite	**5.2×10^{-8}**	**0.0011**	**7.3×10^{-7}**
Calcine and Blend Down at Rocky Flats	Earthquake (Bldg. 707)	8.4×10^{-8}	0.0018	1.2×10^{-6}
	Composite (Bldg. 707)	8.8×10^{-8}	0.0018	1.2×10^{-6}
	Earthquake (Bldg. 371) [b]	6.6×10^{-9}	0.000091	6.1×10^{-8}
	Composite (Bldg. 371) [b]	9.6×10^{-9}	0.00013	9.0×10^{-8}

	Accident Scenario	Offsite Public Maximally Exposed Individual Risk (Probability of a Latent Cancer Fatality)	Offsite Public Population Risk (Number of Latent Cancer or Traffic Fatalities)	Noninvolved Onsite Worker Risk (Probability of a Latent Cancer Fatality)
Graphite Fines				
Alternative 1 (No Action)				
Cement at Rocky Flats	Earthquake (Bldg. 371)	9.4×10^{-9}	0.00013	8.8×10^{-8}
	Composite (Bldg. 371)	1.4×10^{-8}	0.00019	1.3×10^{-7}
	Earthquake (Bldg. 707) [a]	1.2×10^{-7}	0.0025	1.7×10^{-6}
	Composite (Bldg. 707) [a]	1.3×10^{-7}	0.0026	1.8×10^{-6}
Alternative 2 (without Plutonium Separation)				
Vitrify at Rocky Flats	**Earthquake (Bldg. 707)**	**7.4×10^{-8}**	**0.0015**	**1.0×10^{-6}**
	Composite	**7.8×10^{-8}**	**0.0016**	**1.1×10^{-6}**
Calcine and Blend Down at Rocky Flats	Earthquake (Bldg. 707)	1.2×10^{-7}	0.0025	1.7×10^{-6}
	Composite (Bldg. 707)	1.3×10^{-7}	0.0026	1.8×10^{-6}
	Earthquake (Bldg. 371) [b]	9.4×10^{-9}	0.00013	8.8×10^{-8}
	Composite (Bldg. 371) [b]	1.4×10^{-8}	0.00019	1.3×10^{-7}
Alternative 3 (with Plutonium Separation)				
Preprocess at Rocky Flats	Earthquake (Bldg. 707)	4.5×10^{-7}	0.0095	1.3×10^{-5}
	Composite	4.7×10^{-7}	0.0097	1.3×10^{-5}
Transport to Savannah River Site	Traffic Fatality	N/A	0.0007 [a]	N/A
	Radioactive Release	N/A	1.6×10^{-7}	N/A
MEO/Purex at Savannah River Site	Earthquake (H-Canyon)	9.6×10^{-10}	0.000043	2.5×10^{-7}
	Composite	1.6×10^{-9}	0.000074	2.5×10^{-7}

MEO = mediated electrochemical oxidation N/A = not applicable

[a] Building 707 is designated as an alternate location for the Calcine and Cement process at Rocky Flats.

[b] Building 371 is designated as an alternate location for the Calcine and Blend Down process at Rocky Flats.

[c] This risk is due to the mechanical impact of a potential accident, not cancer due to radiation. This risk includes members of the public and transportation workers.

[d] HB-Line operates 12.5 percent of the time.

Note: The risks due to the preferred processing option are presented in bold type.

- *Incinerator Ash and Firebrick Fines*—Highest consequences to all three receptors would occur if DOE decides to implement the mediated electrochemical oxidation option at the Savannah River Site and a major earthquake strong enough to cause the collapse of Building 707 occurs during the preprocessing of residues to be shipped to the Savannah River Site for final processing.

  The highest risk to the public maximally exposed individual is estimated to be 1.5×10^{-6}, which is due to either an earthquake during processing the residue with the calcine and cement option in Rocky Flats Building 707, an earthquake during processing of the residue with the blend down option in Rocky Flats Building 707, an earthquake during preprocessing of the residue at Rocky Flats for the Purex option at the Savannah River Site, or an earthquake during preprocessing of the residue at Rocky Flats for the mediated electrochemical oxidation option at the Savannah River Site. This individual's chance of incurring a latent cancer fatality would be increased by less than one in one hundred thousand. The highest risk to the public population is estimated to be 0.031 latent cancer fatalities, which is due to the same four earthquake-initiated accidents listed for the maximally exposed individual. The highest risk to the individual noninvolved onsite worker is estimated to be 0.000042, which is due to either an earthquake during preprocessing of the residue at Rocky Flats for the Purex option at the Savannah River Site or an earthquake during preprocessing of the residue at Rocky Flats for the mediated electrochemical oxidation option at the Savannah River Site. This individual's chance of incurring a latent cancer fatality would be increased by less than one in ten thousand.

- *Sand, Slag, and Crucible Residues*—The highest consequence to the maximally exposed individual would occur if DOE decides to implement the calcine and cement option at Rocky Flats and a major earthquake strong enough to cause the breach of Building 371 occurs during the processing of the residue. The highest consequence to the general public would occur if DOE decides to implement the Purex option at the Savannah River Site and a major earthquake strong enough to cause the collapse of Building 707 occurs during the preprocessing of residues to be shipped to the Savannah River Site for final processing. The highest consequence to the noninvolved onsite worker would occur if DOE decides to implement the Purex option at the Savannah River Site and a major earthquake strong enough to cause the breach of the H-Canyon occurs during the processing of residues at the Savannah River Site.

  The highest risk to the public maximally exposed individual is estimated to be 2.1×10^{-7}, which is due to either an earthquake during processing the residue with the calcine and cement option in Rocky Flats Building 707, an earthquake during processing of the residue with the blend down option in Rocky Flats Building 707, or an earthquake during preprocessing of the residue at Rocky Flats for the Purex option at the Savannah River Site. This individual's chance of incurring a latent cancer fatality would be increased by less than one in one million. The highest risk to the public population is estimated to be 0.0045 latent cancer fatalities, which is also due to an earthquake during preprocessing of the residue at Rocky Flats for the Purex option at the Savannah River Site. The highest risk to the individual noninvolved onsite worker is estimated to be 3.0×10^{-6}, which is due to an earthquake during preprocessing of the residue at Rocky Flats for the Purex option at the Savannah River Site. This individual's chance of incurring a latent cancer fatality would be increased by less than one in one hundred thousand.

- *Inorganic Ash* —The highest consequence to the maximally exposed individual would occur if DOE decides to implement the calcine and blend down option at Rocky Flats and a major earthquake strong enough to cause the breach of Building 371 occurs during the processing of the residue. The highest consequences to the general public or the noninvolved onsite worker would occur if DOE decides to implement the blend down option at Rocky Flats and a major earthquake strong enough to cause the collapse of Building 707 or breach Building 371 occurs during the processing of residues.

  The highest risk to the public maximally exposed individual is estimated to be 8.5×10^{-8}, which is due to an earthquake during processing of the residue with the calcine and cement option in Rocky Flats Building 707. This individual's chance of incurring a latent cancer fatality would be increased by less than one in

ten million. The highest risk to the public population is estimated to be 0.0018 latent cancer fatalities, which is due to an earthquake during processing of the residue at Rocky Flats with either the cement or the blend down option in Building 707. The highest risk to the individual noninvolved onsite worker is estimated to be 1.2×10^{-6}, which is also due to an earthquake during processing of the residue with either the cement or the blend down option in Building 707. This individual's chance of incurring a latent cancer fatality would be increased by less than one in one hundred thousand.

- *Graphite Fines*—The highest consequences to all three receptors would occur if DOE decides to implement the mediated electrochemical oxidation option at the Savannah River Site and a major earthquake strong enough to cause the collapse of Building 707 occurs during the preprocessing of residues to be shipped to the Savannah River Site for final processing.

  The highest risk to the public maximally exposed individual is estimated to be 4.5×10^{-7}, which is due to an earthquake during preprocessing of the residue at Rocky Flats for the mediated electrochemical oxidation option at the Savannah River Site. This individual's chance of incurring a latent cancer fatality would be increased by less than one in one million. The highest risk to the public population is estimated to be 0.0095 latent cancer fatalities, which is also due to an earthquake during preprocessing of the residue at Rocky Flats for the mediated electrochemical oxidation option at the Savannah River Site. The highest risk to the individual noninvolved onsite worker is estimated to be 0.000013, which is also due to an earthquake during preprocessing of the residue at Rocky Flats for the mediated electrochemical oxidation option at the Savannah River Site. This individual's chance of incurring a latent cancer fatality would be increased by less than one in ten thousand.

4.3 Impacts of Managing Pyrochemical Salt Residues

The inventory of pyrochemical salt residues assessed in this EIS is divided into two subcategories: electrorefining and molten salt extraction salt residues and direct oxide reduction salt residues. The inventory of electrorefining and molten salt extraction salt residues weighs about 13,400 kg (29,500 lb), including 890 kg (2,000 lb) of plutonium. This inventory of electrorefining and molten salt extraction salt residues is stored in 593 drums and approximately 5,650 small metal containers. Some of the small metal containers are inside the drums. The inventory of direct oxide reduction salt residues weighs about 2,160 kg (4,760 lb), including about 190 kg (420 lb) of plutonium. The entire inventory of direct oxide reduction salt residues is stored in 80 drums and approximately 917 small metal containers. Some of the small metal containers are inside the drums.

About 670 kg (1,500 lb) of salt residues are in both subcategories because it is not clear which subcategory they should be assigned to. For the purposes of calculating the impacts in this EIS, these residues are double-counted. This is a conservative assumption because it causes slight overestimates of the environmental impacts.

As discussed in Chapter 2, the alternatives for electrorefining and molten salt extraction pyrochemical salt residues include one option under the No Action Alternative, one option under the Process without Plutonium Separation Alternative, and four options under the Process with Plutonium Separation Alternative. The alternatives for direct oxide reduction pyrochemical salt residues include all the same options except for one: salt distillation at Rocky Flats is not possible for direct oxide reduction salt residues. The preferred processing option for electrorefining and molten salt extraction salt residues is salt distillation at Rocky Flats. The preferred processing option for direct oxide reduction salt residues is pyro-oxidation at Rocky Flats followed by water leach at Los Alamos National Laboratory.

This section presents the environmental impacts of managing the entire inventory of each subcategory under each of the options. The results in this section were used in the calculation of the total impacts of the No Action Alternative and the Preferred Management Approach which are presented in Sections 4.20 and 4.21, respectively, and of the rest of the management approaches which are presented in Section 4.22.

4.3.1 Products and Wastes

Every processing option for pyrochemical salt residues would generate some quantity of transuranic waste and thus would involve preparation of this waste for disposal in WIPP. Every option would also generate some quantity of low-level waste, which would be disposed of routinely using existing procedures at each site. A small portion of the low-level waste generated at Rocky Flats could possibly be low-level mixed waste, but this waste would also be disposed of routinely using existing procedures. The No Action Alternative would generate stabilized residues that would have to remain in storage indefinitely. The Process without Plutonium Separation Alternative would generate transuranic waste directly from the residue. The stabilized residues and transuranic waste would be placed in pipe components inside 210-L (55-gal) drums as shown in Figure 2-13 in Chapter 2.

High-level waste and saltstone would be generated only at the Savannah River Site if the scrub alloy resulting from salt scrubbing at Rocky Flats were shipped to that site for plutonium separation. The final form for the high-level waste would be glass poured into stainless steel canisters, which would be stored at the Savannah River Site until a geologic repository is ready to receive them. Saltstone is a cement form of low-level waste that is generated as a by-product of the Savannah River Site tank farm operations and is routinely disposed of onsite in concrete vaults.

If plutonium is separated at Rocky Flats, the Savannah River Site, or Los Alamos National Laboratory, it would be stored securely onsite until a decision is made on its disposition. No increase in proliferation risk would result and this plutonium would not be used for nuclear explosive purposes. Any plutonium separated at Rocky Flats or Los Alamos National Laboratory would contain americium, while at the Savannah River Site the americium would go into the high-level waste. This distinction could be important for the electrorefining and molten salt extraction salt residues because they contain relatively high levels of americium, which emits gamma radiation. The mixture of plutonium and americium that might be generated at Rocky Flats or Los Alamos National Laboratory would be more difficult to transport and store than the rest of the plutonium that might be separated under this EIS because the gamma radiation from americium would increase the workers' doses. This issue will be discussed, if necessary, in the Surplus Plutonium Disposition EIS, which is in preparation (see Chapter 1, Section 1.6.6).

The solid plutonium-bearing products and wastes that would be generated from pyrochemical salt residues under each of the options are presented in **Table 4–10.** The shaded areas of Table 4–10 indicate types of solid products and wastes that would not be generated under the various options. The products and wastes from the preferred processing options are presented in bold type. The stabilized residues from the No Action Alternative could actually be stored in small metal containers in a vault, but for the purpose of comparisons in this EIS, DOE considered that these stabilized residues would be stored in drums like the rest of the stabilized residues.

- **Electrorefining and Molten Salt Extraction Salt Residues**—The largest amount of transuranic waste (13,994 drums) would be generated in the option to water leach at Rocky Flats, but the option to pyro-oxidize and blend down at Rocky Flats would generate almost as much (12,911 drums). The amount of waste from the water leach process is high because it is a liquid process, assumed to generate 3.4 drums of waste per kilogram of residue, with 30 percent of this being transuranic waste. The amount of waste from the pyro-oxidize and blend down process is high because blending down requires a large volume increase. These two options would generate much more transuranic waste than the other options, which would generate no more than about 1,500 drums. These two processing options would also stress the capacity for transuranic waste storage at Rocky Flats. The quantities of low-level waste are low under all the options and the sites would manage this waste using routine procedures. The maximum amount of plutonium that could be separated from electrorefining and molten salt extraction pyrochemical salt residues is 881 kg (1,940 lb).

Table 4–10 Products and Wastes from Pyrochemical Salt Residues

	Stabilized Residues (Drums)	*Transuranic Waste (Drums)*	*High-Level Waste (Canisters of Glass)*	*Separated Plutonium (kg)* [a]	*Low-Level Waste (Drums)*	*Saltstone (cubic yards)*
Electrorefining and Molten Salt Extraction Salt Residues						
Alternative 1 (No Action) Pyro-Oxidize at Rocky Flats	1,097	590			1,057	
Alternative 2 (without Plutonium Separation) Pyro-Oxidize and Blend Down at Rocky Flats		12,911			1,057	
Alternative 3 (with Plutonium Separation) **Pyro-Oxidize and Salt Distill at Rocky Flats**		**655**		**881**	**1,057**	
Pyro-Oxidize and Water Leach at Rocky Flats		13,994		855	32,011	
Pyro-Oxidize at Rocky Flats Salt Distill at Los Alamos National Laboratory		590 467		– 881	1,057 938	
Salt Scrub at Rocky Flats Purex at Savannah River Site		1,409 101	– 1	– 867	1,057 368	– 599
Direct Oxide Reduction Salt Residues						
Alternative 1 (No Action) Pyro-Oxidize at Rocky Flats	177	96			167	
Alternative 2 (without Plutonium Separation) Pyro-Oxidize and Blend Down at Rocky Flats		2,082			167	
Alternative 3 (with Plutonium Separation) Pyro-Oxidize and Water Leach at Rocky Flats		2,265		182	5,157	
Pyro-Oxidize at Rocky Flats Water Leach at Los Alamos National Laboratory		**96 2,234**		**– 188**	**167 5,141**	
Salt Scrub at Rocky Flats Purex at Savannah River Site		228 16	– <1	– 140	167 59	– 97

[a] To convert to pounds, multiply by 2.2.

Notes: Shaded areas indicate the types of solid products and waste that would not be generated. The products and wastes from the preferred processing option are presented in bold type. The storage capacities at each site are adequate to store the products and wastes listed in this table, except as noted in the text.

- **Direct Oxide Reduction Salt Residues**—The largest amount of transuranic waste (2,330 drums) would be generated at two sites in the option to pyro-oxidize at Rocky Flats and water leach at the Los Alamos National Laboratory, but two other options would generate almost as much (over 2,000 drums). These three options would generate much more transuranic waste than the remaining two options, which would generate no more than 244 drums. The quantities of low-level waste are low under all the options and the sites would manage this waste using routine procedures. The maximum amount of plutonium that could be separated from direct oxide reduction pyrochemical salt residues is 188 kg (414 lb).

4.3.2 Public and Occupational Health and Safety Impacts

This section describes the radiological and hazardous chemical impacts that could result from the alternatives associated with the management of salt residues. These impacts are presented for incident-free operation and postulated accident scenarios. The detailed site and transportation analyses are presented in Appendices D and E, respectively.

The round-trip highway distance from Rocky Flats to the Savannah River Site is 5,233 km (3,250 mi). If DOE decides to ship all the residues that might be electrorefining and molten salt extraction salt residues to the Savannah River Site for Purex processing, then 24 shipments would be required and the total round-trip shipping distance would be 126,000 km (78,000 mi). Shipping all the residues that might be direct oxide reduction salt residues to the Savannah River Site would require four shipments, and the total round-trip shipping distance would be 21,000 km (13,000 mi).

The round-trip highway distance from Rocky Flats to the Los Alamos National Laboratory is 1,468 km (910 mi). If DOE decides to ship all the residues that might be electrorefining and molten salt extraction salt residues to the Los Alamos National Laboratory for processing, then 52 shipments would be required and the total round-trip shipping distance would be 76,000 km (47,000 mi). Shipping all the residues that might be direct oxide reduction salt residues to the Los Alamos National Laboratory would require 13 shipments, and the total round-trip shipping distance would be 19,000 km (12,000 mi).

No construction of new facilities is included in any of the alternatives, but DOE may need to modify certain existing facilities for some of the alternatives. Mitigation measures during modifications would ensure that any radiological or hazardous chemical releases would be extremely small. Worker exposures to contaminated material would be limited to ensure that doses are maintained as low as reasonably achievable.

4.3.2.1 Incident-Free Operations

- **Radiological Impacts**

  - *Electrorefining and Molten Salt Extraction Salt Residues*—The radiological impacts to the public and the workers associated with incident-free operations of each option are presented in **Table 4-11**. The impacts due to the preferred processing option are presented in bold type. The impacts are those which are anticipated to occur as a result of process operations and transportation over whatever time period is necessary to process the entire inventory of electrorefining and molten salt extraction salt residues. The length of time necessary to process these residues will depend on which option DOE decides to implement. Impacts associated with subsequent incident-free storage of stabilized residues, separated plutonium, and wastes would be much smaller than from processing or transportation. Cumulative impacts are provided in Section 4.25.

Table 4–11 Radiological Impacts Due to Incident-Free Management of Pyrochemical Salt Residues

	Offsite Public Maximally Exposed Individual		*Offsite Public Population*		*Maximally Exposed Individual Involved Worker*		*Involved Worker Population*	
	Dose (mrem)	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*	*Dose (mrem/ yr)*	*Probability of a Latent Cancer Fatality per year*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*
Electrorefining and Molten Salt Extraction Salt Residues								
Alternative 1 (No Action)								
Pyro-Oxidize at Rocky Flats	0.000045	2.3×10^{-11}	0.0019	9.5×10^{-7}	2,000	0.0008	168	0.067
Alternative 2 (without Plutonium Separation)								
Pyro-Oxidize and Blend Down at Rocky Flats	0.00022	1.1×10^{-10}	0.0047	2.4×10^{-6}	2,000	0.0008	719	0.29
Alternative 3 (with Plutonium Separation)								
Pyro-Oxidize and Salt Distill at Rocky Flats	**0.000091**	**4.6×10^{-11}**	**0.0037**	**1.8×10^{-6}**	**2,000**	**0.0008**	**253**	**0.10**
Pyro-Oxidize and Water Leach at Rocky Flats	0.00043	2.2×10^{-10}	0.010	5.0×10^{-6}	2,000	0.0008	536	0.21
Pyro-Oxidize at Rocky Flats	0.000041	2.0×10^{-11}	0.0017	8.5×10^{-7}	2,000	0.0008	180	0.072
Transport to LANL	11	5.5×10^{-6}	1.4	0.0007	100	0.00004	2.2	0.00088
Salt Distill at LANL	0.00024	1.2×10^{-10}	0.00071	3.6×10^{-7}	2,000	0.0008	15	0.0060
Salt Scrub at Rocky Flats	0.000065	3.3×10^{-11}	0.0027	1.4×10^{-6}	2,000	0.0008	200	0.080
Transport to Savannah River Site	11	5.5×10^{-6}	0.66	0.0003	100	0.00004	3.7	0.0015
Purex at Savannah River Site [a]	0.0010	5.0×10^{-10}	0.11	0.000055	2,000	0.0008	106	0.042
Direct Oxide Reduction Salt Residues								
Alternative 1 (No Action)								
Pyro-Oxidize at Rocky Flats	6.2×10^{-6}	3.1×10^{-12}	0.00025	1.3×10^{-7}	2,000	0.0008	23	0.0092
Alternative 2 (without Plutonium Separation)								
Pyro-Oxidize and Blend Down at Rocky Flats	0.000031	1.6×10^{-11}	0.00066	3.3×10^{-7}	2,000	0.0008	100	0.040
Alternative 3 (with Plutonium Separation)								
Pyro-Oxidize and Water Leach at Rocky Flats	0.00015	7.5×10^{-11}	0.0031	1.6×10^{-6}	2,000	0.0008	115	0.046
Pyro-Oxidize at Rocky Flats	**0.000014**	**7.0×10^{-12}**	**0.00055**	**2.8×10^{-7}**	**2,000**	**0.0008**	**23**	**0.0092**
Transport to LANL	**11**	**5.5×10^{-6}**	**0.36**	**0.00018**	**100**	**0.00004**	**0.54**	**0.00022**
Water Leach at LANL	**0.000083**	**4.2×10^{-11}**	**0.00024**	**1.2×10^{-7}**	**2,000**	**0.0008**	**14**	**0.0056**
Salt Scrub at Rocky Flats	0.000010	5.0×10^{-12}	0.00041	2.0×10^{-7}	2,000	0.0008	29	0.012
Transport to Savannah River Site	11	5.5×10^{-6}	0.40	0.0002	100	0.00004	0.62	0.00025
Purex at Savannah River Site [a]	0.00014	7.0×10^{-11}	0.015	7.5×10^{-6}	2,000	0.0008	14	0.0056

LANL = Los Alamos National Laboratory

[a] Impacts to the public and workers are presented for F-Canyon operations. It has been determined that H-Canyon operations result in lower impacts to these groups.

Note: The impacts due to the preferred processing option are presented in bold type.

The highest estimated public maximally exposed individual dose in Table 4–11 is 11 mrem, which could occur only during transportation. This hypothetical individual's latent fatal cancer risk would be increased by less than one in one hundred thousand. The public maximally exposed individual risks near the sites would be much lower under all of the options. The highest total of the public population radiation doses listed in Table 4–11 would occur if DOE decides to implement the option to perform Purex processing at the Savannah River Site. The sum of these doses is 2.4 person-rem, which would cause far less than one additional latent fatal cancer among the population living near both sites and traveling along the truck route. The population living near the truck route would receive a much smaller radiation dose.

The highest involved worker population radiation dose would be 719 person-rem, which would occur if DOE decides to implement the option to pyro-oxidize and blend down at Rocky Flats. This dose would cause 0.29 additional latent cancer fatalities among the workers directly involved in the operation. Onsite workers who are not involved with the actual processing of the residues are designated as "noninvolved workers." The impacts to these workers would be expected to be much smaller than the impacts to the involved workers

- *Direct Oxide Reduction Salt Residues*—The radiological impacts to the public and the workers associated with incident-free operations of each option are presented in Table 4-11. The impacts due to the preferred processing option are presented in bold type. The impacts are those which are anticipated to occur as a result of process operations and transportation over whatever time period is necessary to process the entire inventory of direct oxide reduction salt residues. The length of time necessary to process these residues will depend on which option DOE decides to implement. Impacts associated with subsequent incident-free storage of stabilized residues, separated plutonium, and wastes would be much smaller than from processing or transportation. Cumulative impacts are provided in Section 4.25.

  The highest estimated public maximally exposed individual dose in Table 4-11 is 11 mrem, which could occur only during transportation. This hypothetical individual's latent fatal cancer risk would be increased by less than one in one hundred thousand. The public maximally exposed individual risks near the sites would be much lower under all of the options. The highest total of the public population radiation doses listed in Table 4-11 would occur if DOE decides to implement the option to water leach at the Los Alamos National Laboratory. The sum of these doses is 0.36 person-rem, which would cause far less than one additional latent fatal cancer among the population living near both sides and traveling along the truck route. The population living near the truck route would receive a much smaller radiation dose.

  The highest involved worker population radiation dose would be 115 person-rem, which would occur if DOE decides to implement the option to pyro-oxidize and water leach at Rocky Flats. This dose would cause 0.046 additional latent cancer fatalities among the workers directly involved in the operation. Onsite workers who are not involved with the actual processing of the residues are designated as "noninvolved workers." The impacts to these workers would be expected to be much smaller than the impacts to the involved workers.

❒ **Hazardous Chemical Impacts**—The impacts of exposure to hazardous chemicals from the processing and storage of pyrochemical salt residues at Rocky Flats and at the Los Alamos National Laboratory were not evaluated. Hazardous chemicals are not expected to be released from the proposed operations at these sites because they are not reported to be used in these technologies.

The processing at the Savannah River Site of the scrub alloy that results from salt scrubbing at Rocky Flats involves releases of only noncarcinogenic hazardous chemicals. The estimated offsite population

and noninvolved worker Hazard Index values presented in **Table 4–12** are less than one, which suggests that noncancer health effects as a result of releases of phosphoric acid, ammoniuim nitrate, and fluorides are not expected. The impacts due to the preferred processing option are presented in bold type.

Table 4–12 Chemical Impacts Due to Incident-Free Management of Pyrochemical Salt Residues

	Offsite Public Maximally Exposed Individual		*Offsite Public Population*	*Maximally Exposed Individual Worker*		*Worker Population*
	Probability of a Cancer Incidence	*Hazard Index*	*Number of Cancer Incidences or Fatalities* [a]	*Probability of a Cancer Incidence*	*Hazard Index*	*Number of Cancer Incidences or Fatalities* [a]
Electrorefining and Molten Salt Extraction Salt Residues						
Alternative 1 (No Action)						
Pyro-Oxidize at Rocky Flats [b]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 2 (without Plutonium Separation)						
Pyro-Oxidize and Blend Down at Rocky Flats [b]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 3 (with Plutonium Separation)						
Pyro-Oxidize and Salt Distill at Rocky Flats [b]	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**
Pyro-Oxidize and Water Leach at Rocky Flats [b]	N/E	N/E	N/E	N/E	N/E	N/E
Pyro-Oxidize at Rocky Flats [b]	N/E	N/E	N/E	N/E	N/E	N/E
Transport to Los Alamos National Laboratory	N/A	N/A	0.00024 [c]	N/A	N/A	(c)
Salt Distill at Los Alamos National Laboratory [b]	N/E	N/E	N/E	N/E	N/E	N/E
Salt Scrub at Rocky Flats [b]	N/E	N/E	N/E	N/E	N/E	N/E
Transport to Savannah River Site	N/A	N/A	0.00011 [c]	N/A	N/A	(c)
Purex at Savannah River Site [d, e]	N/E	0.022	N/E	N/E	0.33	N/E
Direct Oxide Reduction Salt Residues						
Alternative 1 (No Action)						
Pyro-Oxidize at Rocky Flats [b]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 2 (without Plutonium Separation)						
Pyro-Oxidize and Blend Down at Rocky Flats [b]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 3 (with Plutonium Separation)						
Pyro-Oxidize and Water Leach at Rocky Flats [b]	N/E	N/E	N/E	N/E	N/E	N/E
Pyro-Oxidize at Rocky Flats [b]	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**
Transport to Los Alamos National Laboratory	**N/A**	**N/A**	**0.00006 [c]**	**N/A**	**N/A**	**(c)**
Water Leach at Los Alamos National Laboratory [b]	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**
Salt Scrub at Rocky Flats [b]	N/E	N/E	N/E	N/E	N/E	N/E
Transport to Savannah River Site	N/A	N/A	0.00002 [c]	N/A	N/A	(c)
Purex at Savannah River Site [d, e]	N/E	0.005	N/E	N/E	0.07	N/E

N/E = no emissions N/A = not applicable—the maximally exposed individual is undefined for vehicle emissions

[a] Cancer incidences and fatalities are calculated for process emissions and transportation emissions, respectively.

[b] No hazardous chemicals are released from process; therefore, no associated health risks exist.

[c] Cancer fatalities due to vehicle emissions into the air. This impact is listed only once under public population because the vehicle emissions affect the public and worker populations collectively. However, the risk to the public dominates. See Appendix E, Section E.4 for additional details.

[d] Impacts are presented for F-Canyon operations. H-Canyon operations are expected to result in similar or lower impacts.

[e] No carcinogenic chemicals are released from the process; therefore, only noncancer health risks are evaluated.

Note: The impacts due to the preferred processing option are presented in bold type.

4.3.2.2 Accidents

The potential radiological impacts to the public and the noninvolved onsite workers due to accidents with pyrochemical salt residues are summarized and presented in this section. The detailed analysis of onsite accidents, with the associated assumptions, is presented in Appendix D, Section D.3. The detailed analysis considered a wide spectrum of potential accident scenarios, including fire, explosion, spill, criticality, earthquake, and aircraft crash. The accident scenarios with the highest consequences and risks were selected and carried forward to this section for the purpose of consequence and risk comparison. A composite of the risk due to major onsite accident scenarios in each spectrum (including the nonbounding accidents) was also

computed and used for comparisons. The composite risk estimates are accurate enough for the purpose of comparing processing options against each other. The detailed analysis of transportation accidents, with the associated assumptions, is presented in Appendix E, Sections E.5 and E.6.

The accident frequencies and process durations of the selected accidents are presented in **Table 4–13**. The impacts due to the preferred processing option are presented in bold type. The onsite accident frequencies are given on a per year basis because many accidents, such as earthquakes, are commonly expressed this way. The duration of each process is given in years. The actual probability of occurrence of each onsite accident can be obtained by multiplying the accident frequency times the option's duration. In this way, the calculated probabilities are based on the total amount of residue in this category rather than a standard unit of time.

The calculation of accident probability is slightly different for traffic accident fatalities. The frequency of traffic accidents is given in terms of the number of fatal accidents per round trip shipment from Rocky Flats to the Savannah River Site or to Los Alamos National Laboratory, as appropriate. The process duration for traffic accidents is given as the number of round trip shipments. Thus, the actual probability of a fatal traffic accident can be obtained by multiplying the frequency (fatal accidents per round-trip shipment) times the duration (number of round-trip shipments).

The consequences for the public and a noninvolved onsite worker are also presented in Table 4–13, for the direct oxide reduction and the electrorefining and molten salt extraction pyrochemical salt residues. Five processing options are under consideration for the direct oxide reduction salt residues and six processing options are under consideration for the electrorefining and molten salt extraction salt residues.

The risks associated with each accident are calculated by multiplying the probability times the consequences. The risks to the public and an onsite worker are presented in **Table 4–14**, for each of the processing options for pyrochemical salt residue. The risk associated with the highest risk accident and a composite risk associated with all major accidents are both presented. The risks associated with the preferred processing option are presented in bold type.

The public maximally exposed individual is a hypothetical individual who resides at the site boundary in the downwind direction. The public population is defined as the residential population within a radius of 80 km (50 mi). A noninvolved onsite worker is defined as an individual worker who is located 100 m (328 ft) or more downwind from the release point when an accidental release of radioactive material occurs.

- **Electrorefining and Molten Salt Extraction Salt Residues**—The highest consequences to all three receptors would occur if DOE decides to implement Alternative 1, the pyro-oxidize option at Rocky Flats, and a major earthquake strong enough to cause the collapse of Building 707 occurs during residue processing. The highest risk to the public maximally exposed individual is estimated to be 0.000020, which is due to either an earthquake during processing of the residue with the blend down option in Building 707, an earthquake during processing of the residue with the salt distillation option at Rocky Flats, or an earthquake during preprocessing of the residue at Rocky Flats for the salt distillation option at Los Alamos National Laboratory. This individual's chance of incurring a latent cancer fatality would be increased by less than one in ten thousand. The highest risk to the public population is estimated to be 0.34 latent cancer fatalities, which is due to either an earthquake during processing of the residue with the pyro-oxidize option, an earthquake during processing of the residue with the blend down option in Building 707, an earthquake during processing of the residue with the salt distillation option at Rocky Flats, or an earthquake during preprocessing of the residue at Rocky Flats for the salt distillation option at Los Alamos National Laboratory. The highest risk to the individual noninvolved onsite worker is estimated to be 0.00035, which is due to the same four earthquake-initiated accidents listed for the public population. This individual's chance of incurring a latent cancer fatality would be increased by less than one in one thousand.

Table 4–13 Accident Frequencies, Process Durations, and Consequences for Accidents with Pyrochemical Salt Residues

				Offsite Public Maximally Exposed Individual Consequences		*Offsite Public Population Consequences*		*Noninvolved Onsite Worker Consequences*	
	Accident Scenario	*Accident Frequency (per year)*	*Process Duration (years)*	*Dose (mrem)*	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer or Traffic Fatalities*	*Dose (mrem)*	*Probability of a Latent Cancer Fatality*
Electrorefining and Molten Salt Extraction Salts									
Alternative 1 (No Action)									
Pyro-Oxidize at Rocky Flats	Earthquake (Bldg. 707)	0.0018	1.28	16,700	0.0084	293,000	147	188,000	0.15
Alternative 2 (without Plutonium Separation)									
Pyro-Oxidize and Blend Down at Rocky Flats	Earthquake (Bldg. 707)	0.0018	10.37	2,090	0.0011	36,600	18	23,500	0.019
	Earthquake (Bldg. 371) [a]	0.000094	10.37	3,140	0.0016	36,600	18	23,500	0.019
Alternative 3 (with Plutonium Separation)									
Pyro-Oxidize and Salt Distill at Rocky Flats	**Earthquake (Bldg. 707)**	**0.0018**	**2.41**	**9,000**	**0.0045**	**158,000**	**79**	**101,000**	**0.081**
Pyro-Oxidize and Water Leach at Rocky Flats	Earthquake (Bldg. 371) [b]	0.000094	2.10	15,500	0.0078	181,000	91	116,000	0.093
	Earthquake (Bldg 707A) [c]	0.0008	1.61	12,200	0.0061	227,000	114	148,000	0.12
Pyro-Oxidize at Rocky Flats	Earthquake (Bldg. 707)	0.0018	2.41	9,000	0.0045	158,000	79	101,000	0.081
Transport to Los Alamos National Laboratory	Traffic Fatality	7.4×10^{-6} per shipment	52 shipments	N/A	N/A	N/A	1.0 [d]	N/A	[e]
Salt Distill at Los Alamos National Laboratory	Earthquake	0.0005	5.36	13,500	0.0068	17,800	8.9	146,000	0.12
Salt Scrub at Rocky Flats	Earthquake (Bldg. 707)	0.0018	1.42	9,400	0.0047	165,000	83	106,000	0.085
Transport to Savannah River Site	Traffic Fatality	0.00010 per shipment	24 shipments	N/A	N/A	N/A	1.0 [d]	N/A	[e]
Purex at Savannah River Site	Earthquake (H-Canyon)	0.000182	1.98	407	0.00020	18,100	9.1	136,000	0.11

	Accident Scenario	Accident Frequency (per year)	Process Duration (years)	Offsite Public Maximally Exposed Individual Consequences		Offsite Public Population Consequences		Noninvolved Onsite Worker Consequences	
				Dose (mrem)	Probability of a Latent Cancer Fatality	Dose (person-rem)	Number of Latent Cancer or Traffic Fatalities	Dose (mrem)	Probability of a Latent Cancer Fatality
Direct Oxide Reduction Salts									
Alternative 1 (No Action)									
Pyro-Oxidize at Rocky Flats	Earthquake (Bldg. 707)	0.0018	0.18	16,700	0.0084	293,000	147	188,000	0.15
Alternative 2 (without Plutonium Separation)									
Pyro-Oxidize and Blend Down at Rocky Flats	Earthquake (Bldg. 707)	0.0018	2.21	2,090	0.0011	36,600	18	23,500	0.019
	Earthquake (Bldg. 371) [e]	0.000094	2.21	3,140	0.0016	36,600	18	23,500	0.019
Alternative 3 (with Plutonium Separation)									
Pyro-Oxidize and Water Leach at Rocky Flats	Earthquake (Bldg. 371) [a]	0.000094	0.45	15,500	0.0078	181,000	91	116,000	0.093
	Earthquake (Bldg 707A) [b]	0.0008	0.34	12,200	0.0061	227,000	114	148,000	0.12
Pyro-Oxidize at Rocky Flats	**Earthquake (Bldg. 707)**	**0.0018**	**0.56**	**8,310**	**0.0042**	**145,000**	**73**	**93,500**	**0.075**
Transport to Los Alamos National Laboratory	**Traffic Fatality**	**7.4×10^{-6} per shipment**	**13 shipments**	**N/A**	**N/A**	**N/A**	**1.0 [d]**	**N/A**	**(e)**
Water Leach at Los Alamos National Laboratory	**Earthquake**	**0.0005**	**1.10**	**15,100**	**0.0076**	**19,800**	**9.9**	**163,000**	**0.13**
Salt Scrub at Rocky Flats	Earthquake (Bldg. 707)	0.0018	0.30	9,400	0.0047	165,000	83	106,000	0.085
Transport to Savannah River Site	Traffic Fatality	0.00010 per shipment	4 shipments	N/A	N/A	N/A	1.0 [d]	N/A	(e)
Purex at Savannah River Site	Earthquake (H-Canyon)	0.000182	0.27	407	0.00020	18,100	9.1	136,000	0.11

N/A = not applicable

[a] Building 371 is designated as an alternate location for the Pyro-Oxidize and Blend Down process at Rocky Flats

[b] Water Leach process in Building 371.

[c] Final calcination process in Building 707A.

[d] This fatality is due to the mechanical impact of the accident, not cancer due to radiation. The radiological consequences of a radioactive release on the highway are impossible to list in a single number because the accident could occur at any point along the route and meteorological conditions and population distributions vary greatly along the route.

[e] The consequence of a high-speed traffic accident would be at least one fatality among the transportation workers due to trauma.

Note: The impacts due to the preferred processing option are presented in bold type.

Table 4–14 Risks Due to Accidents with Pyrochemical Salt Residues

	Accident Scenario	Offsite Public Maximally Exposed Individual Risk (Probability of a Latent Cancer Fatality)	Offsite Public Population Risk (Number of Latent Cancer or Traffic Fatalities)	Noninvolved Onsite Worker Risk (Probability of a Latent Cancer Fatality)
Electrorefining and Molten Salt Extraction Salts				
Alternative 1 (No Action)				
Pyro-Oxidize at Rocky Flats	Earthquake (Bldg. 707)	0.000019	0.34	0.00035
	Composite	0.000020	0.34	0.00035
Alternative 2 (without Plutonium Separation)				
Pyro-Oxidize and Blend Down at Rocky Flats	Earthquake (Bldg. 707)	0.000020	0.34	0.00035
	Composite (Bldg. 707)	0.000020	0.35	0.00036
	Earthquake (Bldg. 371) [a]	1.5×10^{-6}	0.018	0.000018
	Composite (Bldg. 371) [a]	2.2×10^{-6}	0.025	0.000022
Alternative 3 (with Plutonium Separation)				
Pyro-Oxidize and Water Leach at Rocky Flats	Earthquake (Bldg. 371) [b]	1.5×10^{-6}	0.018	0.000018
	Composite (Bldg. 371) [b]	2.2×10^{-6}	0.026	0.000022
	Earthquake (Bldg. 707A) [c]	7.9×10^{-6}	0.15	0.00016
	Composite (Bldg. 707A) [c]	8.2×10^{-6}	0.15	0.00016
Pyro-Oxidize and Salt Distill at Rocky Flats	**Earthquake (Bldg. 707)**	**0.000020**	**0.34**	**0.00035**
	Composite	**0.000020**	**0.35**	**0.00036**
Pyro-Oxidize at Rocky Flats	Earthquake (Bldg. 707)	0.000020	0.34	0.00035
	Composite	0.000020	0.35	0.00036
Transport to Los Alamos National Laboratory	Traffic Fatality	N/A	0.00038 [d]	N/A
	Radioactive Release	N/A	3.2×10^{-7}	N/A
Salt Distill at Los Alamos National Laboratory	Earthquake	0.000018	0.024	0.00031
	Composite	0.000018	0.024	0.00032
Salt Scrub at Rocky Flats	Earthquake (Bldg. 707)	0.000012	0.21	0.00022
	Composite	0.000012	0.22	0.00022
Transport to Savannah River Site	Traffic Fatality	N/A	0.00018 [d]	N/A
	Radioactive Release	N/A	1.9×10^{-7}	N/A
Purex at Savannah River Site	Earthquake (H-Canyon)	7.3×10^{-8}	0.0033	0.000039
	Composite	1.1×10^{-7}	0.0053	0.000039

	Accident Scenario	Offsite Public Maximally Exposed Individual Risk (Probability of a Latent Cancer Fatality)	Offsite Public Population Risk (Number of Latent Cancer or Traffic Fatalities)	Noninvolved Onsite Worker Risk (Probability of a Latent Cancer Fatality)
Direct Oxide Reduction Salts				
Alternative 1 (No Action)				
Pyro-Oxidize at Rocky Flats	Earthquake (Bldg. 707)	2.7×10^{-6}	0.047	0.000049
	Composite	2.8×10^{-6}	0.048	0.000049
Alternative 2 (without Plutonium Separation)				
Pyro-Oxidize and Blend Down at Rocky Flats	Earthquake (Bldg. 707)	4.2×10^{-6}	0.073	0.000075
	Composite (Bldg. 707)	4.3×10^{-6}	0.074	0.000076
	Earthquake (Bldg. 371) [a]	$3.2.10^{-7}$	0.0038	3.9×10^{-6}
	Composite (Bldg. 371) [a]	4.6×10^{-7}	0.0053	4.7×10^{-6}
Alternative 3 (with Plutonium Separation)				
Pyro-Oxidize and Water Leach at Rocky Flats	Earthquake (Bldg. 371) [b]	3.3×10^{-7}	0.0038	3.9×10^{-6}
	Composite (Bldg. 371) [b]	4.8×10^{-7}	0.0055	4.7×10^{-6}
	Earthquake (Bldg. 707A) [c]	1.7×10^{-6}	0.031	0.000032
	Composite (Bldg. 707A) [c]	1.7×10^{-6}	0.032	0.000033
Pyro-Oxidize at Rocky Flats	**Earthquake (Bldg. 707)**	**4.2×10^{-6}**	**0.073**	**0.000076**
	Composite	**4.3×10^{-6}**	**0.075**	**0.000076**
Transport to Los Alamos National Laboratory	**Traffic Fatality**	**N/A**	**0.00010 [c]**	**N/A**
	Radioactive Release	**N/A**	**4.4×10^{-7}**	**N/A**
Water Leach at Los Alamos National Laboratory	**Earthquake**	**4.2×10^{-6}**	**0.0055**	**0.000072**
	Composite	**4.2×10^{-6}**	**0.0055**	**0.000072**
Salt Scrub at Rocky Flats	Earthquake (Bldg. 707)	2.5×10^{-6}	0.044	0.000046
	Composite	2.6×10^{-6}	0.045	0.000046
Transport to Savannah River Site	Traffic Fatality	N/A	0.0003 [c]	N/A
	Radioactive Release	N/A	2.6×10^{-8}	N/A
Purex at Savannah River Site	Earthquake (H-Canyon)	1.0×10^{-8}	0.00044	5.3×10^{-6}
	Composite	1.5×10^{-8}	0.00073	5.3×10^{-6}

N/A = not applicable
[a] Building 371 is designated as an alternate location for the Pyro-Oxidize and Blend Down process at Rocky Flats.
[b] Water Leach process in Building 371.
[c] Final calcination process in Building 707A.
[d] This risk is due to the mechanical impact of a potential accident, not cancer due to radiation. This risk includes members of the public and transportation workers.
Note: The risks due to the preferred processing option are presented in bold type.

- **Direct Oxide Reduction Salt Residues**—The highest consequences to all three receptors would occur if DOE decides to implement Alternative 1, the pyro-oxidize option at Rocky Flats and a major earthquake strong enough to cause the collapse of Building 707 occurs during residue processing.

  The highest risk to the public maximally exposed individual is estimated to be 4.2×10^{-6}, which is due to either an earthquake during processing of the residue with the blend down option in Building 707, an earthquake during preprocessing of the residue at Rocky Flats for the water leach option at Los Alamos National Laboratory, or an Earthquake during processing of the residue with the water leach option at Los Alamos National Laboratory. This individual's chance of incurring a latent cancer fatality would be increased by less than one in one hundred thousand. The highest risk to the public population is estimated to be 0.073 latent cancer fatalities, which is due to either an earthquake during processing of the residue with the blend down option in Building 707 or an earthquake during preprocessing of the residue at Rocky Flats for the water leach option at Los Alamos National Laboratory.

  The highest risk to the individual noninvolved onsite worker is estimated to be 0.000076, which is due to an earthquake during preprocessing of the residue at Rocky Flats for the water leach option at Los Alamos National Laboratory. This individual's chance of incurring a latent cancer fatality would be increased by less than one in ten thousand.

4.4 Impacts of Managing Combustible Residues

The inventory of combustible residues assessed in this EIS weighs 1,140 kg (2,513 lb), including 21.3 kg (47 lb) of plutonium. This inventory is stored in 70 drums with no internal metal containers.

As discussed in Chapter 2, the alternatives for combustible residues include one option under the No Action Alternative, four options under the Process without Plutonium Separation Alternative, and one option under the Process with Plutonium Separation Alternative. The no action processing option is a combination of three different types of processes, one for each subcategory of combustible residues. The preferred processing option is identical to the no action processing option.

This section presents the environmental impacts of managing the entire inventory of combustible residues under each of the six options. The results in this section were used in the calculation of the total impacts of the No Action Alternative and the Preferred Management Approach which are presented in Section 4.20 and 4.21, respectively, and of the rest of the management approaches which are presented in Section 4.22.

4.4.1 Products and Wastes

Every processing option for combustible residues would generate some quantity of transuranic waste and would prepare this waste for disposal in WIPP. Every option would also generate some quantity of low-level waste, which would be disposed of routinely using existing procedures at Rocky Flats. A small portion of the low-level waste generated at Rocky Flats could possibly be low-level mixed waste, but this waste would also be disposed of routinely using existing procedures. The No Action Alternative would generate stabilized residues, containing plutonium in excess of the safeguards termination limits. The Process without Plutonium Separation Alternative would generate transuranic waste directly from the residue. The stabilized residues and transuranic waste would be placed in pipe components inside 210-L (55-gal) drums as shown in Figure 2-13 in Chapter 2.

High-level waste and saltstone would not be generated from combustible residues because none of the options involve shipping the residues to the Savannah River Site for plutonium separation. If plutonium is separated at Rocky Flats, it would be stored securely onsite until a decision is made on its disposition. No increase in

proliferation risk would result and this plutonium would not be used for nuclear explosive purposes. This separated plutonium would also contain the americium from the combustible residues.

The solid plutonium-bearing products and wastes that would be generated from combustible residues under each of the options are presented in **Table 4–15**. The shaded areas of Table 4–15 indicate types of solid products and wastes that would not be generated under the various options. The products and wastes from the preferred processing option are presented in bold type. The largest amount of transuranic waste (1,276 drums) would be generated in the catalytic chemical oxidation option, but the mediated electrochemical oxidation option would generate almost as much (1,220 drums). These two options would generate much more transuranic waste than the other options, which would generate no more than 423 drums. The quantities of low-level waste are low under all the options and the site would manage this waste using routine procedures. The maximum amount of plutonium that could be separated from combustible residues is 21 kg (46 lb).

Table 4–15 Products and Wastes from Combustible Residues

	Stabilized Residues (Drums)	*Transuranic Waste (Drums)*	*High-Level Waste (Canisters of Glass)*	*Separated Plutonium (kg)*[a]	*Low-Level Waste (Drums)*	*Saltstone (cubic yards)*
Alternative 1 (No Action) **Combination at Rocky Flats**	**220**	**92**			**230**	
Alternative 2 (without Plutonium Separation) Sonic Wash at Rocky Flats		423			230	
Catalytic Chemical Oxidation at Rocky Flats		1,276			2,727	
Thermal Destruction at Rocky Flats		219			230	
Shred and Blend Down at Rocky Flats		220			230	
Alternative 3 (with Plutonium Separation) Mediated Electrochemical Oxidation at Rocky Flats		1,220		21	2,783	

[a] To convert to pounds, multiply by 2.2.

Notes: Shaded areas indicate the types of solid products and waste that would not be generated. The products and wastes from the preferred processing option are presented in bold type. The storage capacities at each site are adequate to store the products and wastes listed in this table.

The no action processing option and the preferred processing option are identical and they would both generate about 220 drums of stabilized residues, containing plutonium in excess of the safeguards termination limits. For the combustible residues, however, DOE has decided to grant variances to these limits, which will allow these 220 drums to be disposed of in WIPP.

4.4.2 Public and Occupational Health and Safety Impacts

This section describes the radiological and hazardous chemical impacts that could result from the alternatives associated with the management of combustible residues. These impacts are presented for incident-free operation and postulated accident scenarios, respectively. The detailed site analyses are presented in Appendix D. No construction of new facilities is included in any of the alternatives, but DOE may need to modify certain existing facilities for some of the alternatives. Mitigation measures during modifications would ensure that any radiological or hazardous chemical releases would be extremely small. Worker exposures to contaminated material would be limited to assure that doses are maintained as low as reasonably achievable.

4.4.2.1 Incident-Free Operations

- **Radiological Impacts**—The radiological impacts to the public and the workers associated with incident-free operations of each option are presented in **Table 4–16**. The impacts due to the preferred processing option are presented in bold type. The impacts are those which are anticipated to occur as a result of process operations over whatever time period is necessary to process the entire inventory of combustible residues. The length of time necessary to process the combustible residues will depend on which option DOE decides to implement. Impacts associated with subsequent incident-free storage of stabilized residues, separated plutonium, and wastes would be much smaller than from processing. Cumulative impacts are provided in Section 4.25.

  The highest estimated public maximally exposed individual dose in Table 4–16 is 7.4×10^{-6} mrem, which would occur during the mediated electrochemical oxidation process at Rocky Flats. This hypothetical individual's latent fatal cancer risk would be increased by less than one in one-hundred billion. The highest public population radiation dose listed in Table 4–16 would also occur for the mediated electrochemical oxidation process, if DOE decides to implement this option. This dose is estimated to be 0.00016 person-rem, which would cause far less than one additional latent fatal cancer among the population living near Rocky Flats.

  The highest involved worker population radiation dose would be 42 person-rem, which would occur if DOE decides to implement the catalytic chemical oxidation dissolution (digestion) option. This dose would cause 0.017 additional latent fatal cancers among the workers directly involved in the operation. Onsite workers who are not involved with the actual processing of the residues are designated as "noninvolved workers." The impacts to these workers would be expected to be much smaller than the impacts to the involved workers.

- **Hazardous Chemical Impacts**—The processing and storage of combustible residues at Rocky Flats involves potential releases of carcinogenic and noncarcinogenic chemicals. Under Alternative 1, the thermal desorption processing of organic contaminated combustible residues releases the carcinogen carbon tetrachloride. The probability of excess latent cancer incidence to the public maximally exposed individual as a result of exposure to carbon tetrachloride is 3×10^{-10} (**Table 4–17**). This hypothetical individual's latent cancer incidence risk would be increased by less than one in one billion. Carbon tetrachloride is no longer used at Rocky Flats, but is present in small amounts in some of the residues. The impacts due to the preferred processing option are presented in bold type. Carbon tetrachloride produces central nervous system, pulmonary system, gastrointestinal system, and other systemic toxic effects in humans (Sax and Lewis 1987). The compound is an eye and skin irritant and damages the liver, kidneys, and lungs (Lewis 1991). The liver is the primary target organ for carbon tetrachloride toxicity (EPA 1991a). Less than one excess latent cancer incidence is estimated to occur in the offsite population of 2.4 million individuals living within an 80-km (50-mi) radius of Rocky Flats. The maximally exposed individual worker probability of excess latent cancer incidence is 4×10^{-9}. If all site workers were exposed to the maximally exposed individual concentration of carbon tetrachloride, which is an extremely conservative and unrealistic assumption, less than 1 excess latent cancer would be expected to occur in the workforce population.

  For the sonic wash processing at Rocky Flats, the offsite population maximally exposed individual cancer risk is estimated to be five chances in one hundred billion (5×10^{-11}). Less than one excess latent cancer incidence is estimated to occur in the offsite population of 2.4 million individuals living within an 80 km (50-mi) radius of Rocky Flats. The maximally exposed individual worker probability of excess latent cancer incidence is 3×10^{-9}. If all site workers were exposed to the maximally exposed individual concentration of carbon tetrachloride, less than 1 excess latent cancer would be expected to occur in the workforce population (Table 4–17).

Table 4–16 Radiological Impacts Due to Incident-Free Management of Combustible Residues

	Offsite Public Maximally Exposed Individual		*Offsite Public Population*		*Maximally Exposed Individual Involved Worker*		*Involved Worker Population*	
	Dose (mrem)	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*	*Dose (mrem per year)*	*Probability of a Latent Cancer Fatality per year*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*
Alternative 1 (No Action)								
Combination at Rocky Flats	**3.6×10^{-6}**	**1.8×10^{-12}**	**0.000081**	**4.1×10^{-8}**	**2,000**	**0.0008**	**38**	**0.015**
Alternative 2 (without Plutonium Separation)								
Sonic Wash at Rocky Flats	7.0×10^{-6}	3.5×10^{-12}	0.00015	7.5×10^{-8}	2,000	0.0008	17	0.0068
Catalytic Chemical Oxidation at Rocky Flats	4.5×10^{-6}	2.3×10^{-12}	0.000096	4.8×10^{-8}	2,000	0.0008	42	0.017
Thermal Destruction at Rocky Flats	9.0×10^{-7}	4.5×10^{-13}	0.000037	1.9×10^{-8}	2,000	0.0008	16	0.0064
Shred and Blend Down at Rocky Flats	3.0×10^{-6}	1.5×10^{-12}	0.000064	3.2×10^{-8}	2,000	0.0008	6.8	0.0027
Alternative 3 (with Plutonium Separation)								
Mediated Electrochemical Oxidation at Rocky Flats	7.4×10^{-6}	3.7×10^{-12}	0.00016	8.0×10^{-8}	2,000	0.0008	11	0.0044

Note: The impacts due to the preferred processing option are presented in bold type.

Table 4–17 Chemical Impacts Due to Incident-Free Management of Combustible Residues

	Offsite Public Maximally Exposed Individual		*Offsite Public Population*	*Maximally Exposed Individual Worker*		*Worker Population*
	Probability of Cancer Incidence	*Hazard Index*	*Number of Cancer Incidences*	*Probability of Cancer Incidence*	*Hazard Index*	*Number of Cancer Incidences*
Alternative 1 (No Action)						
Combination at Rocky Flats [a]	**8×10^{-11}**	**N/E**	**<1 [b]**	**4×10^{-9}**	**N/E**	**<1 [c]**
Alternative 2 (without Plutonium Separation)						
Sonic Wash at Rocky Flats [a]	5×10^{-11}	N/E	<1 [b]	3×10^{-9}	N/E	<1 [c]
Catalytic Chemical Oxidation at Rocky Flats [d]	N/E	0.006	N/E	N/E	0.2	N/E
Thermal Destruction at Rocky Flats	(e)	(e)	(e)	(e)	(e)	(e)
Shred and Blend Down at Rocky Flats [f]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 3 (with Plutonium Separation)						
Mediated Electrochemical Oxidation at Rocky Flats[f]	N/E	N/E	N/E	N/E	N/E	N/E

N/E = no emissions

[a] Only carcinogenic chemicals are released from the process; therefore, only cancer health risks are evaluated.

[b] In population of 2.4 million individuals living within 80 km (50 mi) of Rocky Flats.

[c] Based on the extremely conservative assumption that entire Rocky Flats workforce is exposed to the maximally exposed individual concentration.

[d] No carcinogenic chemicals are released from the process; therefore, only noncancer health risks are evaluated.

[e] The hazardous chemical impacts due to installing and operating an incinerator at Rocky Flats are not included in this EIS because this processing option is not a reasonable processing option. If DOE decides to implement this option, then extensive additional analysis would be required. This additional analysis could support additional National Environmental Policy Act (NEPA) documentation and a permit from the State of Colorado, both of which could provide opportunities for additional public input.

[f] No hazardous chemicals are released from process; therefore, no associated health risks exist. See Section 4.12 for additional information.

Note: The impacts due to the preferred processing option are presented in bold type.

The catalytic chemical oxidation process at Rocky Flats would involve the release of hydrochloric acid. Hydrochloric acid is toxic following ingestion and inhalation exposure. The compound is a strong eye, skin, and mucous membrane irritant (Lewis 1991). The estimated Hazard Index values presented in Table 4–17 are less than one for both the offsite population maximally exposed individual and the noninvolved worker maximally exposed individual, which suggests that noncancer health effects are not expected.

The hazardous chemical impacts due to installing and operating an incinerator at Rocky Flats are not included in this EIS because this processing option is not a reasonable processing option. If DOE decides to implement this option, then extensive additional analysis would be required. This additional analysis could support additional NEPA documentation and a permit from the State of Colorado, both of which could provide opportunities for additional public input.

4.4.2.2 Accidents

The potential radiological impacts to the public and the noninvolved onsite workers due to accidents with combustible residues are summarized and presented in this section. The detailed analysis of onsite accidents, with the associated assumptions, is presented in Appendix D, Section D.3. The detailed analysis considered a wide spectrum of potential accident scenarios, including fire, explosion, spill, criticality, earthquake, and aircraft crash. The accident scenarios with the highest consequences and risks were selected and carried forward to this section for the purpose of consequence and risk comparison. A composite of the risks due to major onsite accident scenarios in each spectrum (including the nonbounding accidents) was also computed and used for comparisons. The composite risk estimates are accurate enough for the purpose of comparing processing options against each other.

The accident frequencies and process durations of the selected accidents are presented in **Table 4–18**. The impacts due to the preferred processing option are presented in bold type. The onsite accident frequencies are given on a per year basis because many accidents, such as earthquakes, are commonly expressed this way. The duration of each process is given in years. The actual probability of occurrence of each onsite accident can be obtained by multiplying the accident frequency times the option's duration. In this way, the calculated probabilities are based on the total amount of residue in this category rather than a standard unit of time.

The consequences for the public and a noninvolved onsite worker are also presented in Table 4–18 for each of the six combustible residue processing options. The public maximally exposed individual is a hypothetical individual who resides at the site boundary in the downwind direction. The public population is defined as the residential population within a radius of 80 km (50 mi). A noninvolved onsite worker is defined as an individual worker who is located 100 m (328 ft) or more downwind from the release point when an accidental release of radioactive material occurs. The highest consequence to the maximally exposed individual would occur if DOE decides to implement either the neutralize and dry, the thermal desorption and steam passivation, the sonic wash, the catalytic chemical oxidation, the blend down, or the mediated electrochemical oxidation option at Rocky Flats and a fire occurs on the loading dock of Building 371. The highest consequence to the public population and the noninvolved onsite worker would occur if DOE decides to implement the mediated electrochemical oxidation process at Rocky Flats and a dock fire occurs in Building 707A during the final calcination.

The risks associated with each accident are calculated by multiplying the probability times the consequences. The risks to the public and an onsite worker are presented in **Table 4–19** for each of the six combustible residue processing options. (The No Action processing option is actually a combination of three processing options, one for each kind of combustible residue.) The risk associated with the highest risk accident and a composite risk associated with all major accidents are both presented. The risks associated with the preferred processing option are presented in bold type.

Table 4–18 Accident Frequencies, Process Durations, and Consequences for Accidents with Combustible Residues

				Offsite Public Maximally Exposed Individual Consequences		*Offsite Public Population Consequences*		*Noninvolved Onsite Worker Consequences*	
	Accident Scenario	*Accident Frequency (per year)*	*Process Duration (years)*	*Dose (mrem)*	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*	*Dose (mrem)*	*Probability of a Latent Cancer Fatality*
Alternative 1 (No Action)									
Neutralize and Dry at Rocky Flats (Aqueous Contaminated Residue)	**Dock Fire (Bldg. 371) [a]**	**2.0×10^{-6}**	**0.15**	**1,800**	**0.00090**	**21,000**	**11**	**14,000**	**0.0056**
	Room Fire (Bldg. 371) [b]	**0.0005**	**0.15**	**219**	**0.00011**	**2,560**	**1.3**	**1,710**	**0.00068**
Thermal Desorption and Steam Passivation at Rocky Flats (Organic Contaminated Residue)	**Dock Fire (Bldg. 371) [a]**	**2.0×10^{-6}**	**0.48**	**1,800**	**0.00090**	**21,000**	**11**	**14,000**	**0.0056**
	Room Fire (Bldg. 371) [b]	**0.0005**	**0.48**	**48**	**0.000024**	**557**	**0.28**	**371**	**0.00015**
Repackage at Rocky Flats (Dry contaminated Residue)	**Dock Fire (Bldg. 707) [a]**	**2.0×10^{-6}**	**0.013**	**1,200**	**0.00060**	**21,000**	**11**	**14,000**	**0.0056**
	Earthquake (Bldg. 707) [b]	**0.0018**	**0.013**	**562**	**0.00028**	**9,830**	**4.9**	**6,550**	**0.0026**
Alternative 2 (without Plutonium Separation)									
Sonic Wash at Rocky Flats	Dock Fire (Bldg. 371) [a]	2.0×10^{-6}	0.31	1,800	0.00090	21,000	11	14,000	0.0056
	Room Fire (Bldg. 371) [b]	0.0005	0.31	151	0.000076	1,760	0.88	1,170	0.00047
Catalytic Chemical Oxidation at Rocky Flats	Dock Fire (Bldg. 371) [a]	2.0×10^{-6}	1.03	1,800	0.00090	21,000	11	14,000	0.0056
	Room Fire (Bldg. 371) [b]	0.0005	1.03	110	0.000055	1,280	0.64	854	0.00034
Thermal Destruction at Rocky Flats	Dock Fire (Bldg. 776) [a]	2.0×10^{-6}	0.31	1,200	0.00060	21,000	11	14,000	0.0056
	Earthquake (Bldg. 776) [b]	0.0010	0.31	92	0.000046	1,600	0.8	1,070	0.00043
Shred and Blend Down at Rocky Flats	Dock Fire (Bldg. 371) [a]	2.0×10^{-6}	0.059	1,800	0.00090	21,000	11	14,000	0.0056
	Room Fire (Bldg. 371) [b]	0.0005	0.059	1,260	0.00063	14,700	7.4	9,820	0.0039
	Dock Fire (Bldg. 707) [a, c]	2×10^{-6}	0.059	1,200	0.00060	21,000	11	14,000	0.0056
	Earthquake (Bldg. 707) [b, c]	0.0018	0.059	492	0.00025	8,600	4.3	5,730	0.0023
Alternative 3 (with Plutonium Separation)									
Mediated Electrochemical Oxidation at Rocky Flats	Dock Fire (Bldg. 371) [a, d]	2.0×10^{-6}	0.16	1,800	0.00090	21,000	11	14,000	0.0056
	Room Fire (Bldg. 371) [b, d]	0.0005	0.16	473	0.00024	5,510	2.8	3,680	0.0015
	Dock Fire (Bldg. 707A) [a, e]	2.0×10^{-6}	0.13	1,200	0.00060	25,000	13	21,000	0.017
	Room Fire (Bldg. 707A) [b, e]	0.0005	0.13	180	0.000090	3,750	1.9	3,150	0.0013

[a] Highest consequence accident for this processing option.
[b] Highest risk accident for this processing option.
[c] Mediated electrochemical oxidation process in Building 371.
[d] Building 707 is designated as an alternate location for the Shred and Blend Down process at Rocky Flats.
[e] Final calcination process in Building 707A.
Note: The impacts due to the preferred processing option are presented in bold type.

Table 4–19 Risks Due to Accidents with Combustible Residues

	Accident Scenario	*Offsite Public Maximally Exposed Individual Risk (Probability of a Latent Cancer Fatality)*	*Offsite Public Population Risk (Number of Latent Cancer Fatalities)*	*Noninvolved Onsite Worker Risk (Probability of a Latent Cancer Fatality)*
Alternative 1 (No Action)				
Neutralize and Dry at Rocky Flats (Aqueous Contaminated Residue)	**Room Fire (Bldg. 371)**	**8.2×10^{-9}**	**0.000096**	**5.1×10^{-8}**
	Composite	**9.4×10^{-9}**	**0.00011**	**5.9×10^{-8}**
Thermal Desorption and Steam Passivation at Rocky Flats (Organic Contaminated Residue)	**Room Fire (Bldg. 371)**	**5.7×10^{-9}**	**0.000067**	**3.6×10^{-8}**
	Composite	**7.2×10^{-9}**	**0.000084**	**4.5×10^{-8}**
Repackage at Rocky Flats (Dry Contaminated Residue)	**Earthquake (Bldg. 707)**	**6.6×10^{-9}**	**0.00012**	**6.1×10^{-8}**
	Composite	**9.8×10^{-9}**	**0.00017**	**9.1×10^{-8}**
Alternative 2 (without Plutonium Separation)				
Sonic Wash at Rocky Flats	Room Fire (Bldg. 371)	1.2×10^{-8}	0.00014	7.3×10^{-8}
	Composite	1.4×10^{-8}	0.00016	8.4×10^{-8}
Catalytic Chemical Oxidation at Rocky Flats	Room Fire (Bldg. 371)	2.8×10^{-8}	0.00033	1.8×10^{-7}
	Composite	7.4×10^{-8}	0.00039	2.2×10^{-7}
Thermal Destruction at Rocky Flats	Earthquake (Bldg. 776)	1.4×10^{-8}	0.00025	1.3×10^{-7}
	Composite	2.9×10^{-8}	0.00050	2.7×10^{-7}
Shred and Blend Down at Rocky Flats	Room Fire (Bldg. 371)	1.9×10^{-8}	0.00022	1.2×10^{-7}
	Composite (Bldg. 371)	2.1×10^{-8}	0.00024	1.3×10^{-7}
	Earthquake (Bldg. 707 [a]	2.6×10^{-8}	0.00046	2.4×10^{-7}
	Composite (Bldg. 707) [a]	3.9×10^{-8}	0.00068	3.6×10^{-7}
Alternative 3 (with Plutonium Separation)				
Mediated Electrochemical Oxidation at Rocky Flats	Room Fire (Bldg. 371) [b]	1.9×10^{-8}	0.00022	1.2×10^{-7}
	Composite	2.8×10^{-8}	0.00030	1.3×10^{-7}
	Room Fire (Bldg. 707A) [c]	5.9×10^{-9}	0.00012	8.2×10^{-8}
	Composite	1.3×10^{-8}	0.00027	1.9×10^{-7}

[a] Building 707 is designated as an alternate location for the Shred and Blend Down process at Rocky Flats.
[b] Mediated electrochemical oxidation process in Building 371.
[c] Final calcination process in Building 707A.
Note: The risks due to the preferred processing option are presented in bold type.

The highest risk to the public maximally exposed individual is estimated to be 2.8×10^{-8}, which is due to a room fire during processing of the residue with the catalytic chemical oxidation option at Rocky Flats. This individual's chance of incurring a latent cancer fatality would be increased by less than one in ten million. The highest risk to the public population is estimated to be 0.00033 latent cancer fatalities, which is also due to a room fire during processing of the residue with the catalytic chemical oxidation option. The highest risk to the individual noninvolved onsite worker is estimated to be 1.8×10^{-7}, which is due to the same accident scenario in the same option. This individual's chance of incurring a latent cancer fatality would be increased by less than one in one million.

4.5 IMPACTS OF MANAGING PLUTONIUM FLUORIDE

The inventory of plutonium fluoride residues assessed in this EIS weighs 315 kg (694 lb), including 142 kg (313 lb) of plutonium. This inventory is stored in 256 small individual containers.

As discussed in Chapter 2, the alternatives for plutonium fluoride residues include one option under the No Action Alternative, one option under Process without Plutonium Separation Alternative, and two options under the Process with Plutonium Separation Alternative. The preferred processing option is to repackage the residues at Rocky Flats and to use Purex at the Savannah River Site.

This section presents the environmental impacts of managing the entire inventory of plutonium fluoride residues under each of the four options. The results in this section were used in the calculation of the total impacts of the No Action Alternative and the Preferred Management Approach which are presented in Sections 4.20 and 4.21, respectively, and of the rest of the management approaches which are presented in Section 4.22.

4.5.1 Products and Wastes

Every processing option for plutonium fluoride residues would generate some quantity of transuranic waste and would prepare this waste for disposal in WIPP. Every option would also generate some quantity of low-level waste, which would be disposed of routinely using existing procedures at each site. A small portion of the low-level waste generated at Rocky Flats could possibly be low-level mixed waste, but this waste would also be disposed of routinely using existing procedures.

The No Action Alternative would generate stabilized residues that would have to remain in storage indefinitely. The Process without Plutonium Separation Alternative would generate transuranic waste directly from the residue. The stabilized residues and transuranic waste would be placed in pipe components inside 210-L (55-gal) drums as shown in Figure 2-13 in Chapter 2.

High-level waste and saltstone would be generated only at the Savannah River Site if the residues are shipped to that site for plutonium separation. The final form for the high-level waste would be glass poured into stainless steel canisters, which would be stored at the Savannah River Site until a geologic repository is ready to receive them. Saltstone is a cement form of low-level waste that is generated as a by-product of the Savannah River Site tank farm operations and is routinely disposed of onsite in concrete vaults.

If plutonium is separated at Rocky Flats or the Savannah River Site, it would be stored securely onsite until a decision is made on its disposition. No increase in proliferation risk would result and this plutonium would not be used for nuclear explosive purposes. Any plutonium separated at Rocky Flats would contain americium, while at the Savannah River Site the americium would go into the high-level waste.

The solid plutonium-bearing products and wastes that would be generated from plutonium fluoride residues under each of the options are presented in **Table 4–20**. The shaded areas of Table 4–20 indicate types of solid products and wastes that would not be generated under the various options. The products and wastes from the preferred processing option are presented in bold type. The largest amount of transuranic waste (3,923 drums) would be generated in the blend down option. This amount is much higher than the other options, which would generate no more than 333 drums of transuranic waste.

The quantities of high-level waste, low-level waste, and saltstone would be very low under all the options and the sites would manage these wastes using routine procedures. The maximum amount of plutonium that could be separated is 141 kg (310 lb).

4.5.2 Public and Occupational Health and Safety Impacts

This section describes the radiological and hazardous chemical impacts which could result from the alternatives associated with the management of plutonium fluoride residues. These impacts are presented for incident-free operation and postulated accident scenarios, respectively. The detailed site and transportation analyses are presented in Appendices D and E, respectively.

The round-trip highway distance from Rocky Flats to the Savannah River Site is 5,233 km (3,250 mi). If DOE decides to ship the plutonium fluoride residues to the Savannah River Site for Purex processing, then seven shipments would be required and the total round-trip shipping distance would be 37,000 km (23,000 mi).

No construction of new facilities is included in any of the alternatives, but DOE may need to modify certain existing facilities for some of the alternatives. Mitigation measures during modifications would ensure that any radiological or hazardous chemical releases would be extremely small. Worker exposures to contaminated material would be limited to assure that doses are maintained as low as reasonably achievable.

4.5.2.1 Incident-Free Operations

- **Radiological Impacts**—The radiological impacts to the public and the workers associated with incident-free operations of each option are presented in **Table 4–21**. The impacts due to the preferred processing option are presented in bold type. The impacts are those which are anticipated to occur as a result of process operations and transportation over whatever time period is necessary to process the entire inventory of plutonium fluoride residues. The length of time necessary to process the plutonium fluoride residues will depend on which option DOE decides to implement. Impacts associated with subsequent incident-free storage of stabilized residues, separated plutonium, and wastes would be much smaller than from processing or transportation. Cumulative impacts are provided in Section 4.25.

  The highest estimated public maximally exposed individual dose in Table 4–21 is 11 mrem, which could occur only during transportation. This hypothetical individual's latent fatal cancer risk would be increased by less than one in one hundred thousand. The public maximally exposed individual risks near the sites would be much lower under all of the options. The highest total of the public population radiation doses listed in Table 4–21 would occur if DOE decides to implement the option to perform Purex processing at the Savannah River Site. The sum of these doses is 0.71 person-rem, which would cause far less than one additional latent fatal cancer among the population living near both sites and traveling along the truck route. The population living near the truck route would receive a much smaller radiation dose.

Table 4–20 Products and Wastes from Plutonium Fluoride Residues

	Stabilized Residues (Drums)	*Transuranic Waste (Drums)*	*High-Level Waste (Canisters of Glass)*	*Separated Plutonium (kg)* [a]	*Low-Level Waste (Drums)*	*Saltstone (cubic yards)*
Alternative 1 (No Action) Dissolve and Oxidize at Rocky Flats	141	333			750	
Alternative 2 (without Plutonium Separation) Blend Down at Rocky Flats		3,923			60	
Alternative 3 (with Plutonium Separation) Dissolve and Oxidize at Rocky Flats		333		141	750	
Preprocess at Rocky Flats		**28**	**–**	**–**	**60**	**–**
Purex at the Savannah River Site		**12**	**<1**	**141**	**45**	**23**

[a] To convert to pounds, multiply by 2.2.

Notes: Shaded areas indicate the types of solid products and waste that would not be generated. The products and wastes from the preferred processing option are presented in bold type. The storage capacities at each site are adequate to store the products and wastes listed in this table.

Table 4–21 Radiological Impacts Due to Incident-Free Management of Plutonium Fluoride Residues

	Offsite Public Maximally Exposed Individual		*Offsite Public Population*		*Maximally Exposed Individual Involved Worker*		*Involved Worker Population*	
	Dose (mrem)	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*	*Dose (mrem per year)*	*Probability of a Latent Cancer Fatality per year*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*
Alternative 1 (No Action) Dissolve and Oxidize at Rocky Flats	0.000043	2.2×10^{-11}	0.00098	4.9×10^{-7}	2,000	0.0008	45	0.018
Alternative 2 (without Plutonium Separation) Blend Down at Rocky Flats	N/E	–	N/E	–	2,000	0.0008	356	0.142
Alternative 3 (with Plutonium Separation) Dissolve and Oxidize at Rocky Flats	0.000043	2.2×10^{-11}	0.00098	4.9×10^{-7}	2,000	0.0008	51	0.020
Preprocess at Rocky Flats	**9.9×10^{-6}**	**5.0×10^{-12}**	**0.00021**	**1.1×10^{-7}**	**2,000**	**0.0008**	**41**	**0.016**
Transport to Savannah River Site	**11**	**5.5×10^{-6}**	**0.69**	**0.00035**	**100**	**0.00004**	**1.1**	**0.00044**
Purex at Savannah River Site [a]	**0.00020**	**1×10^{-10}**	**0.022**	**0.000011**	**2,000**	**0.0008**	**34**	**0.013**

N/E = no emissions—therefore, there are no radiological impacts to the public

[a] Impacts to the public and workers are presented for F-Canyon operations. It has been determined that H-Canyon operations result in lower impacts to these groups.

Note: The impacts due to the preferred processing option are presented in bold type.

The highest involved worker population radiation dose would be 356 person-rem, which would occur if DOE decides to implement the option to blend down at Rocky Flats. This dose would cause 0.14 additional latent cancer fatalities among the workers directly involved in the operation. Onsite workers who are not involved with the actual processing of the residues are designated as "noninvolved workers." The impacts to these workers would be expected to be much smaller than the impacts to the involved workers.

- **Hazardous Chemical Impacts**—The processing of plutonium fluoride residues at Rocky Flats would not involve airborne releases of hazardous chemicals.

  No carcinogenic chemicals would be released from the Purex process at the Savannah River Site. Noncancer health risks resulting from releases of phosphoric acid, ammonium nitrate, and fluorides are low; the Hazard Index values presented in **Table 4–22** are less than one. The impacts due to the preferred processing option are presented in bold type. Phosphoric acid, the constituent of the process source term that accounts for the largest increment of noncancer risk, is a corrosive irritant to the eyes, skin and mucous membranes and a respiratory tract irritant following inhalation exposure (Lewis 1991, EPA 1995a).

4.5.2.2 Accidents

The potential radiological impacts to the public and the noninvolved onsite workers due to accidents with plutonium fluoride residues are summarized and presented in this section. The detailed analysis of onsite accidents, with the associated assumptions, is presented in Appendix D, Section D.3. The detailed analysis considered a wide spectrum of potential accident scenarios, including fire, explosion, spill, criticality, earthquake, and aircraft crash. The accident scenarios with the highest consequences and risks were selected and carried forward to this section for the purpose of consequence and risk comparison. A composite of the risks due to major onsite accident scenarios in each spectrum (including the nonbounding accidents) was also computed and used for comparisons. The composite risk estimates are accurate enough for the purpose of comparing processing options against each other. The detailed analysis of transportation accidents, with the associated assumptions, is presented in Appendix E, Sections E.5 and E.6.

The accident frequencies and process durations of the selected accidents are presented in **Table 4–23**. The impacts due to the preferred processing option are presented in bold type. The onsite accident frequencies are given on a per year basis because many accidents, such as earthquakes, are commonly expressed this way. The duration of each process is given in years. The actual probability of occurrence of each onsite accident can be obtained by multiplying the accident frequency times the option's duration. In this way, the calculated probabilities are based on the total amount of residue in this category rather than a standard unit of time.

The calculation of accident probability is slightly different for traffic accident fatalities. The frequency of traffic accidents is given in terms of the number of fatal accidents per round trip shipment from Rocky Flats to the Savannah River Site. The process duration for traffic accidents is given as the number of round trip shipments. Thus, the actual probability of a fatal traffic accident can be obtained by multiplying the frequency (fatal accidents per round-trip shipment) times the duration (number of round-trip shipments).

The consequences for the public and a noninvolved onsite worker are also presented in Table 4–23, for each of the four plutonium fluoride residue processing options. The public maximally exposed individual is a hypothetical individual who resides at the site boundary in the downwind direction. The public population is defined as the residential population within a radius of 80 km (50 mi). A noninvolved onsite worker is defined as an individual worker who is located 100 m (328 ft) or more downwind from the release point when an accidental release of radioactive material occurs.

Table 4–22 Chemical Impacts Due to Incident-Free Management of Plutonium Fluoride Residues

	Offsite Public Maximally Exposed Individual		*Offsite Public Population*	*Maximally Exposed Individual Worker*		*Worker Population*
	Probability of Cancer Incidence	*Hazard Index*	*Number of Cancer Incidences or Fatalities* [a]	*Probability of Cancer Incidence*	*Hazard Index*	*Number of Cancer Incidences or Fatalities* [a]
Alternative 1 (No Action) Dissolve and Oxidize at Rocky Flats [b]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 2 (without Plutonium Separation) Blend Down at Rocky Flats [b]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 3 (with Plutonium Separation) Dissolve and Oxidize at Rocky Flats [b]	N/E	N/E	N/E	N/E	N/E	N/E
Preprocess at Rocky Flats [b]	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**
Transport to Savannah River Site	**N/A**	**N/A**	**0.00009 [c]**	**N/A**	**N/A**	**(c)**
Purex at Savannah River Site [d, e]	**N/E**	**0.007**	**N/E**	**N/E**	**0.1**	**N/E**

N/E = no emissions N/A = not applicable—the maximally exposed individual is undefined for vehicle emissions

[a] Cancer incidences and fatalities are calculated for process emissions and transportation emissions, respectively.

[b] No hazardous chemicals are released from this process; therefore, no associated health risks exist.

[c] Cancer fatalities due to vehicle emissions into the air. This impact is listed only once under public population because the vehicle emissions affect the public and worker populations collectively; however, the risk to the public dominates. See Appendix E, Section E.4 for additional details.

[d] Impacts are presented for F-Canyon operations. H-Canyon operations are expected to result in similar or lower impacts.

[e] No carcinogenic chemicals are released from the process; therefore, only noncancer health risks are evaluated.

Note: The impacts due to the preferred processing option are presented in bold type.

Table 4–23 Accident Frequencies, Process Durations, and Consequences for Accidents with Plutonium Fluoride Residues

	Accident Scenario	Accident Frequency (per year)	Process Duration (years)	Offsite Public Maximally Exposed Individual Consequences		Offsite Public Population Consequences		Noninvolved Onsite Worker Consequences	
				Dose (mrem)	Probability of a Latent Cancer Fatality	Dose (person-rem)	Number of Latent Cancer or Traffic Fatalities	Dose (mrem)	Probability of a Latent Cancer Fatality
Alternative 1 (No Action)									
Dissolve and Oxidize at Rocky Flats	Earthquake (Bldg. 371) [a]	0.000094	0.49	1,600	0.00080	18,600	9.3	12,400	0.0050
	Earthquake (Bldg 707A) [b]	0.0008	0.34	760	0.00038	15,800	7.9	13,300	0.0053
Alternative 2 (without Plutonium Separation)									
Blend Down at Rocky Flats	Earthquake (Bldg. 707)	0.0018	1.57	330	0.00017	5,780	2.9	3,850	0.0015
	Earthquake (Bldg. 371) [c]	0.000094	1.57	496	0.00025	5,780	2.9	3,850	0.0015
Alternative 3 (with Plutonium Separation)									
Dissolve and Oxidize at Rocky Flats	Earthquake (Bldg. 371) [a]	0.000094	0.49	1,600	0.00080	18,600	9.3	12,400	0.0050
	Earthquake (Bldg 707A) [b]	0.0008	0.34	760	0.00038	15,800	7.9	13,300	0.0053
Preprocess at Rocky Flats	**Earthquake (Bldg. 371)**	**0.000094**	**0.17**	**4,490**	**0.0023**	**52,400**	**26**	**34,900**	**0.028**
Transport to Savannah River Site	**Traffic Fatality**	**0.00010 per shipment**	**7 shipments**	**N/A**	**N/A**	**N/A**	**1.0 [c]**	**N/A**	**N/A [e]**
Purex at Savannah River Site	**Earthquake (H- Canyon) [f]**	**0.000182**	**1.58**	**74**	**0.000037**	**3,330**	**1.7**	**23,600**	**0.019**

N/A = not applicable

[a] Acid dissolution process in Building 371.

[b] Final calcination process in Building 707A.

[c] Building 371 is designated as an alternate location for the Blend Down process at Rocky Flats.

[d] This fatality is due to the mechanical impact of the accident, not cancer due to radiation. The radiological consequences of a radioactive release on the highway are impossible to list in a single number because the accident could occur at any point along the route and meteorological conditions and population distributions vary greatly along the route.

[e] The consequence of a high-speed traffic accident would be at least one fatality among the transportation workers due to trauma.

[f] HB-Line operates 12.5 percent of the time. Dose estimates assumed the HB-Line was operating at the time of the accident.

Note: The impacts due to the preferred processing option are presented in bold type.

The highest consequences to all three receptors would occur if DOE decides to implement the preferred processing option and a major earthquake strong enough to cause the breach of Building 371 occurs during the 0.17 years of preprocessing the residue at Rocky Flats.

The risks associated with each accident are calculated by multiplying the probability times the consequences. The risks to the public and an onsite worker are presented in **Table 4–24**, for each of the four plutonium fluoride residue processing options. The risk associated with the highest risk accident and a composite risk due to all major accidents are both presented. The risks associated with the preferred processing option are presented in bold type.

The highest risk to the public maximally exposed individual is estimated to be 4.7×10^{-7}, which is due to an earthquake during processing of the residue with the blend down option in Rocky Flats Building 707. This individual's chance of incurring a latent cancer fatality would be increased by less than one in one million. The highest risk to the public population is estimated to be 0.0082 latent cancer fatalities, which is also due to an earthquake at Rocky Flats during processing of the residue with the blend down option in Building 707. The highest risk to the individual noninvolved onsite worker is estimated to be 4.4×10^{-6}, which is due to the same accident scenario in the same option. This individual's chance of incurring a latent cancer fatality would be increased by less than one in one hundred thousand.

4.6 Impacts of Managing Filter Media Residues

The inventory of filter media residues is divided into two subcategories: high-efficiency particulate air and Ful Flo filter media residues. The inventory of high-efficiency particulate air filter media residues weighs 1,830 kg (4,030 lb), including 92.6 kg (204 lb) of plutonium. The high-efficiency particulate air filter media residues are stored in 207 drums (with no internal metal containers) and 7 other containers. The inventory of Ful Flo filter media residues weighs 800 kg (1,760 lb), including 19.6 kg (43.2 lb) of plutonium. The Ful Flo filter media residues are stored in 74 drums (with no internal metal containers) and one other container.

As discussed in Chapter 2, the alternatives for high-efficiency particulate air filter media residues include one option under the No Action Alternative, four options under the Process without Plutonium Separation Alternative, and one option under the Process with Plutonium Separation Alternative. The alternatives for Ful Flo filter media residues include all the same options except for one: vitrification is not possible for the Ful Flo filter media residues. DOE has not specified a preferred processing option for any filter media residues.

This section presents the environmental impacts of managing the entire inventory of each subcategory of filter media residues under each of the options. The results in this section were used in the calculation of the total impacts of the No Action Alternative and the Preferred Management Approach which are presented in Sections 4.20 and 4.21, respectively, and of the rest of the management approaches which are presented in Section 4.22.

4.6.1 Products and Wastes

Every processing option for filter media residues would generate some quantity of transuranic waste and would prepare this waste for disposal in WIPP. Every option would also generate some quantity of low-level waste, which would be disposed of routinely using existing procedures at the Rocky Flats. A small portion of the low-level waste generated at Rocky Flats could possibly be low-level mixed waste, but this waste would also be disposed of routinely using existing procedures. The No Action Alternative would generate stabilized residues that would have to remain in storage indefinitely. The Process without Plutonium Separation Alternative would generate transuranic waste directly from the residue. The stabilized residues and transuranic waste would be placed in pipe components inside 210-L (55-gal) drums as shown in Figure 2-13 in Chapter 2.

Table 4–24 Risks Due to Accidents with Plutonium Fluoride Residues

	Accident Scenario	Offsite Public Maximally Exposed Individual Risk (Probability of a Latent Cancer Fatality)	Offsite Public Population Risk (Number of Latent Cancer or Traffic Fatalities)	Noninvolved Onsite Worker Risk (Probability of a Latent Cancer Fatality)
Alternative 1 (No Action)				
Dissolve and Oxidize at Rocky Flats	Earthquake (Bldg. 371) [a]	3.7×10^{-8}	0.00043	2.3×10^{-7}
	Composite	5.9×10^{-8}	0.00063	2.5×10^{-7}
	Earthquake (Bldg. 707A) [b]	1.0×10^{-7}	0.0022	1.5×10^{-6}
	Composite	1.0×10^{-7}	0.0022	1.5×10^{-6}
Alternative 2 (without Plutonium Separation)				
Blend Down at Rocky Flats	Earthquake (Bldg. 707)	4.7×10^{-7}	0.0082	4.4×10^{-6}
	Composite (Bldg. 707)	4.8×10^{-7}	0.0084	4.5×10^{-6}
	Earthquake (Bldg. 371) [c]	3.7×10^{-8}	0.00043	2.3×10^{-7}
	Composite (Bldg. 371) [c]	4.5×10^{-8}	0.00053	2.8×10^{-7}
Alternative 3 (with Plutonium Separation)				
Dissolve and Oxidize at Rocky Flats	Earthquake (Bldg. 371) [a]	3.7×10^{-8}	0.00043	2.3×10^{-7}
	Composite	5.9×10^{-8}	0.00063	2.5×10^{-7}
	Earthquake (Bldg. 707A) [b]	1.0×10^{-7}	0.0022	1.5×10^{-6}
	Composite	1.0×10^{-7}	0.0022	1.5×10^{-6}
Preprocess at Rocky Flats	**Earthquake (Bldg. 371)**	**3.6×10^{-8}**	**0.00042**	**4.5×10^{-7}**
	Composite	**3.7×10^{-8}**	**0.00043**	**4.5×10^{-7}**
Transport to Savannah River Site	**Traffic Fatality**	**N/A**	**0.0007 [d]**	**N/A**
	Radioactive Release	**N/A**	**1.5×10^{-6}**	**N/A**
Purex at Savannah River Site	**Earthquake (H-Canyon) [e]**	**3.5×10^{-9}**	**0.00016**	**1.8×10^{-6}**
	Composite [d]	**6.6×10^{-9}**	**0.00030**	**1.8×10^{-6}**

N/A = not applicable
[a] Acid dissolution process in Building 371.
[b] Final calcination process in Building 707A.
[c] Building 371 is designated as an alternate location for the Blend Down process at Rocky Flats.
[d] This risk is due to the mechanical impact of a potential accident, not cancer due to radiation. This risk includes members of the public and transportation workers.
[e] HB-Line is operational 12.5 percent of the time.
Note: The risks due to the preferred processing option are presented in bold type.

High-level waste and saltstone will not be generated from filter media residues because none of the options involve shipping the residues to the Savannah River Site for plutonium separation. If plutonium is separated at Rocky Flats, it would be stored securely onsite until a decision is made on its disposition. No increase in proliferation risk would result and this plutonium would not be used for nuclear explosive purposes. This separated plutonium would also contain the americium from the filter media residues.

The solid plutonium-bearing products and wastes that would be generated from high-efficiency particulate air filter media residues under each of the options are presented in **Table 4–25**. The shaded areas of Table 4–25 indicate types of solid products and wastes that would not be generated under the various options. The largest amount of transuranic waste from high-efficiency particulate air filter media residues (1,956 drums) would be generated in the mediated electrochemical oxidation option. All the options under Alternative 2 would generate lower amounts of transuranic waste (between 600 and 800 drums). The quantity of low-level waste would also be highest under the mediated electrochemical oxidation option, and much lower under all the other options. The site would manage this waste using routine procedures. The maximum amount of plutonium that could be separated from high-efficiency particulate air filter media residues is 91 kg (201 lb).

The solid plutonium-bearing products and wastes that would be generated from Ful Flo filter media residues under each of the options are also presented in Table 4–25. The largest amount of transuranic waste from Ful Flo filter media residues (880 drums) would also be generated in the mediated electrochemical oxidation option. All the options under Alternative 2 would generate lower amounts of transuranic waste (between 250 and 350 drums). The quantity of low-level waste would also be highest under the mediated electrochemical oxidation option, and much lower under all the other options. The site would manage this waste using routine procedures. The maximum amount of plutonium that could be separated from Ful Flo filter media residues is 18 kg (40 lb).

4.6.2 Public and Occupational Health and Safety Impacts

This section describes the radiological and hazardous chemical impacts which could result from the alternatives associated with the management of filter media residues. These impacts are presented for incident-free operation and postulated accident scenarios, respectively. The detailed site analyses are presented in Appendix D.

No construction of new facilities is included in any of the alternatives, but DOE may need to modify certain existing facilities for some of the alternatives. Mitigation measures during modification would ensure that any radiological or hazardous chemical releases would be extremely small. Worker exposures to contaminated material would be limited to assure that doses are maintained as low as reasonably achievable.

4.6.2.1 Incident-Free Operations

- **Radiological Impacts**—The radiological impacts to the public and the workers associated with incident-free operations of each option are presented in **Table 4–26**. The impacts are those which are anticipated to occur as a result of process operations over whatever time period is necessary to process the entire inventory of filter media residues. The length of time necessary to process these residues will depend on which option DOE decides to implement. Impacts associated with subsequent incident-free storage of stabilized residues, separated plutonium, and wastes would be much smaller than from processing. Cumulative impacts are provided in Section 4.25.

  - *High-Efficiency Particulate Air Filter Media*—The highest estimated public maximally exposed individual dose from high-efficiency particulate air filter media operations is 0.000027 mrem, which would occur during the sonic washing of high-efficiency particulate air filter media process at Rocky Flats. This hypothetical individual's latent fatal cancer risk would be increased by less than one in ten-billion.

Table 4–25 Products and Wastes from Filter Media Residues

	Stabilized Residues (Drums)	*Transuranic Waste (Drums)*	*High-Level Waste (Canisters of Glass)*	*Separated Plutonium (kg)* [a]	*Low-Level Waste (Drums)*	*Saltstone (cubic yards)*
High-Efficiency Particulate Air Filter Media						
Alternative 1 (No Action) Neutralize/Dry at Rocky Flats	465	147			385	
Alternative 2 (without Plutonium Separation) Vitrify at Rocky Flats		702			385	
Shred and Blend Down at Rocky Flats		612			385	
Thermal Destruction at Rocky Flats		604			385	
Sonic Wash at Rocky Flats		781			385	
Alternative 3 (with Plutonium Separation) MEO at Rocky Flats		1,956		91	4,373	
Ful Flo Filter Media						
Alternative 1 (No Action) Neutralize/Dry at Rocky Flats	206	65			167	
Alternative 2 (without Plutonium Separation) Shred and Blend Down at Rocky Flats		270			167	
Thermal Destruction at Rocky Flats		267			167	
Sonic Wash at Rocky Flats		345			167	
Alternative 3 (with Plutonium Separation) MEO at Rocky Flats		880		18	1,929	

MEO = meditated electrochemical oxidation

[a] To convert to pounds, multiply by 2.2.

Notes: Shaded areas indicate the types of solid products and waste that would not be generated. The storage capacities at each site are adequate to store the products and wastes listed in this table. DOE has not chosen a preferred processing option for filter media.

Table 4–26 Radiological Impacts Due to Incident-Free Management of Filter Media Residues

	Offsite Public Maximally Exposed Individual		*Offsite Public Population*		*Maximally Exposed Individual Involved Worker*		*Involved Worker Population*	
	Dose (mrem)	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*	*Dose (mrem/yr)*	*Probability of a Latent Cancer Fatality per year*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*
High-Efficiency Particulate Air Filter Media								
Alternative 1 (No Action) Neutralize/Dry at Rocky Flats	0.000019	9.5×10^{-12}	0.00041	2.0×10^{-7}	2,000	0.0008	24	0.0096
Alternative 2 (without Plutonium Separation) Vitrify at Rocky Flats	4.2×10^{-6}	2.1×10^{-12}	0.00017	8.5×10^{-8}	2,000	0.0008	23	0.0092
Shred and Blend Down at Rocky Flats	0.000013	6.5×10^{-12}	0.00027	1.4×10^{-7}	2,000	0.0008	26	0.010
Thermal Destruction at Rocky Flats	5.9×10^{-6}	3.0×10^{-12}	0.00024	1.2×10^{-7}	2,000	0.0008	68	0.027
Sonic Wash at Rocky Flats	0.000027	1.4×10^{-11}	0.00057	2.8×10^{-7}	2,000	0.0008	40	0.016
Alternative 3 (with Plutonium Separation) MEO at Rocky Flats	0.000026	1.3×10^{-11}	0.00054	2.7×10^{-7}	2,000	0.0008	29	0.012
Ful Flo Filter Media								
Alternative 1 (No Action) Neutralize/Dry at Rocky Flats	4.3×10^{-6}	2.2×10^{-12}	0.000090	4.5×10^{-8}	2,000	0.0008	5.2	0.0021
Alternative 2 (without Plutonium Separation) Shred and Blend Down at Rocky Flats	2.7×10^{-6}	1.4×10^{-12}	0.000057	2.9×10^{-8}	2,000	0.0008	5.5	0.0022
Thermal Destruction at Rocky Flats	1.3×10^{-6}	6.5×10^{-13}	0.000052	2.6×10^{-8}	2,000	0.0008	15	0.0060
Sonic Wash at Rocky Flats	5.7×10^{-6}	2.8×10^{-12}	0.00012	6.0×10^{-8}	2,000	0.0008	8.9	0.0036
Alternative 3 (with Plutonium Separation) MEO at Rocky Flats	5.5×10^{-6}	2.8×10^{-12}	0.00012	6.0×10^{-8}	2,000	0.0008	6.2	0.0025

MEO = mediated electrochemical oxidation
Note: DOE has not yet chosen a preferred processing option for filter media.

The highest public population radiation dose from high-efficiency particulate air filter media operations would also occur for the sonic washing of high-efficiency particulate air filter media process, if DOE decides to implement this option. This dose is estimated to be 0.00057 person-rem, which would cause far less than one additional latent fatal cancer among the population living near Rocky Flats.

The highest involved worker population radiation dose for high-efficiency particulate air filter media operations would be 68 person-rem, which would occur if DOE decides to implement the thermal destruction of high-efficiency particulate air filter media option. DOE does not consider this to be a reasonable processing option, however, so the highest reasonable dose would be 40 person-rem. This dose would occur if DOE decides to implement the sonic was option and it would cause 0.016 additional latent cancer fatalities among the workers directly involved in the operation. Onsite workers who are not involved with the actual processing of the residues are designated as "noninvolved workers." The impacts to these workers would be expected to be much smaller than the impacts to the involved workers.

- *Ful Flo Filter Media*—The highest estimated public maximally exposed individual dose from Ful Flo filter media operations is 5.7×10^{-6} mrem, which would occur during the sonic washing of Ful Flo filter media process at Rocky Flats. This hypothetical individual's latent fatal cancer risk would be increased by less than one in one hundred billion. The highest public population radiation dose from Ful Flo filter media operations would occur for both the sonic washing and meditated electrochemical oxidation processes, if DOE decides to implement either option. The dose is estimated to be 0.00012 person-rem, which would cause far less than one additional latent fatal cancer among the population living near Rocky Flats.

  The highest involved worker population radiation dose for Ful Flo filter media operations would be 15 person-rem, which would occur if DOE decides to implement the thermal destruction of Ful Flo filter media option. DOE does not consider this to be a reasonable processing option, however, so the highest reasonable dose would be 8.9 person-rem. This dose would occur is DOE decides to implement the sonic wash option and it would cause 0.0036 additional latent cancer fatalities among the workers directly involved in the operation. Onsite workers who are not involved with the actual processing of the residues are designated as "noninvolved workers." The impacts to these workers would be expected to be much smaller than the impacts to the involved workers.

❒ **Hazardous Chemical Impacts**—The processing of filter media residues at Rocky Flats involves potential releases of the carcinogen carbon tetrachloride. Carbon tetrachloride is no longer used at Rocky Flats, but is present in small amounts in some of the residues. Under Alternative 2, the sonic wash processing has an estimated probability of excess latent cancer incidence for the offsite population maximally exposed individual of 9×10^{-11} for high-efficiency particulate air filter media and 3×10^{-11} for Ful Flo filter media (**Table 4–27**). This hypothetical individual's latent cancer chance would be increased by less than one in one billion. Less than one excess latent cancer incidence is estimated to occur in the offsite population of 2.4 million individuals living within an 80-km (50-mi) radius of Rocky Flats for both types of media. The maximally exposed individual worker probability of excess latent cancer incidence is 5×10^{-9} for high-efficiency particulate air filter media processing and 2×10^{-9} for Ful Flo filter media processing. This hypothetical individual's chance of incurring a latent cancer would be increased by about one in one hundred million. If all site workers were exposed to the maximally exposed individual worker concentrations of carbon tetrachloride, less than 1 excess latent cancer would be expected to occur in the workforce population.

Table 4–27 Chemical Impacts Due to Incident-Free Management of Filter Media Residues

	Offsite Public Maximally Exposed Individual		*Offsite Public Population*	*Maximally Exposed Individual Worker*		*Worker Population*
	Probability of a Cancer Incidence	*Hazard Index*	*Number of Cancer Incidences*	*Probability of a Cancer Incidence*	*Hazard Index*	*Number of Cancer Incidences*
High-Efficiency Particulate Air Filter Media						
Alternative 1 (No Action) Neutralize/Dry at Rocky Flats [a]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 2 (without Plutonium Separation) Vitrify at Rocky Flats [a]	N/E	N/E	N/E	N/E	N/E	N/E
Shred and Blend Down at Rocky Flats [a]	N/E	N/E	N/E	N/E	N/E	N/E
Thermal Destruction at Rocky Flats	(b)	(b)	(b)	(b)	(b)	(b)
Sonic Wash at Rocky Flats [c]	9×10^{-11}	N/E	<1 [d]	5×10^{-9}	N/E	<1 [e]
Alternative 3 (with Plutonium Separation) Mediated Electrochemical Oxidation at Rocky Flats [a]	N/E	N/E	N/E	N/E	N/E	N/E
Ful Flo Filter Media						
Alternative 1 (No Action) Neutralize/Dry at Rocky Flats [a]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 2 (without Plutonium Separation) Shred and Blend at Rocky Flats [a]	N/E	N/E	N/E	N/E	N/E	N/E
Thermal Destruction at Rocky Flats	(b)	(b)	(b)	(b)	(b)	(b)
Sonic Wash at Rocky Flats	3×10^{-11}	N/E	<1 [d]	2×10^{-9}	N/E	<1 [e]
Alternative 3 (with Plutonium Separation) Mediated Electrochemical Oxidation at Rocky Flats [a]	N/E	N/E	N/E	N/E	N/E	N/E

N/E = No emissions.

[a] No hazardous chemicals are released from process; therefore, no associated health risks exist.

[b] The hazardous chemical impacts due to installing and operating an incinerator at Rocky Flats are not included in this EIS because this processing option is not a reasonable processing option. If DOE decides to implement this option, then extensive additional analysis would be required. This additional analysis could support additional NEPA documentation and a permit from the State of Colorado, both of which could provide opportunities for additional public input.

[c] No noncarcinogenic hazardous chemicals are released from the process; therefore, only cancer health risks are evaluated.

[d] In population of 2.4 million individuals living within 80 km (50 mi) of Rocky Flats.

[e] Based on extremely conservative assumption that entire Rocky Flats workforce is exposed to the maximally exposed individual worker concentration.

Note: DOE has not yet chosen a preferred processing option for filter media.

4.6.2.2 Accidents

The potential radiological impacts to the public and the noninvolved onsite workers due to accidents with filter media residues are summarized and presented in this section. The detailed analysis of onsite accidents, with the associated assumptions, is presented in Appendix D, Section D.3. The detailed analysis considered a wide spectrum of potential accident scenarios, including fire, explosion, spill, criticality, earthquake, and aircraft crash. The accident scenarios with the highest consequences and risks were selected and carried forward to this section for the purpose of consequence and risk comparison. A composite of the risks due to major onsite accident scenarios in each spectrum (including the nonbounding accidents) was also computed and used for comparisons. The composite risk estimates are accurate enough for the purpose of comparing processing options against each other.

The accident frequencies and process durations of the selected accidents are presented in **Table 4–28**. The onsite accident frequencies are given on a per year basis because many accidents, such as earthquakes, are commonly expressed this way. The duration of each process is given in years. The actual probability of occurrence of each onsite accident can be obtained by multiplying the accident frequency times the option's duration. In this way, the calculated probabilities are based on the total amount of residue in this category rather than a standard unit of time.

The consequences for the public and a noninvolved onsite worker are also presented in Table 4–28 for each of the six filter media residue processing options. The public maximally exposed individual is a hypothetical individual who resides at the site boundary in the downwind direction. The public population is defined as the residential population within a radius of 80 km (50 mi). A noninvolved onsite worker is defined as an individual worker who is located 100 m (328 ft) or more downwind from the release point when an accidental release of radioactive material occurs. The highest consequences to all three receptors would occur if DOE decides to implement the blend down option and a major earthquake strong enough to cause the breach of Building 371 occurs during the 0.31 years of residue processing at Rocky Flats.

The risks associated with each accident are calculated by multiplying the probability times the consequences. The risks to the public and an onsite worker are presented in **Table 4–29** for each of the six filter media residue processing options. The risk associated with the highest risk accident and a composite risk associated with all major accidents are both presented.

The highest risk to the public maximally exposed individual is estimated to be 3.7×10^{-7}, which is due to an earthquake during processing of the residue with the blend option in Rocky Flats Building 707. This individual's chance of incurring a latent cancer fatality would be increased by less than one in one million. The highest risk to the public population is estimated to be 0.0065 latent cancer fatalities, which is also due to an earthquake during processing of the residue with the blend down option in Building 707. The highest risk to the individual noninvolved onsite worker is estimated to be 3.5×10^{-6}, which is due to the same accident scenario in the same option. This individual's chance of incurring a latent cancer fatality would be increased by less than one in one hundred thousand.

4.7 Impacts of Managing Sludge Residues

The inventory of sludge residues weighs 619 kg (1,364 lb), including 26.7 kg (58.9 lb) of plutonium. The entire inventory is stored in 54 drums (with about 270 internal metal containers) and 34 other small individual containers.

As discussed in Chapter 2, the alternatives for sludge residues include one option under the No Action Alternative, two options under the Process without Plutonium Separation Alternative, and one option under the Process with Plutonium Separation Alternative. DOE has not specified a preferred processing option for sludge residues.

Table 4–28 Accident Frequencies, Process Durations, and Consequences for Accidents with Filter Media Residues

				Offsite Public Maximally Exposed Individual Consequences		Offsite Public Population Consequences		Noninvolved Onsite Worker Consequences	
	Accident Scenario	Accident Frequency (per year)	Process Duration (years)	Dose (mrem)	Probability of a Latent Cancer Fatality	Dose (person-rem)	Number of Latent Cancer Fatalities	Dose (mrem)	Probability of a Latent Cancer Fatality
Alternative 1 (No Action)									
Neutralize/Dry at Rocky Flats	Earthquake (Bldg. 371)	0.000094	0.73	846	0.00042	9,870	4.9	6,580	0.0026
Alternative 2 (without Plutonium Separation)									
Vitrify at Rocky Flats	Earthquake (Bldg. 707)	0.0018	0.22	914	0.00046	16,000	8.0	10,700	0.0043
Shred and Blend Down at Rocky Flats	Earthquake (Bldg. 371)	0.000094	0.31	2,000	0.0010	23,300	12	15,600	0.0062
	Earthquake (Bldg. 707) [a]	0.0018	0.31	1,330	0.00067	23,300	12	15,600	0.0062
Thermal Destruction at Rocky Flats	Earthquake (Bldg. 776)	0.001	0.71	569	0.00028	9970	5.0	6,640	0.0027
Sonic Wash at Rocky Flats	Earthquake (Bldg. 371)	0.000094	0.72	544	0.00027	6350	3.2	4,230	0.0017
Alternative 3 (with Plutonium Separation)									
Mediated Electrochemical Oxidation at Rocky Flats	Earthquake (Bldg. 371) [b]	0.000094	0.39	1,590	0.00080	18,500	9.3	12,400	0.0050
	Earthquake (Bldg. 707A) [c]	0.0008	0.47	570	0.00029	11,900	6.0	9,980	0.0040

[a] Building 707 is designated as an alternate location for the Shred and Blend Down process at Rocky Flats.
[b] Mediated electrochemical oxidation process in Building 371.
[c] Final calcination process in Building 707A.
Note: DOE has not yet chosen a preferred processing option for filter media.

Table 4–29 Risks Due to Accidents with Filter Media Residues

	Accident Scenario	Offsite Public Maximally Exposed Individual Risk (Probability of a Latent Cancer Fatality)	Offsite Public Population Risk (Number of Latent Cancer Fatalities)	Noninvolved Onsite Worker Risk (Probability of a Latent Cancer Fatality)
Alternative 1 (No Action)				
Neutralize/Dry at Rocky Flats	Earthquake (Bldg. 371)	2.9×10^{-8}	0.00034	1.8×10^{-7}
	Composite	4.1×10^{-8}	0.00048	2.5×10^{-7}
Alternative 2 (without Plutonium Separation)				
Vitrify at Rocky Flats (High-Efficiency Particulate Air only)	Earthquake (Bldg. 707)	1.8×10^{-7}	0.0032	1.7×10^{-6}
	Composite	1.9×10^{-7}	0.0032	1.7×10^{-6}
Shred and Blend Down at Rocky Flats	Earthquake (Bldg. 371)	2.9×10^{-8}	0.00034	1.8×10^{-7}
	Composite (Bldg. 371)	4.1×10^{-8}	0.00048	2.6×10^{-7}
	Earthquake (Bldg. 707) [a]	3.7×10^{-7}	0.0065	3.5×10^{-6}
	Composite (Bldg. 707) [a]	3.8×10^{-7}	0.0067	3.6×10^{-6}
Thermal Destruction at Rocky Flats	Earthquake (Bldg. 776)	2.0×10^{-7}	0.0035	1.9×10^{-6}
	Composite	2.1×10^{-7}	0.0037	2.0×10^{-6}
Sonic Wash at Rocky Flats	Earthquake (Bldg. 371)	1.8×10^{-8}	0.00022	1.1×10^{-7}
	Composite	2.6×10^{-8}	0.00030	1.6×10^{-7}
Alternative 3 (with Plutonium Separation)				
Mediated Electrochemical Oxidation at Rocky Flats	Earthquake (Bldg. 371)	2.9×10^{-8}	0.00034	1.8×10^{-7}
	Composite	5.6×10^{-8}	0.00061	2.6×10^{-7}
	Earthquake (Bldg. 707A)	1.1×10^{-7}	0.0023	1.5×10^{-6}
	Composite	1.1×10^{-7}	0.0024	1.6×10^{-6}

[a] Building 707 is designated as an alternate location for the Shred and Blend Down process at Rocky Flats.
Note: DOE has not yet chosen a preferred processing option for filter media.

This section presents the environmental impacts of managing the entire inventory of sludge residues under each of the four options. The results in this section were used in the calculation of the total impacts of the No Action Alternative and the Preferred Management Approach which are presented in Sections 4.20 and 4.21, respectively, and of the rest of the management approaches which are presented in Section 4.22.

As stated in Chapter 2, the greasy and oily sludge residues (IDCs 089, 099, and 332) could not be processed by the dissolve and oxidize technology. These three sludge residues have a combined mass of 7 kg (15 lb), including 1.0 kg (2.2 lb) of plutonium. If DOE decides to implement this option, the greasy and oily sludge residues would have to be managed under one of the other three options. The impacts of the other three options are all lower than the impacts of the dissolve and oxidize option, so DOE performed the impact calculations as if the greasy and oily sludge residues were also included in the dissolve and oxidize option. This procedure is conservative because the actual impacts of managing these residues are expected to be lower than the calculated impacts.

4.7.1 Products and Wastes

Every processing option for sludge residues would generate some quantity of transuranic waste and would prepare this waste for disposal in WIPP. Every option would also generate some quantity of low-level waste, which would be disposed of routinely using existing procedures at Rocky Flats. A small portion of the low-level waste generated at Rocky Flats could be possibly low-level mixed waste, but this waste would also be disposed of routinely using existing procedures. The No Action Alternative would generate stabilized residues that would have to remain in storage indefinitely. The Process without Plutonium Separation Alternative would generate transuranic waste directly from the residue. The stabilized residues and transuranic waste would be placed in pipe components inside 210-L (55-gal) drums as shown in Figure 2-13 in Chapter 2.

High-level waste and saltstone will not be generated from sludge residues because none of the options involve shipping the residues to the Savannah River Site for plutonium separation. If plutonium is separated at Rocky Flats, it would be stored securely onsite until a decision is made on its disposition. No increase in proliferation risk would result and this plutonium would not be used for nuclear explosive purposes. This separated plutonium would also contain the americium from the sludge residues.

The solid plutonium-bearing products and wastes that would be generated from sludge residues under each of the options are presented in **Table 4–30**. The shaded areas of Table 4–30 indicate types of solid products and wastes that would not be generated under the various options. The largest amount of transuranic waste (661 drums) would be generated in the dissolve and oxidize option. The two options under Alternative 2 would generate only about one-third as much transuranic waste. The quantity of low-level waste would also be highest under the dissolve and oxidize option, and much lower under all the other options. The site would manage this waste using routine procedures. The maximum amount of plutonium that could be separated from sludge residues is 26 kg (57 lb).

4.7.2 Public and Occupational Health and Safety Impacts

This section describes the radiological and hazardous chemical impacts which could result from the alternatives associated with the management of sludge residues. These impacts are presented for incident-free operation and postulated accident scenarios, respectively. The detailed site analyses are presented in Appendix D. No construction of new facilities is included in any of the alternatives, but DOE may need to modify certain existing facilities for some of the alternatives. Mitigation measures during modifications would ensure that any radiological or hazardous chemical releases would be extremely small. Worker exposures to contaminated material would be limited to assure that doses are maintained as low as reasonably achievable.

Table 4–30 Products and Wastes from Sludge Residues

	Stabilized Residues (Drums)	*Transuranic Waste (Drums)*	*High-Level Waste (Canisters of Glass)*	*Separated Plutonium (kg)* [a]	*Low-Level Waste (Drums)*	*Saltstone (cubic yards)*
Alternative 1 (No Action) Filter/Dry at Rocky Flats	160	60			128	
Alternative 2 (without Plutonium Separation) Vitrify at Rocky Flats		218			128	
Blend Down at Rocky Flats		218			128	
Alternative 3 (with Plutonium Separation) Dissolve and Oxidize at Rocky Flats		661		26	1,484	

[a] To convert to pounds, multiply by 2.2.

Notes: Shaded areas indicate the types of solid products and waste that would not be generated. The storage capacities at each site are adequate to store the products and wastes listed in this table. DOE has not yet chosen a preferred processing option for filter media.

4.7.2.1 Incident-Free Operations

- **Radiological Impacts**—The radiological impacts to the public and the workers associated with incident-free operations of each option are presented in **Table 4–31**. The impacts are those which are anticipated to occur as a result of process operations over whatever time period is necessary to process the entire inventory of sludge residues. The length of time necessary to process these residues will depend on which option DOE decides to implement. Impacts associated with subsequent incident-free storage of stabilized residues, separated plutonium, and wastes would be much smaller than from processing. Cumulative impacts are provided in Section 4.25.

  The highest estimated public maximally exposed individual dose in Table 4–31 is 7.6×10^{-6} mrem, which would occur during the dissolve and oxidize process at Rocky Flats. This hypothetical individual's latent fatal cancer risk would be increased by less than one in one-hundred billion. The highest public population radiation dose listed in Table 4–31 would also occur for the dissolve and oxidize process, if DOE decides to implement this option. This dose is estimated to be 0.00017 person-rem, which would cause far less than one additional latent fatal cancer among the population living near Rocky Flats.

  The highest involved worker population radiation dose would be 39 person-rem, which would occur if DOE decides to implement the dissolve and oxidize option. This dose would cause 0.016 additional latent cancer fatalities among the workers directly involved in the operation. Onsite workers who are not involved with the actual processing of the residues are designated as "noninvolved workers." The impacts to these workers would be expected to be much smaller than the impacts to the involved workers.

- **Hazardous Chemical Impacts**—The impacts of exposure to hazardous chemicals from the processing of sludge residues at Rocky Flats were not evaluated because hazardous chemicals are not expected to be released from the proposed operations at this site.

4.7.2.2 Accidents

The potential radiological impacts to the public and the noninvolved onsite workers due to accidents with sludge residues are summarized and presented in this section. The detailed analysis of onsite accidents, with the associated assumptions, is presented in Appendix D, Section D.3. The detailed analysis considered a wide spectrum of potential accident scenarios, including fire, explosion, spill, criticality, earthquake, and aircraft crash. The accident scenarios with the highest consequences and risks were selected and carried forward to this section for the purpose of consequence and risk comparison. A composite of the risks due to major onsite accident scenarios in each spectrum (including the nonbounding accidents) was also computed and used for comparisons. The composite risk estimates are accurate enough for the purpose of comparing processing options against each other.

The accident frequencies and process durations of the selected accidents are presented in **Table 4–32**. The onsite accident frequencies are given on a per year basis because many accidents, such as earthquakes, are commonly expressed this way. The duration of each process is given in years. The actual probability of occurrence of each onsite accident can be obtained by multiplying the accident frequency times the option's duration. In this way, the calculated probabilities are based on the total amount of residue in this category rather than a standard unit of time.

The consequences for the public and a noninvolved onsite worker are also presented in Table 4–32, for each of the four sludge residue processing options. The public maximally exposed individual is a hypothetical individual who resides at the site boundary in the downwind direction. The public population is defined as the residential population within a radius of 80 km (50 mi). A noninvolved onsite worker is defined as an individual worker who is located 100 m (328 ft) or more downwind from the release point when an accidental release of radioactive material occurs.

Table 4–31 Radiological Impacts Due to Incident-Free Management of Sludge Residues

	Offsite Public Maximally Exposed Individual Risk		*Offsite Public Population*		*Maximally Exposed Individual Involved Worker*		*Involved Worker Population*	
	Dose (mrem)	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*	*Dose (mrem/yr)*	*Probability of a Latent Cancer Fatality per year*	*Dose (person-rem)*	*Number of Cancer Incidences*
Alternative 1 (No Action) Filter/Dry at Rocky Flats	3.8×10^{-6}	1.9×10^{-12}	0.000080	4.0×10^{-8}	2,000	0.0008	15	0.0060
Alternative 2 (without Plutonium Separation) Vitrify at Rocky Flats	1.3×10^{-6}	6.5×10^{-13}	0.000052	2.6×10^{-8}	2,000	0.0008	6.6	0.0026
Blend Down at Rocky Flats	3.7×10^{-6}	1.8×10^{-12}	0.000080	4.0×10^{-8}	2,000	0.0008	6.6	0.0026
Alternative 3 (with Plutonium Separation) Dissolve and Oxidize at Rocky Flats	7.6×10^{-6}	3.8×10^{-12}	0.00017	8.5×10^{-8}	2,000	0.0008	39	0.016

Note: DOE has not yet chosen a preferred processing option for sludge residues.

Table 4–32 Accident Frequencies, Process Durations, and Consequences for Accidents with Sludge Residues

				Offsite Public Maximally Exposed Individual Consequences		*Offsite Public Population Consequences*		*Noninvolved Onsite Worker Consequences*	
	Accident Scenario	*Accident Frequency (per year)*	*Process Duration (years)*	*Dose (mrem)*	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*	*Dose (mrem)*	*Probability of a Latent Cancer Fatality*
Alternative 1 (No Action) Filter/Dry at Rocky Flats	Earthquake (Bldg. 371)	0.000094	0.42	347	0.00017	4,050	2.0	2,700	0.0011
Alternative 2 (without Plutonium Separation) Vitrify at Rocky Flats	Explosion (Bldg. 707) [a]	0.00005	0.064	960	0.00048	16,800	8.4	11,200	0.0045
	Earthquake (Bldg. 707) [b]	0.0018	0.064	914	0.00046	16,000	8.0	10,700	0.0043
Blend Down at Rocky Flats	Earthquake (Bldg. 707)	0.0018	0.064	1,520	0.00076	26,700	13	17,800	0.0071
	Earthquake (Bldg. 371) [c]	0.000094	0.064	2,290	0.0011	26,700	13	17,800	0.0071
Alternative 3 (with Plutonium Separation) Dissolve and Oxidize at Rocky Flats	Criticality (Bldg. 371) [d]	0.0001	0.88	790	0.00040	6,980	3.5	321	0.00013
	Earthquake (Bldg. 707A) [e]	0.0008	0.061	760	0.00038	15,800	7.9	13,300	0.0053

[a] Highest consequence accident for this processing option.
[b] Highest risk accident for this processing option.
[c] Building 371 is designated as an alternate location for the Blend Down process at Rocky Flats.
[d] Acid dissolution process in Building 371.
[e] Final calcination process in Building 707A.
Note: DOE has not yet chosen a preferred processing option for sludge residues.

The highest consequences to all three receptors would occur if DOE decides to implement the blend down option and a major earthquake strong enough to cause the breach of Building 371 occurs during the 0.064 years of residue processing at Rocky Flats.

The risks associated with each accident are calculated by multiplying the probability times the consequences. The risks to the public and an onsite worker are presented in **Table 4–33**, for each of the four sludge residue processing options. The risk associated with the highest risk accident and a composite risk associated with all major accidents are both presented.

The highest risk to the public maximally exposed individual is estimated to be 8.8×10^{-8}, which is due to an earthquake during processing of the residue with the blend down option in Rocky Flats Building 707. This individual's chance of incurring a latent cancer fatality would be increased by less than one in ten million. The highest risk to the public population is estimated to be 0.0015 latent cancer fatalities, which is also due to an earthquake during processing of the residue with the blend down option in Building 707. The highest risk to the individual noninvolved onsite worker is estimated to be 8.2×10^{-7}, which is due to the same accident scenario in the same option. This individual's chance of incurring a latent cancer fatality would be increased by less than one in one million.

4.8 Impacts of Managing Glass Residues

The inventory of glass residues weighs 134 kg (295 lb), including 5.1 kg (11.2 lb) of plutonium. The entire inventory is stored in 10 drums with no internal metal containers.

As discussed in Chapter 2, the alternatives for glass residues include one option under the No Action Alternative, three options under the Process without Plutonium Separation Alternative, and one option under the Process with Plutonium Separation Alternative. The preferred processing option is to neutralize and dry the glass residues at Rocky Flats.

This section presents the environmental impacts of managing the entire inventory of glass residues under each of the five options. The results in this section were used in the calculation of the total impacts of the No Action Alternative and the Preferred Management Approach which are presented in Sections 4.20 and 4.21, respectively, and of the rest of the management approaches which are presented in Section 4.22.

4.8.1 Products and Wastes

Every processing option for glass residues would generate some quantity of transuranic waste and would prepare this waste for disposal in WIPP. Every option would also generate some quantity of low-level waste, which would be disposed of routinely using existing procedures at Rocky Flats. A small portion of the low-level waste generated at Rocky Flats could possibly be low-level mixed waste, but this waste would also be disposed of routinely using existing procedures. The No Action Alternative would generate stabilized residues, containing plutonium in excess of the safeguards termination limits. The Process without Plutonium Separation Alternative would generate transuranic waste directly from the residue. The stabilized residues and transuranic waste would be placed in pipe components inside 210-L (55-gal) drums as shown in Figure 2-13 in Chapter 2.

High-level waste and saltstone will not be generated from glass residues because none of the options involve shipping the residues to the Savannah River Site for plutonium separation. If plutonium is separated at Rocky Flats, it would be stored securely onsite until a decision is made on its disposition. No increase in proliferation risk would result and this plutonium would not be used for nuclear explosive purposes. This separated plutonium would also contain the americium from glass residues.

Table 4–33 Risks Due to Accidents with Sludge Residues

	Accident Scenario	Offsite Public Maximally Exposed Individual Risk (Probability of a Latent Cancer Fatality)	Offsite Public Population Risk (Number of Latent Cancer Fatalities)	Noninvolved Onsite Worker Risk (Probability of a Latent Cancer Fatality)
Alternative 1 (No Action)				
Filter/Dry at Rocky Flats	Earthquake (Bldg. 371)	6.9×10^{-9}	0.000080	4.3×10^{-8}
	Composite	1.2×10^{-8}	0.00014	7.4×10^{-8}
Alternative 2 (without Plutonium Separation)				
Vitrify at Rocky Flats	Earthquake (Bldg. 707)	5.3×10^{-8}	0.00092	4.9×10^{-7}
	Composite	5.6×10^{-8}	0.00097	5.2×10^{-7}
Blend Down at Rocky Flats	Earthquake (Bldg. 707)	8.8×10^{-8}	0.0015	8.2×10^{-7}
	Composite (Bldg. 707)	9.1×10^{-8}	0.0016	8.5×10^{-7}
	Earthquake (Bldg. 371) [a]	6.8×10^{-9}	0.00008	4.3×10^{-8}
	Composite (Bldg. 371) [a]	1.0×10^{-8}	0.00012	6.2×10^{-8}
Alternative 3 (with Plutonium Separation)				
Dissolve and Oxidize at Rocky Flats	Criticality (Bldg. 371) [b]	3.5×10^{-8}	0.00031	1.1×10^{-8}
	Composite	4.3×10^{-8}	0.00042	8.1×10^{-8}
	Earthquake (Bldg. 707A) [c]	1.9×10^{-8}	0.00039	2.6×10^{-7}
	Composite	2.0×10^{-8}	0.00041	2.8×10^{-7}

[a] Building 371 is designated as an alternate location for the Blend Down process at Rocky Flats.
[b] Acid dissolution process in Building 371.
[c] Final calcination process in Building 707A.
Note: DOE has not yet chosen a preferred processing option for sludge residues.

The solid plutonium-bearing products and wastes that would be generated from glass residues under each of the options are presented in **Table 4–34**. The shaded areas of Table 4–34 indicate types of solid products and wastes that would not be generated under the various options. The products and wastes from the preferred processing option are presented in bold type. The largest amount of transuranic waste (145 drums) would be generated in the mediated electrochemical oxidation option. The three options under Alternative 2 would generate only about one-third as much transuranic waste. The quantity of low-level waste would also be highest under the mediated electrochemical oxidation option, and much lower under all the other options. The site would manage this waste using routine procedures. The maximum amount of plutonium that could be separated from glass residues is 5 kg (11 lb).

The no action processing option and the preferred processing option are identical and would both generate about 7 drums of stabilized residues, containing plutonium in excess of the safeguards termination limits. For the glass residues, however, DOE has decided to grant variances to these limits, which will allow these 7 drums to be disposed of in WIPP.

4.8.2 Public and Occupational Health and Safety Impacts

This section describes the radiological and hazardous chemical impacts that could result from the alternatives associated with the management of glass residues. These impacts are presented for incident-free operation and postulated accident scenarios, respectively. The detailed site analyses are presented in Appendix D.

No construction of new facilities is included in any of the alternatives, but DOE may need to modify certain existing facilities for some of the alternatives. Mitigation measures during modifications would ensure that any radiological or hazardous chemical releases would be extremely small. Worker exposures to contaminated material would be limited to assure that doses are maintained as low as reasonably achievable.

4.8.2.1 Incident-Free Operations

- **Radiological Impacts**—The radiological impacts to the public and the workers associated with incident-free operations of each option are presented in **Table 4–35**. The impacts due to the preferred processing option are presented in bold type. The impacts are those which are anticipated to occur as a result of process operations over whatever time period is necessary to process the entire inventory of Raschig ring and glass residues. The length of time necessary to process these residues will depend on which option DOE decides to implement. Impacts associated with subsequent incident-free storage of stabilized residues, separated plutonium, and wastes would be much smaller than from processing. Cumulative impacts are provided in Section 4.25.

  The highest estimated public maximally exposed individual dose in Table 4–35 is 1.8×10^{-6} mrem, which would occur during the mediated electrochemical oxidation process at Rocky Flats. This hypothetical individual's latent fatal cancer risk would be increased by less than one in one trillion. The highest public population radiation dose listed in Table 4–35 would also occur for the mediated electrochemical oxidation process, if DOE decides to implement this option. This dose is estimated to be 0.000038 person-rem, which would cause far less than one additional latent fatal cancer among the population living near Rocky Flats.

  The highest total involved worker population radiation dose would be 1.9 person-rem, which would occur if DOE decides to implement either the sonic wash or mediated electrochemical oxidation option. This dose would cause far less than one additional latent fatal cancer among the workers directly involved in either operation. Onsite workers who are not involved with the actual processing of the residues are designated as "noninvolved workers." The impacts to these workers would be expected to be much smaller than the impacts to the involved workers.

Table 4–34 Products and Wastes from Glass Residues

	Stabilized Residues (Drums)	*Transuranic Waste (Drums)*	*High-Level Waste (Canisters of Glass)*	*Separated Plutonium (kg)* [a]	*Low-Level Waste (Drums)*	*Saltstone (cubic yards)*
Alternative 1 (No Action) **Neutralize/Dry at Rocky Flats**	**7**	**11**			**27**	
Alternative 2 (without Plutonium Separation) Vitrify at Rocky Flats		41			27	
Blend Down at Rocky Flats		41			27	
Sonic Wash at Rocky Flats		48			27	
Alternative 3 (with Plutonium Separation) Mediated Electrochemical Oxidation at Rocky Flats		145		5	321	

[a] To convert to pounds, multiply by 2.2.

Notes: Shaded areas indicate the types of solid products and waste that would not be generated; the products and wastes from the preferred processing option are presented in bold type. The storage capacities at each site are adequate to store the products and wastes listed in this table.

Table 4–35 Radiological Impacts Due to Incident-Free Management of Glass Residues

	Offsite Public Maximally Exposed Individual		*Offsite Public Population*		*Maximally Exposed Individual Involved Worker*		*Involved Worker Population*	
	Dose (mrem)	*Probability of Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*	*Dose (mrem/yr)*	*Probability of a Latent Cancer Fatality per year*	*Dose (person rem)*	*Number of Latent Cancer Fatalities*
Alternative 1 (No Action) **Neutralize/Dry at Rocky Flats**	**N/E**	**–**	**N/E**	**–**	**2,000**	**0.0008**	**1.5**	**0.00060**
Alternative 2 (without Plutonium Separation) Vitrify at Rocky Flats	2.1×10^{-7}	1.0×10^{-13}	8.6×10^{-6}	4.3×10^{-9}	2,000	0.0008	1.0	0.00040
Blend Down at Rocky Flats	7.1×10^{-7}	3.6×10^{-13}	0.000015	7.5×10^{-9}	2,000	0.0008	1.1	0.00044
Sonic Wash at Rocky Flats	N/E	–	N/E	–	2,000	0.0008	1.9	0.00076
Alternative 3 (with Plutonium Separation) Mediated Electrochemical Oxidation at Rocky Flats	1.8×10^{-6}	9.0×10^{-13}	0.000038	1.9×10^{-8}	2,000	0.0008	1.9	0.00076

N/E = no emissions—therefore, there are no radiological impacts to the public

Note: The impacts due to the preferred processing option are presented in bold type.

- **Hazardous Chemical Impacts**—The impacts of exposure to hazardous chemicals from the processing of glass residues at Rocky Flats were not evaluated because hazardous chemicals are not expected to be released from the proposed operations at this site.

4.8.2.2 Accidents

The potential radiological impacts to the public and the noninvolved onsite workers due to accidents with glass residues are summarized and presented in this section. The detailed analysis of onsite accidents, with the associated assumptions, is presented in Appendix D, Section D.3. The detailed analysis considered a wide spectrum of potential accident scenarios, including fire, explosion, spill, criticality, earthquake, and aircraft crash. The accident scenarios with the highest consequences and risks were selected and carried forward to this section for the purpose of consequence and risk comparison. A composite of the risks due to major onsite accident scenarios in each spectrum (including the nonbounding accidents) was also computed and used for comparisons. The composite risk estimates are accurate enough for the purpose of comparing processing options against each other.

The accident frequencies and process durations of the selected accidents are presented in **Table 4–36**. The impacts due to the preferred processing option are presented in bold type. The onsite accident frequencies are given on a per year basis because many accidents, such as earthquakes, are commonly expressed this way. The duration of each process is given in years. The actual probability of occurrence of each onsite accident can be obtained by multiplying the accident frequency times the option's duration. In this way, the calculated probabilities are based on the total amount of residue in this category rather than a standard unit of time.

The consequences for the public and a noninvolved onsite worker are also presented in Table 4–36, for each of the five glass residue processing options. The public maximally exposed individual is a hypothetical individual who resides at the site boundary in the downwind direction. The public population is defined as the residential population within a radius of 80 km (50 mi). A noninvolved onsite worker is defined as an individual worker who is located 100 m (328 ft) or more downwind from the release point when an accidental release of radioactive material occurs. The highest consequences to the maximally exposed individual would occur if DOE decides to implement the blend down option and a major earthquake strong enough to cause the breach of Building 371 occurs during the 0.014 years of residue processing at Rocky Flats. The highest consequences to other two receptors would occur if DOE decides to implement the mediated electrochemical oxidation option and a major earthquake strong enough to cause the breach of Building 707A occurs during the 0.0064 years of residue processing at Rocky Flats.

The risks associated with each accident are calculated by multiplying the probability times the consequences. The risks to the public and an onsite worker are presented in **Table 4–37**, for each of the five glass residue processing options. The risk associated with the highest risk accident and a composite risk due to all major accidents are both presented. The risks associated with the preferred processing option are presented in bold type.

The highest risk to the public maximally exposed individual is estimated to be 9.9×10^{-9}, which is due to an earthquake during processing of the residue with the vitrification option at Rocky Flats. This individual's chance of incurring a latent cancer fatality would be increased by less than one in one hundred million. The highest risk to the public population is estimated to be 0.00017 latent cancer fatalities, which is also due to an earthquake during processing of the residue with the vitrification option. The highest risk to the individual noninvolved onsite worker is estimated to be 1.6×10^{-7}, which is due to a major earthquake strong enough to cause the collapse of Building 707 during the blend down process at Rocky Flats. This individual's chance of incurring a latent cancer fatality would be increased by less than one in ten million.

Table 4–36 Accident Frequencies, Process Durations, and Consequences for Accidents with Glass Residues

				Offsite Public Maximally Exposed Individual Consequences		*Offsite Public Population Consequences*		*Noninvolved Onsite Worker Consequences*	
	Accident Scenario	*Accident Frequency (per year)*	*Process Duration (years)*	*Dose (mrem)*	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*	*Dose (mrem)*	*Probability of a Latent Cancer Fatality*
Alternative 1 (No Action) **Neutralize/Dry at Rocky Flats**	**Earthquake (Bldg. 371)**	**0.000094**	**0.037**	**754**	**0.00038**	**8,800**	**4.4**	**5,870**	**0.0024**
Alternative 2 (without Plutonium Separation) Vitrify at Rocky Flats	Explosion (Bldg. 707) [a]	0.00005	0.012	960	0.00048	16,800	8.4	11,200	0.0045
	Earthquake(Bldg. 707) [b]	0.0018	0.012	914	0.00046	16,000	8.0	10,700	0.0043
Blend Down at Rocky Flats	Earthquake(Bldg. 371)	0.000094	0.014	2,000	0.0010	23,300	12	15,600	0.0062
	Earthquake (Bldg. 707) [c]	0.0018	0.014	1,330	0.00067	23,300	23	15,600	0.0062
Sonic Wash at Rocky Flats	Earthquake(Bldg. 371)	0.000094	0.037	453	0.00023	5,280	2.6	3,520	0.0014
Alternative 3 (with Plutonium Separation) MEO at Rocky Flats	Earthquake(Bldg. 371) [d]	0.000094	0.019	1,480	0.00074	17,200	8.6	11,500	0.0046
	Earthquake(Bldg. 707A) [e]	0.0008	0.0064	1,400	0.00070	29,100	15	24,400	0.020

MEO = mediated electrochemical oxidation
[a] Highest consequence accident for this processing option.
[b] Highest risk accident for this processing option.
[c] Building 707 is designated as an alternate location for the Blend Down process at Rocky Flats.
[d] Mediated electrochemical oxidation process in Building 371.
[e] Final calcination process in Building 707A.
Note: The impacts due to the proposed processing option are presented in bold type.

Table 4–37 Risks Due to Accidents with Glass Residues

	Accident Scenario	*Offsite Public Maximally Exposed Individual Risk (Probability of a Latent Cancer Fatality)*	*Offsite Public Population Risk (Number of Latent Cancer Fatalities)*	*Noninvolved Onsite Worker Risk (Probability of a Latent Cancer Fatality)*
Alternative 1 (No Action)				
Neutralize/Dry at Rocky Flats	**Earthquake (Bldg. 371)**	**1.3×10^{-9}**	**0.000015**	**8.2×10^{-9}**
	Composite	**1.9×10^{-9}**	**0.000022**	**1.2×10^{-8}**
Alternative 2 (without Plutonium Separation)				
Vitrify at Rocky Flats	Earthquake (Bldg. 707)	9.9×10^{-9}	0.00017	9.2×10^{-8}
	Composite	1.0×10^{-8}	0.00018	9.7×10^{-8}
Blend Down at Rocky Flats	Earthquake (Bldg. 371)	1.3×10^{-9}	0.000015	8.2×10^{-9}
	Composite (Bldg. 371)	1.9×10^{-9}	0.000022	1.2×10^{-8}
	Earthquake (Bldg. 707) [a]	1.7×10^{-8}	0.00029	1.6×10^{-7}
	Composite (Bldg. 707) [a]	1.8×10^{-8}	0.00031	1.6×10^{-7}
Sonic Wash at Rocky Flats	Earthquake (Bldg. 371)	7.9×10^{-10}	9.2×10^{-6}	4.9×10^{-9}
	Composite	1.1×10^{-9}	0.000013	6.9×10^{-9}
Alternative 3 (with Plutonium Separation)				
Mediated Electrochemical Oxidation at Rocky Flats	Earthquake (Bldg. 371) [b]	1.3×10^{-9}	0.000015	8.2×10^{-9}
	Composite	2.6×10^{-9}	0.000028	1.2×10^{-8}
	Earthquake (Bldg. 707A) [c]	3.6×10^{-9}	0.000074	1.0×10^{-7}
	Composite	3.8×10^{-9}	0.000079	1.0×10^{-7}

[a] Building 707 is designated as an alternate location for the Blend Down process at Rocky Flats.
[b] Mediated electrochemical oxidation process in Building 371.
[c] Final calcination process in Building 707A.
Note: The impacts due to the proposed processing option are presented in bold type.

4.9 IMPACTS OF MANAGING GRAPHITE RESIDUES

The inventory of graphite residues weighs 1,880 kg (4,141 lb), including 97.4 kg (214.7 lb) of plutonium. The entire inventory is stored in 106 drums (with about 530 internal metal containers) and 39 small individual containers.

As discussed in Chapter 2, the alternatives for graphite residues include one option under the No Action Alternative, three options under the Process without Plutonium Separation Alternative, and two options under the Process with Plutonium Separation Alternative. The preferred processing option is to repackage the graphite residues at Rocky Flats.

This section presents the environmental impacts of managing the entire inventory of graphite residues under each of the six options. The results in this section were used in the calculation of the total impacts of the No Action Alternative and the Preferred Management Approach which are presented in Sections 4.20 and 4.21, respectively, and of the rest of the management approaches which are presented in Section 4.22.

4.9.1 Products and Wastes

Every processing option for graphite residues would generate some quantity of transuranic waste and would prepare this waste for disposal in WIPP. Every option would also generate some quantity of low-level waste, which would be disposed of routinely using existing procedures at each site. A small portion of the low-level waste generated at Rocky Flats could possibly be low-level mixed waste, but this waste would also be disposed of routinely using existing procedures.

The No Action Alternative would generate stabilized residues, containing plutonium in excess of the safeguards termination limits. The Process without Plutonium Separation Alternative would generate transuranic waste directly from the residue. The stabilized residues and transuranic waste would be placed in pipe components inside 210-L (55-gal) drums as shown in Figure 2-13 in Chapter 2.

High-level waste and saltstone would be generated only at the Savannah River Site if the residues were shipped to that site for plutonium separation. The final form for the high-level waste would be glass poured into stainless steel canisters, which would be stored at the Savannah River Site until a geologic repository is ready to receive them. Saltstone is a cement form of low-level waste that is generated as a by-product of Savannah River Site tank farm operations and is routinely disposed of onsite in concrete vaults. If plutonium is separated at Rocky Flats or the Savannah River Site, it would be stored securely onsite until a decision is made on its disposition. No increase in proliferation risk would result and this plutonium would not be used for nuclear explosive purposes. Any plutonium separated at Rocky Flats would contain americium, while at the Savannah River Site the americium would go into the high-level waste.

The solid plutonium-bearing products and wastes that would be generated from graphite residues under each of the options are presented in **Table 4–38**. The shaded areas of Table 4–38 indicate types of solid products and wastes that would not be generated under the various options. The products and wastes from the preferred processing option are presented in bold type. The largest amount of transuranic waste (2,056 drums) would be generated in the option to perform mediated electrochemical oxidation at Rocky Flats under Alternative 2b.

The three options under Alternative 2 would each generate only about one-third as much transuranic waste as would the option to perform mediated electrochemical oxidation at Rocky Flats, under Alternative 3. The other option under Alternative 3 (preprocess at Rocky Flats, then mediated electrochemical oxidation and Purex at Savannah River Site) would only generate 119 drums of transuranic waste. The quantity of low-level waste generated (4,495 drums) would also be highest under the option to perform mediated electrochemical oxidation at Rocky Flats, and would be much lower under all the other options. The site would manage this

Table 4–38 Products and Wastes from Graphite Residues

	Stabilized Residues (Drums)	*Transuranic Waste (Drums)*	*High-Level Waste (Canisters of Glass)*	*Separated Plutonium (kg)*[a]	*Low-Level Waste (Drums)*	*Saltstone (cubic yards)*
Alternative 1 (No Action)						
Repackage at Rocky Flats	**575**	**171**			**376**	
Alternative 2 (without Plutonium Separation)						
Cement at Rocky Flats		756			376	
Vitrify at Rocky Flats		650			153	
Blend Down at Rocky Flats		650			153	
Alternative 3 (with Plutonium Separation)						
Mediated Electrochemical Oxidation at Rocky Flats		2,056		95	4,495	
Preprocess at Rocky Flats		75	–	–	153	–
Mediated Electrochemical Oxidation/Purex at Savannah River Site		44	8	96	63	136

[a] To convert to pounds, multiply by 2.2.

Note: Shaded areas indicate the types of solid products and waste that would not be generated. The products and wastes from the preferred processing option are presented in bold type. The storage capacities at each site are adequate to store the products and wastes in this table.

waste using routine procedures. The maximum amount of plutonium that could be separated from graphite residues is 96 kg (212 lb).

The no action processing option and the preferred processing option are identical and would both generate about 575 drums of stabilized residues, containing plutonium in excess of the safeguards termination limits. For the graphite residues, however, DOE has decided to grant variances to these limits, which will allow these 575 drums to be disposed of in WIPP.

4.9.2 Public and Occupational Health and Safety Impacts

This section describes the radiological and hazardous chemical impacts which could result from the alternatives associated with the management of graphite residues. These impacts are presented for incident-free operation and postulated accident scenarios. The detailed site and transportation analyses are presented in Appendices D and E, respectively.

The round-trip highway distance from Rocky Flats to the Savannah River Site is 5,233 km (3,250 mi). If DOE decides to ship the graphite residues to the Savannah River Site for mediated electrochemical oxidation/Purex processing, then 16 shipments would be required and the total round-trip shipping distance would be 84,000 km (52,000 mi).

No construction of new facilities is included in any of the alternatives, but DOE may need to modify certain existing facilities for some of the alternatives. Mitigation measures during modifications would ensure that any radiological or hazardous chemical releases would be extremely small. Worker exposures to contaminated material would be limited to assure that doses are maintained as low as reasonably achievable.

4.9.2.1 Incident-Free Operations

- **Radiological Impacts**—The radiological impacts to the public and the workers associated with incident-free operations of each option are presented in **Table 4–39**. The impacts due to the preferred processing option are presented in bold type. The impacts are those which are anticipated to occur as a result of process operations and transportation over whatever time period is necessary to process the entire inventory of graphite residues. The length of time necessary to process the graphite residues will depend on which option DOE decides to implement. Impacts associated with subsequent incident-free storage of stabilized residues, separated plutonium, and wastes would be much smaller than from processing or transportation. Cumulative impacts are provided in Section 4.25.

  The highest estimated public maximally exposed individual risk in Table 4–39 is 11 mrem, which could occur only during transportation. This hypothetical individual's cancer risk would be increased by less than one in one hundred thousand. The public maximally exposed individual risks near the sites would be much lower under all of the options. The highest total of the public population radiation doses listed in Table 4–39 would occur if DOE decides to implement the option to perform mediated electrochemical oxidation at the Savannah River Site. The sum of these doses is 1.6 person-rem, which would cause far less than one additional cancer among the population living near both sites and traveling along the truck route. The population living near the truck route would receive a much smaller radiation dose.

  The highest involved worker population radiation dose would be approximately 43 person-rem, which would occur if DOE decides to implement the option to perform mediated electrochemical oxidation at the Savannah River Site. This dose would cause 0.017 additional latent cancer fatalities among the workers directly involved in the operation. Onsite workers who are not involved with the actual processing of the residues are designated as "noninvolved workers." The impacts to these workers would be much smaller than the impacts to the involved workers.

Table 4–39 Radiological Impacts Due to Incident-Free Management of Graphite Residues

	Offsite Public Maximally Exposed Individual		*Offsite Public Population*		*Maximally Exposed Individual Involved Worker*		*Involved Worker Population*	
	Dose (mrem)	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*	*Dose (mrem/yr)*	*Probability of a Latent Cancer Fatality per year*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*
Alternative 1 (No Action)								
Repackage at Rocky Flats	**N/E**	**–**	**N/E**	**–**	**2,000**	**0.0008**	**18**	**0.0072**
Alternative 2 (without Plutonium Separation)								
Cement at Rocky Flats	2.8×10^{-6}	1.4×10^{-12}	0.00060	3.0×10^{-7}	2,000	0.0008	34	0.014
Vitrify at Rocky Flats	4.0×10^{-6}	2.0×10^{-12}	0.00016	8.0×10^{-8}	2,000	0.0008	19	0.0076
Blend Down at Rocky Flats	0.000014	6.8×10^{-12}	0.00028	1.4×10^{-7}	2,000	0.0008	19	0.0076
Alternative 3 (with Plutonium Separation)								
MEO at Rocky Flats	0.000034	1.7×10^{-11}	0.00072	3.6×10^{-7}	2,000	0.0008	36	0.014
Preprocess at Rocky Flats	6.9×10^{-6}	3.4×10^{-12}	0.00015	7.5×10^{-8}	2,000	0.0008	15	0.0060
Transport to Savannah River Site	11	5.5×10^{-6}	1.6	0.0008	100	0.00004	2.5	0.0010
Mediated Electrochemical Oxidation/Purex at Savannah River Site[a]	0.00012	6.0×10^{-11}	0.014	7.0×10^{-6}	2,000	0.0008	25	0.010

MEO = Mediated electrochemical oxidation N/E = no emissions—therefore, there are no radiological impacts to the public

[a] Impacts to the public and workers are presented for F-Canyon operations. It has been determined that H-Canyon operations result in lower impacts to these groups.

Note: The impacts due to the preferred processing option are presented in bold type.

- **Hazardous Chemical Impacts**—The processing of graphite residues at Rocky Flats would not involve airborne releases of hazardous chemicals. No carcinogenic chemicals would be released from the mediated electrochemical oxidation process at Savannah River Site. Noncancer health risks resulting from releases of phosphoric acid, ammonium nitrate, and fluorides are low; the Hazard Index values presented in **Table 4–40** are less than one. The impacts due to the preferred processing option are presented in bold type.

4.9.2.2 Accidents

The potential radiological impacts to the public and the noninvolved onsite workers due to accidents with graphite residues are summarized and presented in this section. The detailed analysis of onsite accidents, with the associated assumptions, is presented in Appendix D, Section D.3. The detailed analysis considered a wide spectrum of potential accident scenarios, including fire, explosion, spill, criticality, earthquake, and aircraft crash. The accident scenarios with the highest consequences and risks were selected and carried forward to this section for the purpose of consequence and risk comparison. A composite of the risks due to major onsite accident scenarios in each spectrum (including the nonbounding accidents) was also computed and used for comparisons. The composite risk estimates are accurate enough for the purpose of comparing processing options against each other. The detailed analysis of transportation accidents, with the associated assumptions, is presented in Appendix E, Sections E.5 and E.6.

The accident frequencies and process durations of the selected accidents are presented in **Table 4–41**. The impacts due to the preferred processing option are presented in bold type. The onsite accident frequencies are given on a per year basis because many accidents, such as earthquakes, are commonly expressed this way. The duration of each process is given in years. The actual probability of occurrence of each onsite accident can be obtained by multiplying the accident frequency times the option's duration. In this way, the calculated probabilities are based on the total amount of residue in this category rather than a standard unit of time.

The calculation of accident probability is slightly different for traffic accident fatalities. The frequency of traffic accidents is given in terms of the number of fatal accidents per round trip shipment from Rocky Flats to Savannah River Site. The process duration for traffic accidents is given as the number of round trip shipments. Thus, the actual probability of a fatal traffic accident can be obtained by multiplying the frequency (fatal accidents per round-trip shipment) times the duration (number of round-trip shipments).

The consequences for the public and a noninvolved onsite worker are also presented in Table 4–41, for each of the six graphite residue processing options. The public maximally exposed individual is a hypothetical individual who resides at the site boundary in the downwind direction. The public population is defined as the residential population within a radius of 80 km (50 mi). A noninvolved onsite worker is defined as an individual worker who is located 100 m (328 ft) or more downwind from the release point when an accidental release of radioactive material occurs.

The highest consequences to the maximally exposed individual would occur if DOE decides to implement the blend down option and a major earthquake strong enough to cause the breach of Building 371 occurs during the 0.23 years of processing at Rocky Flats. The highest consequences to the public population would occur if DOE decides to implement either the repackage or the blend down option and a major earthquake strong enough to cause the collapse of Building 707 occurs during the 0.23 years of processing at Rocky Flats. The highest consequences to the noninvolved onsite worker would occur if DOE decides to implement the option to perform mediated electrochemical oxidation at the Savannah River Site and either of the two earthquake-initiated accidents listed for the public population occurs during the 0.42 years of processing at the Savannah River Site.

Table 4–40 Chemical Impacts Due to Incident-Free Management of Graphite Residues

	Offsite Public Maximally Exposed Individual		*Offsite Public Population*	*Maximally Exposed Individual Worker*		*Worker Population*
	Probability of a Cancer Incidence	*Hazard Index*	*Number of Cancer Incidences or Fatalities*[a]	*Probability of a Cancer Incidence*	*Hazard Index*	*Number of Cancer Incidences or Fatalities*[a]
Alternative 1 (No Action)						
Repackage at Rocky Flats[b]	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**
Alternative 2 (without Plutonium Separation)						
Cement at Rocky Flats[b]	N/E	N/E	N/E	N/E	N/E	N/E
Vitrify at Rocky Flats[b]	N/E	N/E	N/E	N/E	N/E	N/E
Blend Down at Rocky Flats[b]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 3 (with Plutonium Separation)						
Mediated Electrochemical Oxidation at Rocky Flats[b]	N/E	N/E	N/E	N/E	N/E	N/E
Preprocess at Rocky Flats[b]	N/E	N/E	N/E	N/E	N/E	N/E
Transport to Savannah River Site	N/A	N/A	0.00021[c]	N/A	N/A	©
Mediated Electrochemical Oxidation/Purex at Savannah River Site[d, e]	N/E	0.007	N/E	N/E	0.1	N/E

N/E = no emissions N/A = not applicable—the maximally exposed individual is undefined for vehicle emissions

[a] Cancer incidences and fatalities are calculated for process emissions and transportation emissions, respectively.

[b] No hazardous chemicals are released from this process; therefore, no associated health risks exist.

[c] Cancer fatalities due to vehicle emissions into the air. This impact is listed only once under public population because the vehicle emissions affect the public and worker populations collectively. However, the risk to the public dominates. See Appendix E, Section E.4 for additional information.

[d] Impacts are presented for F-Canyon operations. H-Canyon operations are expected to result in similar or lower impacts.

[e] No carcinogenic chemicals are released from the process; therefore, only noncancer health risks are evaluated.

Note: The impacts due to the preferred processing option are presented in bold type.

Table 4–41 Accident Frequencies, Process Durations, and Consequences for Accidents with Graphite Residues

	Accident Scenario	Accident Frequency (per year)	Process Duration (years)	Offsite Public Maximally Exposed Individual Consequences		Offsite Public Population Consequences		Noninvolved Onsite Worker Consequences	
				Dose (mrem)	Probability of a Latent Cancer Fatality	Dose (Person-rem)	Number of Latent Cancer or Traffic Fatalities	Dose (mrem)	Probability of a Latent Cancer Fatality
Alternative 1 (No Action)									
Repackage at Rocky Flats	**Earthquake (Bldg. 707)**	**0.0018**	**0.23**	**1,520**	**0.00076**	**26,700**	**13**	**17,800**	**0.0071**
Alternative 2 (without Plutonium Separation)									
Cement at Rocky Flats	Earthquake (Bldg. 371)	0.000094	0.32	1,000	0.00050	11,700	5.9	7,780	0.0031
	Explosion (Bldg. 707)[a, b]	0.00005	0.32	960	0.00048	16,800	8.4	11,200	0.0045
	Earthquake (Bldg. 707)[b]	0.0018	0.32	667	0.00033	11,700	5.9	7,780	0.0031
Vitrify at Rocky Flats	Explosion (Bldg. 707) [a]	0.00005	0.23	960	0.00048	16,800	8.4	11,200	0.0045
	Earthquake (Bldg. 707) [c]	0.0018	0.23	914	0.00046	16,000	8.0	10,700	0.0043
Blend Down at Rocky Flats	Earthquake (Bldg. 707)	0.0018	0.23	1,520	0.00076	26,700	13	17,800	0.0071
	Earthquake (Bldg. 371)[d]	0.000094	0.23	2,290	0.0011	26,700	13	17,800	0.0071
Alternative 3 (with Plutonium Separation)									
Mediated Electrochemical Oxidation at Rocky Flats	Earthquake (Bldg. 371) [e]	0.000094	0.33	1,580	0.00079	18,500	9.3	12,300	0.0049
	Earthquake (Bldg. 707A) [f]	0.0008	0.31	570	0.00029	11,900	6.0	9,980	0.0040
Preprocess at Rocky Flats	Earthquake (Bldg. 371)	0.000094	0.31	1,710	0.00086	19,900	10	13,300	0.0053
Transport to Savannah River Site	Traffic Fatality	0.00010 per shipment	16 shipments	N/A	N/A	N/A	1.0 [g]	N/A	(h)
Mediated Electrochemical Oxidation/ Purex at Savannah River Site	Earthquake (H-Canyon)[I]	0.000182	0.42	65	0.000033	2,930	1.5	20,800	0.017

N/A = not applicable

[a] Highest consequence accident for this processing option.

[b] Building 707 is designated as an alternate location for the Cement process at Rocky Flats.

[c] Highest risk accident for this processing option.

[d] Building 371 is designated as an alternate location for the Blend Down process at Rocky Flats.

[e] Mediated electrochemical oxidation process in Building 371.

[f] Final calcination process in Building 707A.

[g] This fatality is due to the mechanical impact of the accident, not cancer due to radiation. The radiological consequences of a radioactive release on the highway are impossible to list in a single number because the accident could occur at any point along the route and meteorological conditions and population distributions vary greatly along the route.

[h] The consequence of a high-speed traffic accident would be at least one fatality among the transportation workers due to trauma.

[i] HB-Line operates 60 percent of the time. Dose estimates assumed the HB-Line was operating at the time of the accident.

Note: The impacts due to the preferred processing option are presented in bold type.

The risks associated with each accident are calculated by multiplying the probability by the consequences. The risks to the public and an onsite worker are presented in **Table 4–42**, for each of the six graphite residue processing options. The risk associated with the highest risk accident and a composite risk due to all major accidents are both presented. The risks associated with the preferred processing option are presented in bold type.

The highest risk to the public maximally exposed individual is estimated to be 3.2×10^{-7}, which is due to an earthquake during processing of the residue with the repackage or the blend down option in Rocky Flats Building 707. This individual's chance of incurring a latent cancer fatality would be increased by less than one in one million. The highest risk to the public population is estimated to be 0.0055 latent cancer fatalities, which is also due to an earthquake during processing of the residue with either the repackage or the blend down option in Building 707. The highest risk to the individual noninvolved onsite worker is estimated to be 2.9×10^{-6}, which is also due to an earthquake during processing of the residue with either the repackage or the blend down option in Building 707. This individual's chance of incurring a latent cancer fatality would be increased by less than one in one hundred thousand.

4.10 Impacts of Managing Inorganic Residues

The inventory of inorganic residues weighs 463 kg (1,021 lb), including 17.7 kg (39 lb) of plutonium. The entire inventory is stored in 22 drums (with no internal metal containers) and 63 small individual containers.

As discussed in Chapter 2, the alternatives for inorganic residues include one option under the No Action Alternative, two options under the Process without Plutonium Separation Alternative, and two options under the Process with Plutonium Separation Alternative. The preferred processing option is to repackage the inorganic residues at Rocky Flats.

This section presents the environmental impacts of managing the entire inventory of inorganic residues under each of the five options. The results in this section were used in the calculation of the total impacts of the No Action Alternative and the Preferred Management Approach which are presented in Sections 4.20 and 4.21, respectively, and of the rest of the management approaches which are presented in Section 4.22.

4.10.1 Products and Wastes

Every processing option for inorganic residues would generate some quantity of transuranic waste and would prepare this waste for disposal in WIPP. Every option would also generate some quantity of low-level waste, which would be disposed of routinely using existing procedures at each site. A small portion of the low-level waste generated at Rocky Flats could possibly be low-level mixed waste, but this waste would also be disposed of routinely using existing procedures. The No Action Alternative would generate stabilized residues, containing plutonium in excess of the safeguards termination limits. The Process without Plutonium Separation Alternative would generate transuranic waste directly from the residue. The stabilized residues and transuranic waste would be placed in pipe components inside 210-L (55-gal) drums as shown in Figure 2-13 in Chapter 2.

High-level waste and saltstone would be generated only at the Savannah River Site if the residues are shipped to that site for plutonium separation. The final form for the high-level waste would be glass poured into stainless steel canisters, which would be stored at the Savannah River Site until a geologic repository is ready to receive them. Saltstone is a cement form of low-level waste that is generated as a by-product of the Savannah River Site tank farm operations and is routinely disposed of onsite in concrete vaults. If plutonium is separated at Rocky Flats or the Savannah River Site, it would be stored securely onsite until a decision is made on its disposition. No increase in proliferation risk would result and this plutonium would not be used

Table 4–42 Risks Due to Accidents with Graphite Residues

	Accident Scenario	Offsite Public Maximally Exposed Individual Risk (Probability of a Latent Cancer Fatality)	Offsite Public Population Risk (Number of Latent Cancer or Traffic Fatalities)	Noninvolved Onsite Worker Risk (Probability of a Latent Cancer Fatality)
Alternative 1 (No Action)				
Repackage at Rocky Flats	**Earthquake (Bldg. 707)**	**3.2×10^{-7}**	**0.0055**	**2.9×10^{-6}**
	Composite	**3.3×10^{-7}**	**0.0058**	**3.1×10^{-6}**
Alternative 2 (without Plutonium Separation)				
Cement at Rocky Flats	Earthquake (Bldg. 371)	1.5×10^{-8}	0.00018	9.3×10^{-8}
	Composite (Bldg. 371)	2.3×10^{-8}	0.00027	1.4×10^{-7}
	Earthquake (Bldg. 707)[a]	1.9×10^{-7}	0.0034	1.8×10^{-6}
	Composite (Bldg. 707)[a]	2.1×10^{-7}	0.0036	1.9×10^{-6}
Vitrify at Rocky Flats	Earthquake (Bldg. 707)	1.9×10^{-7}	0.0033	1.8×10^{-6}
	Composite	2.0×10^{-7}	0.0035	1.9×10^{-6}
Blend Down at Rocky Flats	Earthquake (Bldg. 707)	3.2×10^{-7}	0.0055	2.9×10^{-6}
	Composite (Bldg. 707)	3.3×10^{-7}	0.0058	3.1×10^{-6}
	Earthquake (Bldg. 371)[b]	2.5×10^{-8}	0.00029	1.5×10^{-7}
	Composite (Bldg. 371)[b]	3.6×10^{-8}	0.00042	2.2×10^{-7}
Alternative 3 (with Plutonium Separation)				
Mediated Electrochemical Oxidation at Rocky Flats	Earthquake (Bldg. 371)[c]	2.5×10^{-8}	0.00029	1.5×10^{-7}
	Composite	4.9×10^{-8}	0.00054	2.3×10^{-7}
	Earthquake (Bldg. 707A)[d]	7.1×10^{-8}	0.0015	9.9×10^{-7}
	Composite	7.6×10^{-8}	0.0016	1.1×10^{-6}
Preprocess at Rocky Flats	Earthquake (Bldg. 371)	2.5×10^{-8}	0.00029	1.6×10^{-7}
	Composite	3.7×10^{-8}	0.00043	2.3×10^{-7}
Transport to Savannah River Site	Traffic Fatality	NA	0.0016[e]	NA
	Radioactive Release	NA	2.0×10^{-6}	NA
Mediated Electrochemical Oxidation/Purex at Savannah River Site	Earthquake (H-Canyon)[f]	1.6×10^{-9}	0.000073	8.3×10^{-7}
	Composite[f]	3.1×10^{-9}	0.00015	8.4×10^{-7}

N/A= not applicable

[a] Building 707 is designated as an alternate location for the Cement process at Rocky Flats.

[b] Building 371 is designated as an alternate location for the Blend Down process at Rocky Flats.

[c] Mediated electrochemical oxidation process in Building 371.

[d] Final calcination process in Building 707A.

[e] The risk is due to the mechanical impact of the accident, not cancer due to radiation. This risk includes members of the public and transportation workers.

[f] HB-Line operates 60 percent of the time.

Note: The risks due to the preferred processing option are presented in bold type.

for nuclear explosive purposes. Any plutonium separated at Rocky Flats would also contain americium, while at the Savannah River Site the americium would go into the high-level waste.

The solid plutonium-bearing products and wastes that would be generated from inorganic residues under each of the options are presented in **Table 4–43**. The shaded areas of Table 4–43 indicate types of solid products and wastes that would not be generated under the various options. The products and wastes from the preferred processing option are presented in bold type. The largest amount of transuranic waste (485 drums) would be generated in the option to perform mediated electrochemical oxidation at Rocky Flats. This amount is much higher than the other options, which would generate no more than 120 drums of transuranic waste. The quantity of low-level waste would also be highest under the option to perform mediated electrochemical oxidation at Rocky Flats, and much lower under all the other options. The quantities of high-level waste and saltstone would be low under the option to perform Purex processing at the Savannah River Site, and the site would manage these wastes using routine procedures. The maximum amount of plutonium that could be separated is 17 kg (37 lb).

The no action processing option and the preferred processing option are identical and would both generate about 106 drums of stabilized residues, containing plutonium in excess of the safeguards termination limits. For the inorganic residues, however, DOE has decided to grant variances to these limits, which will allow these 106 drums to be disposed of in WIPP.

4.10.2 Public and Occupational Health and Safety Impacts

This section describes the radiological and hazardous chemical impacts that could result from the alternatives associated with the management of inorganic residues. These impacts are presented for incident-free operation and postulated accident scenarios. The detailed site and transportation analyses are presented in Appendices D and E, respectively.

The round-trip highway distance from Rocky Flats to the Savannah River Site is 5,233 km (3,250 mi). If DOE decides to ship the inorganic residues to the Savannah River Site for mediated electrochemical oxidation/Purex processing, then four shipments would be required and the total round-trip shipping distance would be 21,000 km (13,000 mi).

No construction of new facilities is included in any of the alternatives, but DOE may need to modify certain existing facilities for some of the alternatives. Mitigation measures during modifications would ensure that any radiological or hazardous chemical releases would be extremely small. Worker exposures to contaminated material would be limited to assure that doses are maintained as low as reasonably achievable.

4.10.2.1 Incident-Free Operations

- **Radiological Impacts**—The radiological impacts to the public and the workers associated with incident-free operations of each option are presented in **Table 4–44**. The impacts due to the preferred processing option are presented in bold type. The impacts are those which are anticipated to occur as a result of process operations and transportation over whatever time period is necessary to process the entire inventory of inorganic residues. The length of time necessary to process the inorganic residues will depend on which option DOE decides to implement. Impacts associated with subsequent incident-free storage of stabilized residues, separated plutonium, and wastes would be much smaller than from processing or transportation. Cumulative impacts are provided in Section 4.25.

Table 4–43 Products and Wastes from Inorganic Residues

	Stabilized Residues (Drums)	*Transuranic Waste (Drums)*	*High-Level Waste (Canisters of Glass)*	*Separated Plutonium (kg)*[a]	*Low-Level Waste (Drums)*	*Saltstone (cubic yards)*
Alternative 1 (No Action)						
Repackage at Rocky Flats	**106**	**37**			**94**	
Alternative 2 (without Plutonium Separation)						
Vitrify at Rocky Flats		119			40	
Blend Down at Rocky Flats		120			40	
Alternative 3 (with Plutonium Separation)						
Mediated Electrochemical Oxidation at Rocky Flats		485		17	1,075	
Preprocess at Rocky Flats		14	–	–	40	–
Mediated Electrochemical Oxidation/Purex at the Savannah River Site		10	1	17	12	25

[a] To convert to pounds, multiply by 2.2.

Notes: Shaded areas indicate the types of solid products and waste that would not be generated. The products and wastes from the preferred processing option are presented in bold type. The storage capacities at each site are adequate to store the products and wastes listed in this table.

Table 4–44 Radiological Impacts Due to Incident-Free Management of Inorganic Residues

	Offsite Public Maximally Exposed Individual		*Offsite Public Population*		*Maximally Exposed Individual Involved Worker*		*Involved Worker Population*	
	Dose (mrem)	*Probability of Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*	*Dose (mrem/year)*	*Probability of a Latent Cancer Fatality per year*	*Dose (person-rem)*	*Number of Cancer Fatalities*
Alternative 1 (No Action)								
Repackage at Rocky Flats	**N/E**	**–**	**N/E**	**–**	**2,000**	**0.0008**	**3.3**	**0.0013**
Alternative 2 (without Plutonium Separation)								
Vitrify at Rocky Flats	8.4×10^{-7}	4.2×10^{-13}	0.000034	1.7×10^{-8}	2,000	0.0008	3.8	0.0015
Blend Down at Rocky Flats	2.5×10^{-6}	1.2×10^{-12}	0.000052	2.6×10^{-8}	2,000	0.0008	4.8	0.0019
Alternative 3 (with Plutonium Separation)								
Mediated Electrochemical Oxidation at Rocky Flats	6.3×10^{-6}	3.2×10^{-12}	0.00013	6.5×10^{-8}	2,000	0.0008	7.4	0.0030
Preprocess at Rocky Flats	1.3×10^{-6}	6.5×10^{-13}	0.000027	1.4×10^{-8}	2,000	0.0008	3.5	0.0014
Transport to Savannah River Site	11	5.5×10^{-6}	0.39	0.0002	100	0.00004	0.62	0.00025
Mediated Electrochemical Oxidation/Purex at Savannah River Site[a]	0.000021	1.0×10^{-11}	0.0023	1.2×10^{-6}	2,000	0.0008	4.5	0.0018

N/E = no emissions—therefore, there are no radiological impacts to the public

[a] Impacts to the public and workers are presented for F-Canyon operations. It has been determined that H-Canyon operations result in lower impacts to these groups.

Note: The impacts due to the preferred processing option are presented in bold type.

The highest estimated public maximally exposed individual dose in Table 4–44 is 11 mrem, which could occur only during transportation. This hypothetical individual's latent fatal cancer risk would be increased by less than one in one hundred thousand. The public maximally exposed individual risks near the sites would be much lower under all of the options. The highest total of the public population radiation doses listed in Table 4–44 would occur if DOE decides to implement the option to perform mediated electrochemical oxidation at the Savannah River Site. The sum of these doses is 0.39 person-rem, which would cause far less than one additional latent fatal cancer among the population living near both sites and traveling along the truck route. The population living near the truck route would receive a much smaller radiation dose.

Transportation workers (e.g., drivers) will be held to an annual limit of 100 mrem per year because they are not certified radiation workers. All worker doses are routinely monitored, and if any individual worker's dose approaches the annual limit, he or she would be rotated into another job.

The highest involved worker population radiation dose would be approximately 8.6 person-rem, which would occur if DOE decides to implement the option to perform mediated electrochemical oxidation at the Savannah River Site. This dose would cause 0.0035 additional latent cancer fatalities among the workers directly involved in the operation. Onsite workers who are not involved with the actual processing of the residues are designated as "noninvolved workers." The impacts to these workers would be much smaller than the impacts to the involved workers.

- **Hazardous Chemical Impacts**—The processing of inorganic residues at Rocky Flats would not involve airborne releases of hazardous chemicals. No carcinogenic chemicals are released from the mediated electrochemical oxidation process at the Savannah River Site. Noncancer health risks resulting from releases of phosphoric acid, ammonium nitrate, and fluorides are low; the Hazard Index values presented in **Table 4–45** are less than one. The impacts due to the preferred processing option are presented in bold type.

4.10.2.2 Accidents

The potential radiological impacts to the public and the noninvolved onsite workers due to accidents with inorganic residues are summarized and presented in this section. The detailed analysis of onsite accidents, with the associated assumptions, is presented in Appendix D, Section D.3. The detailed analysis considered a wide spectrum of potential accident scenarios, including fire, explosion, spill, criticality, earthquake, and aircraft crash. The accident scenarios with the highest consequences and risks were selected and carried forward to this section for the purpose of consequence and risk comparison. A composite of the risks due to major onsite accident scenarios in each spectrum (including the nonbounding accidents) was also computed and used for comparisons. The composite risk estimates are accurate enough for the purpose of comparing processing options against each other. The detailed analysis of transportation accidents, with the associated assumptions, is presented in Appendix E, Sections E.5 and E.6.

The accident frequencies and process durations of the selected accidents are presented in **Table 4–46**. The impacts due to the preferred processing option are presented in bold type. The onsite accident frequencies are given on a per year basis because many accidents, such as earthquakes, are commonly expressed this way. The duration of each process is given in years. The actual probability of occurrence of each onsite accident can be obtained by multiplying the accident frequency times the option's duration. In this way, the calculated probabilities are based on the total amount of residue in this category rather than a standard unit of time.

Table 4–45 Chemical Impacts Due to Incident-Free Management of Inorganic Residues

	Offsite Public Maximally Exposed Individual		Offsite Public Population	Maximally Exposed Individual Worker		Worker Population
	Probability of Cancer Incidence	Hazard Index	Number of Cancer Incidences or Fatalities[a]	Probability of Cancer Incidence	Hazard Index	Number of Cancer Incidences or Fatalities[a]
Alternative 1 (No Action)						
Repackage at Rocky Flats[b]	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**
Alternative 2 (without Plutonium Separation)						
Vitrify at Rocky Flats[b]	N/E	N/E	N/E	N/E	N/E	N/E
Blend Down at Rocky Flats[b]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 3 (with Plutonium Separation)						
Mediated Electrochemical Oxidation at Rocky Flats	N/E	N/E	N/E	N/E	N/E	N/E
Preprocess at Rocky Flats[b]	N/E	N/E	N/E	N/E	N/E	N/E
Transport to Savannah River Site	N/A	N/A	0.0005[c]	N/A	N/A	©
Mediated Electrochemical Oxidation/Purex at Savannah River Site[d, e]	N/E	0.001	N/E	N/E	0.02	N/E

N/E = no emissions N/A = not applicable—the maximally exposed individual is undefined for vehicle emissions

[a] Cancer incidences and fatalities are calculated for process emissions and transportation emissions, respectively.

[b] No hazardous chemicals are released from process; therefore, no associated health risks exist.

[c] Cancer fatalities due to vehicle emissions into the air. This impact is listed only once under public population because the vehicle emissions affect the public and worker populations collectively. However, the risk to the public dominates. See Appendix E, Section E.4 for additional information.

[d] Impacts are presented for F-Canyon operations. H-Canyon operations are expected to result in similar or lower impacts.

[e] No carcinogenic chemicals are released from the process; therefore, only noncancer health risks are evaluated.

Note: The impacts due to the preferred processing option are presented in bold type.

Table 4–46 Accident Frequencies, Process Durations, and Consequences for Accidents with Inorganic Residues

	Accident Scenario	Accident Frequency (per year)	Process Duration (years)	Offsite Public Maximally Exposed Individual Consequences		Offsite Public Population Consequences		Noninvolved Onsite Worker Consequences	
				Dose (mrem)	Probability of a Latent Cancer Fatality	Dose (person-rem)	Number of Latent Cancer or Traffic Fatalities	Dose (mrem)	Probability of a Latent Cancer Fatality
Alternative 1 (No Action)									
Repackage at Rocky Flats	**Explosion (Bldg. 707)** [a]	**0.00005**	**0.043**	**960**	**0.00048**	**16,800**	**8.4**	**11,200**	**0.0045**
	Earthquake (Bldg. 707) [b]	**0.0018**	**0.043**	**562**	**0.00028**	**9,830**	**4.9**	**6,550**	**0.0026**
Alternative 2 (without Plutonium Separation)									
Vitrify at Rocky Flats	Explosion (Bldg. 707) [a]	0.00005	0.043	960	0.00048	16,800	8.4	11,200	0.0045
	Earthquake (Bldg. 707) [b]	0.0018	0.043	337	0.00017	5,900	3.0	3,930	0.0016
Blend Down at Rocky Flats	Explosion (Bldg. 707) [a]	0.00005	0.043	960	0.00048	16,800	8.4	11,200	0.0045
	Earthquake (Bldg. 707) [b]	0.0018	0.043	562	0.00028	9,830	4.9	6,550	0.0026
	Earthquake (Bldg. 371) [a, c]	0.000094	0.043	843	0.00042	9,830	4.9	6,550	0.0026
	Room Fire (Bldg. 371) [b, c]	0.0005	0.043	173	0.000087	2,020	1.0	1,350	0.00054
Alternative 3 (with Plutonium Separation)									
Mediated Electrochemical Oxidation at Rocky Flats	Criticality (Bldg. 371) [d]	0.0001	0.063	790	0.00040	6,980	3.5	321	0.00013
	Explosion (Bldg. 707A) [a, e]	0.00005	0.058	236	0.00012	4,920	2.5	4,130	0.0017
	Earthquake (Bldg. 707A) [b, e]	0.0008	0.058	207	0.00010	4,310	2.2	3,620	0.0015
Preprocess at Rocky Flats	Earthquake (Bldg. 371) [a]	0.000094	0.051	698	0.00035	8,140	4.1	5,430	0.0022
	Room Fire (Bldg. 371) [b]	0.0005	0.051	143	0.000072	1,670	0.84	1,110	0.00044
Transport to Savannah River Site	Traffic Fatality	0.00010 per shipment	4 shipments	N/A	N/A	N/A	1.0 [f]	N/A	[g]
Mediated Electrochemical Oxidation/Purex at Savannah River Site	Earthquake (H-Canyon) [h]	0.000182	0.42	65	0.000033	2,930	1.5	20,800	0.017

N/A = not applicable

[a] Highest consequence accident for this processing option.

[b] Highest risk accident for this processing option.

[c] Building 371 is designated as an alternate location for the Blend Down process at Rocky Flats.

[d] Mediated electrochemical oxidation process in Building 371.

[e] Final calcination process in Building 707A.

[f] This fatality is due to the mechanical impact of the accident, not cancer due to radiation. The radiological consequences of a radioactive release on the highway are impossible to list in a single number because the accident could occur at any point along the route and meteorological conditions and population distributions vary greatly along the route.

[g] The consequence of a high-speed traffic accident would be at least one fatality among the transportation workers due to trauma.

[h] HB-Line operates 60 percent of the time. Dose estimates assumed the HB-Line was operating at the time of the accident.

Note: The impacts due to the preferred processing option are presented in bold type.

The calculation of accident probability is slightly different for traffic accident fatalities. The frequency of traffic accidents is given in terms of the number of fatal accidents per round trip shipment from Rocky Flats to the Savannah River Site. The process duration for traffic accidents is given as the number of round trip shipments. Thus, the actual probability of a fatal traffic accident can be obtained by multiplying the frequency (fatal accidents per round-trip shipment) times the duration (number of round-trip shipments).

The consequences for the public and a noninvolved onsite worker are also presented in Table 4–46 for each of the five inorganic residue processing options. The public maximally exposed individual is a hypothetical individual who resides at the site boundary in the downwind direction. The public population is defined as the residential population within a radius of 80 km (50 mi). A noninvolved onsite worker is defined as an individual worker who is located 100 m (328 ft) or more downwind from the release point when an accidental release of radioactive material occurs. The highest consequences to all three receptors would occur if DOE decides to implement either the repackage, the vitrification, or the blend down option and an explosion occurs in Building 707 during the 0.043 years of residue processing at Rocky Flats.

The risks associated with each accident are calculated by multiplying the probability times the consequences. The risks to the public and an onsite worker are presented in **Table 4–47** for each of the five inorganic residue processing options. The risk due to the highest risk accident and a composite risk associated with all major accidents are both presented. The risks due to the preferred processing option are presented in bold type.

The highest risk to the public maximally exposed individual is estimated to be 2.2×10^{-8}, which is due to an earthquake during processing of the residue with the repackage or the blend down option in Rocky Flats Building 707. This individual's chance of incurring a latent cancer fatality would be increased by less than one in ten million. The highest risk to the public population is estimated to be 0.00038 latent cancer fatalities, which is also due to an earthquake during processing of the residue with the repackage or the blend down option in Building 707. The highest risk to the individual noninvolved onsite worker is estimated to be 8.3×10^{-7}, which is due to an earthquake during processing of the residue with the mediated electrochemical oxidation option in the Savannah River Site H-Canyon. This individual's chance of incurring a latent cancer fatality would be increased by less than one in one million.

4.11 Impacts of Managing Scrub Alloy

The inventory of scrub alloy weighs approximately 700 kg (1,540 lb), including approximately 200 kg (440 lb) of plutonium. The entire inventory is stored in 276 small individual containers.

As discussed in Chapter 2, the alternatives for scrub alloy include one option under the No Action Alternative, one option under the Process without Plutonium Separation Alternative, and one option under the Process with Plutonium Separation Alternative. The preferred processing option is to repackage the scrub alloy at Rocky Flats and to use the Purex at Savannah River Site.

This section presents the environmental impacts of managing the entire inventory of scrub alloy under each of the three options. The results in this section were used in the calculation of the total impacts of the No Action Alternative and the Preferred Management Approach which are presented in Sections 4.20 and 4.21, respectively, and of the rest of the management approaches which are presented in Section 4.22.

4.11.1 Products and Wastes

Every processing option for scrub alloy would generate some quantity of transuranic waste and would prepare this waste for disposal in WIPP. Every option would also generate some quantity of low-level waste, which would be disposed of routinely using existing procedures at each site. A small portion of the low-level waste generated at Rocky Flats could possibly be low-level mixed waste, but this waste would also be disposed of

Table 4–47 Risks Due to Accidents with Inorganic Residues

	Accident Scenario	Offsite Public Maximally Exposed Individual Risk (Probability of a Latent Cancer Fatality)	Offsite Public Population Risk (Number of Latent Cancer or Traffic Fatalities)	Noninvolved Onsite Worker Risk (Probability of a Latent Cancer Fatality)
Alternative 1 (No Action)				
Repackage at Rocky Flats	**Earthquake (Bldg. 707)**	**2.2×10^{-8}**	**0.00038**	**2.0×10^{-7}**
	Composite	**2.4×10^{-8}**	**0.00042**	**2.2×10^{-7}**
Alternative 2 (without Plutonium Separation)				
Vitrify at Rocky Flats	Earthquake (Bldg. 707)	1.3×10^{-8}	0.00023	1.2×10^{-7}
	Composite	1.5×10^{-8}	0.00026	1.4×10^{-7}
Blend Down at Rocky Flats	Earthquake (Bldg. 707)	2.2×10^{-8}	0.00038	2.0×10^{-7}
	Composite (Bldg. 707)	2.4×10^{-8}	0.00042	2.2×10^{-7}
	Room Fire (Bldg. 371)[a]	1.9×10^{-9}	0.000022	1.2×10^{-8}
	Composite (Bldg. 371)[a]	3.6×10^{-9}	0.000042	2.2×10^{-8}
Alternative 3 (with Plutonium Separation)				
Mediated Electrochemical Oxidation at Rocky Flats	Criticality (Bldg. 371)[b]	2.5×10^{-9}	0.000022	8.1×10^{-10}
	Composite	6.0×10^{-9}	0.000063	2.3×10^{-8}
	Earthquake (Bldg. 707A)[c]	4.8×10^{-9}	0.00010	6.7×10^{-8}
	Composite	5.8×10^{-9}	0.00012	8.1×10^{-8}
Preprocess at Rocky Flats	Room Fire (Bldg. 371)	1.8×10^{-9}	0.000021	1.1×10^{-8}
	Composite	3.5×10^{-9}	0.000041	2.2×10^{-8}
Transport to Savannah River Site	Traffic Fatality	N/A	0.0004[d]	N/A
	Radioactive Release	N/A	1.6×10^{-7}	N/A
Mediated Electrochemical Oxidation/Purex at Savannah River Site	Earthquake (H-Canyon)[e]	1.6×10^{-9}	0.000073	8.3×10^{-7}
	Composite[e]	3.1×10^{-9}	0.00015	8.4×10^{-7}

N/A = not applicable
[a] Building 371 is designated as an alternate location for the Blend Down process at Rocky Flats.
[b] Mediated electrochemical oxidation process in Building 371.
[c] Final calcination process in Building 707A.
[d] This risk is due to the mechanical impact of a potential accident, not cancer due to radiation. This risk includes members of the public and transportation workers.
[e] HB-Line operates 60 percent of the time.
Note: The risks due to the preferred processing option are presented in bold type.

routinely using existing procedures. The No Action Alternative would generate stabilized residues that would have to remain in storage indefinitely. The Process without Plutonium Separation Alternative would generate transuranic waste directly from the residue. The stabilized residues and transuranic waste would be placed in pipe components inside 210-L (55-gal) drums as shown in Figure 2-13 in Chapter 2.

High-level waste and saltstone would be generated only at the Savannah River Site if the scrub alloy were shipped to that site for plutonium separation. The final form for the high-level waste would be glass poured into stainless steel canisters, which would be stored at the Savannah River Site until a geologic repository is ready to receive them. Saltstone is a cement form of low-level waste that is generated as a byproduct of the Savannah River Site tank farm operations and is routinely disposed of onsite in concrete vaults. If plutonium is separated at the Rocky Flats or the Savannah River Site, it would be stored securely onsite until a decision is made on its disposition. No increase in proliferation risk would result and this plutonium would not be used for nuclear explosive purposes. Any plutonium separated at Rocky Flats would also contain americium, while at the Savannah River Site the americium would go into the high-level waste.

The solid plutonium-bearing products and wastes that would be generated from scrub alloy under each of the options are presented in **Table 4–48**. The shaded areas of Table 4–48 indicate types of solid products and wastes that would not be generated under the various options. The products and wastes from the preferred processing option are presented in bold type. The largest amount of transuranic waste (2,809 drums) would be generated in the calcine and vitrify option. Most of this amount would be generated directly from processing the scrub alloy. Transuranic waste that is derived directly from scrub alloy was not included in the Rocky Flats inventory in the WIPP Supplemental EIS, so additional analysis would be required before most of these 2,809 drums of transuranic waste could be disposed of in WIPP (see Section 2.4.1.0.2). Furthermore, this amount is much higher than the other options, which would generate no more than 81 drums of transuranic waste. The quantities of high-level waste, low-level waste, and saltstone would be low under all the options and the sites would manage these wastes using routine procedures. The maximum amount of plutonium that could be separated is 200 kg (440 lb).

4.11.2 Public and Occupational Health and Safety Impacts

This section describes the radiological and hazardous chemical impacts which could result from the alternatives associated with the management of scrub alloy. These impacts are presented for incident-free operation and postulated accident scenarios. The detailed site and transportation analyses are presented in Appendices D and E, respectively.

The round-trip highway distance from Rocky Flats to the Savannah River Site is 5,233 km (3,250 mi). If DOE decides to ship the scrub alloy to the Savannah River Site for Purex processing, then six shipments would be required and the total round-trip shipping distance would be 31,000 km (19,000 mi).

No construction of new facilities is included in any of the alternatives, but DOE may need to modify certain existing facilities for some of the alternatives. Mitigation measures during modifications would ensure that any radiological or hazardous chemical releases would be extremely small. Worker exposures to contaminated material would be limited to assure that doses are maintained as low as reasonably achievable.

4.11.2.1 Incident-Free Operations

- **Radiological Impacts**—The radiological impacts to the public and the workers associated with incident-free operations of each option are presented in **Table 4–49**. The impacts due to the preferred option are presented in bold type. The impacts are those which are anticipated to occur as a result of process operations and transportation over whatever time period is necessary to process the entire inventory of scrub alloy. The length of time necessary to process the scrub alloy will depend on which option DOE decides

Table 4–48 Products and Wastes from Scrub Alloy

	Repackaged Scrub Alloy (Drums)	Transuranic Waste (Drums)	High-Level Waste (Canisters of Glass)	Separated Plutonium (kg)[a]	Low-Level Waste (Drums)	Saltstone (cubic yards)
Alternative 1 (No Action)						
Repackage at Rocky Flats	276	59			140	
Alternative 2 (without Plutonium Separation)						
Calcine and Vitrify at Rocky Flats		2,809			140	
Alternative 3 (with Plutonium Separation)						
Repackage at Rocky Flats		**58**	**–**	**–**	**140**	**–**
Purex at Savannah River Site		**23**	**< 1**	**200**	**82**	**135**

[a] To convert to pounds, multiply by 2.2.

Notes: Shaded areas indicate the types of solid products and waste that would not be generated. The products and wastes from the preferred processing option are presented in bold type. The storage capacities at each site are adequate to store the products and wastes listed in this table.

Table 4–49 Radiological Impacts Due to Incident-Free Management of Scrub Alloy

	Offsite Public Maximally Exposed Individual		Offsite Public Population		Maximally Exposed Individual Involved Worker		Involved Worker Population	
	Dose (mrem)	Probability of a Latent Cancer Fatality	Dose (person-rem)	Number of Latent Cancer Fatalities	Dose (mrem/yr)	Probability of a Latent Cancer Fatality per year	Dose (person-rem)	Number of Latent Cancer Fatalities
Alternative 1 (No Action)								
Repackage at Rocky Flats	0.000042	2.1×10^{-11}	0.0017	8.5×10^{-7}	2,000	0.0008	32	0.013
Alternative 2 (without Plutonium Separation)								
Calcine and Vitrify at Rocky Flats	0.000063	3.2×10^{-11}	0.0025	1.2×10^{-6}	2,000	0.0008	142	0.057
Alternative 3 (with Plutonium Separation)								
Repackage at Rocky Flats	**0.000066**	**3.3×10^{-11}**	**0.0014**	**7.0×10^{-7}**	**2,000**	**0.0008**	**34**	**0.014**
Transport to Savannah River Site	**11**	**5.5×10^{-6}**	**0.59**	**0.00030**	**100**	**0.00004**	**0.93**	**0.0004**
Purex at Savannah River Site[a]	**0.00024**	**1.2×10^{-10}**	**0.0255**	**0.000013**	**2,000**	**0.0008**	**25**	**0.010**

[a] Impacts to the public and workers are presented for F-Canyon operations. It has been determined that H-Canyon operations result in lower impacts to these groups.

Note: The impacts due to the preferred processing option are presented in bold type.

to implement. Impacts associated with subsequent incident-free storage of stabilized scrub alloy, separated plutonium, and wastes would be much smaller than from processing or transportation. Cumulative impacts are provided in Section 4.25.

The highest estimated public maximally exposed individual dose in Table 4–49 is 11 mrem, which could occur only during transportation. This hypothetical individual's latent fatal cancer risk would be increased by less than one in one hundred thousand. The public maximally exposed individual risks near the sites would be much lower under all of the options. The highest total of the public population radiation doses listed in Table 4–49 would occur if DOE decides to implement the option to perform Purex processing at the Savannah River Site. The sum of these doses is 0.62 person-rem, which would cause far less than one additional latent fatal cancer among the population living near both sites and traveling along the truck route. The population living near the truck route would receive a much smaller radiation dose

The highest involved worker population radiation dose would be approximately 142 person-rem, which would occur if DOE decides to implement the option to calcine and vitrify at Rocky Flats. This dose would cause 0.057 additional latent cancer fatalities among the workers directly involved in the operation. Onsite workers who are not involved with the actual processing of the scrub alloy are designated as "noninvolved workers." The impacts to these workers would be much smaller than the impacts to the involved workers.

- **Hazardous Chemical Impacts**—The processing of scrub alloy at Rocky Flats would not involve airborne releases of hazardous chemicals. No carcinogenic chemicals would be released from the Purex process at the Savannah River Site. Noncancer health risks resulting from the release of phosphoric acid, ammonium nitrate, and fluorides are low; the Hazard Index values presented in **Table 4–50** are much less than one. The impacts due to the preferred processing option are presented in bold type.

4.11.2.2 Accidents

The potential radiological impacts to the public and the noninvolved onsite workers due to accidents with scrub alloy are summarized and presented in this section. The detailed analysis of onsite accidents, with the associated assumptions, is presented in Appendix D, Section D.3. The detailed analysis considered a wide spectrum of potential accident scenarios, including fire, explosion, spill, criticality, earthquake, and aircraft crash. The accident scenarios with the highest consequences and risks were selected and carried forward to this section for the purpose of consequence and risk comparison. A composite of the risks due to major onsite accident scenarios in each spectrum (including the nonbounding accidents) was also computed and used for comparisons. The composite risk estimates are accurate for the purpose of comparing processing options against each other. The detailed analysis of transportation accidents, with the associated assumptions, is presented in Appendix E, Sections E.5 and E.6.

The accident frequencies and process durations of the selected accidents are presented in **Table 4–51**. The impacts due to the preferred processing option are presented in bold type. The onsite accident frequencies are given on a per year basis because many accidents, such as earthquakes, are commonly expressed this way. The duration of each process is given in years. The actual probability of occurrence of each onsite accident can be obtained by multiplying the accident frequency times the option's duration. In this way, the calculated probabilities are based on the total amount of residue in this category rather than a standard unit of time.

The calculation of accident probability is slightly different for traffic accident fatalities. The frequency of traffic accidents is given in terms of the number of fatal accidents per round trip shipment from Rocky Flats to the Savannah River Site. The process duration for traffic accidents is given as the number of round trip shipments. Thus, the actual probability of a fatal traffic accident can be obtained by multiplying the frequency (fatal accidents per round-trip shipment) times the duration (number of round-trip shipments).

Table 4–50 Chemical Impacts Due to Incident-Free Management of Scrub Alloy

	Offsite Public Maximally Exposed Individual		*Offsite Public Population*	*Maximally Exposed Individual Worker*		*Worker Population*
	Probability of a Cancer Incidence	*Hazard Index*	*Number of Cancer Incidences or Fatalities*[a]	*Probability of a Cancer Incidence*	*Hazard Index*	*Number of Cancer Incidences or Fatalities*[a]
Alternative 1 (No Action)						
Repackage at Rocky Flats[b]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 2 (without Plutonium Separation)						
Calcine and Vitrify at Rocky Flats[b]	N/E	N/E	N/E	N/E	N/E	N/E
Alternative 3 (with Plutonium Separation)						
Repackage at Rocky Flats[b]	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**	**N/E**
Transport to Savannah River Site	**N/A**	**N/A**	**0.00008[c]**	**N/A**	**N/A**	**(c)**
Purex at Savannah River Site[d, e]	**N/E**	**0.007**	**N/E**	**N/E**	**0.1**	**N/E**

N/E = no emissions N/A = not applicable—the maximally exposed individual is undefined for vehicle emissions

[a] Cancer incidences and fatalities are calculated for process emissions and transportation emissions, respectively.

[b] No hazardous chemicals are released from process; therefore, no associated health risks exist.

[c] Cancer fatalities due to vehicle emissions into the air. This impact is listed only once under public population because the vehicle emissions affect the public and worker populations collectively. However, the risk to the public dominates. See Appendix E, Section E.4 for additional information.

[d] Impacts are presented for F-Canyon operations. H-Canyon operations are expected to result in similar or lower impacts.

[e] No carcinogenic chemicals are released from the process; therefore, only noncancer health risks are evaluated.

Note: The impacts due to the preferred processing option are presented in bold type.

Table 4–51 Accident Frequencies, Process Durations, and Consequences for Accidents with Scrub Alloy

	Accident Scenario	Accident Frequency (per year)	Process Duration (years)	Offsite Public Maximally Exposed Individual Consequences		Offsite Public Population Consequences		Noninvolved Onsite Worker Consequences	
				Dose (mrem)	Probability of a Latent Cancer Fatality	Dose (person-rem)	Number of Latent Cancer or Traffic Fatalities	Dose (mrem)	Probability of a Latent Cancer Fatality
Alternative 1 (No Action)									
Repackage at Rocky Flats	Earthquake (Bldg. 707)	0.0018	0.11	142	0.000071	2,640	1.3	1,730	0.00069
Alternative 2 (without Plutonium Separation)									
Calcine and Vitrify at Rocky Flats	Earthquake (Bldg. 707) [a] Dock Fire (Bldg. 707) [b]	0.0018 2.0×10^{-6}	2.21 2.21	4.3 25	2.2×10^{-6} 0.000013	79 468	0.040 0.23	52 306	0.000021 0.00012
Alternative 3 (with Plutonium Separation)									
Repackage at Rocky Flats	**Earthquake (Bldg. 371) [b]** **Room Fire (Bldg. 371) [a]**	**0.000094** **0.0005**	**0.12** **0.12**	**131** **27**	**0.000066** **0.000014**	**1,550** **318**	**0.78** **0.16**	**1,010** **208**	**0.00040** **0.000083**
Transport to Savannah River Site	**Traffic Fatality**	**0.00010 per shipment**	**6 shipments**	**N/A**	**N/A**	**N/A**	**1.0 [c]**	**N/A**	**d**
Purex at Savannah River Site	**Earthquake (H-Canyon)**	**0.000182**	**0.50**	**407**	**0.00020**	**18,100**	**9.1**	**136,000**	**0.11**

N/A = not applicable

[a] Highest risk accident for this processing option.

[b] Highest consequence accident for this processing option.

[c] This fatality is due to the mechanical impact of the accident, not cancer due to radiation. The radiological consequences of a radioactive release on the highway are impossible to list in a single number because the accident could occur at any point along the route and meteorological conditions and population distributions vary greatly along the route.

[d] The consequence of a high-speed traffic accident would be at least one fatality among the transportation workers due to trauma.

Note: The impacts due to the preferred processing option are presented in bold type.

The consequences for the public and a noninvolved onsite worker are also presented in Table 4–51, for each of the three scrub alloy processing options. The public maximally exposed individual is a hypothetical individual who resides at the site boundary in the downwind direction. The public population is defined as the residential population within a radius of 80 km (50 mi). A noninvolved onsite worker is defined as an individual worker who is located 100 m (328 ft) or more downwind from the release point when an accidental release of radioactive material occurs. The highest consequences to all three receptors would occur if DOE decides to implement the Purex option at the Savannah River Site and a major earthquake strong enough to cause a breach in the H-Canyon during the 0.50 years of scrub alloy processing at the Savannah River Site.

The risks associated with each accident are calculated by multiplying the probability times the consequences. The risks to the public and an onsite worker are presented in **Table 4–52** for each of the three scrub alloy processing options. The risk associated with the highest risk accident and a composite risk due to all major accidents are both presented. The risks associated with the preferred processing option are presented in bold type.

The highest risk to the public maximally exposed individual is estimated to be 2.9×10^{-8}, which is due to an earthquake during processing of the scrub alloy with the Purex option at the Savannah River Site. This individual's chance of incurring a latent cancer fatality would be increased by less than one in ten million. The highest risk to the public population is estimated to be 0.00013 latent cancer fatalities, which is also due to an earthquake during processing of the scrub alloy with the mediated electrochemical oxidation option at the Savannah River Site. The highest risk to the individual noninvolved onsite worker is estimated to be 9.9×10^{-6}, and is due to the same accident scenario at the Savannah River Site. This individual's chance of incurring a latent cancer fatality would be increased by less than one in one hundred thousand.

4.12 Air Quality

The potential human health impacts of hazardous chemicals (carbon tetrachloride, phosphoric acid, hydrochloric acid, hydrofluoric acid, and calcium fluoride) are evaluated in the hazardous chemical impacts subsections of this chapter. In addition to hazardous chemicals, some of the processing options could release criteria air pollutants. These chemicals are analyzed in this section by comparing their concentrations to Federal and State air pollution standards.

For this EIS, a screening-level technology assessment was developed for the fluidized bed incineration of combustible and filter media residues at Rocky Flats. The technology description for this process includes engineering controls, such as an offgas/particulate separator, a catalytic convertor, and high-efficiency particulate air filters, that would severely limit all airborne releases. Incineration is not a reasonable processing option but is included in the EIS because of its technical feasibility. If DOE decides to implement this option, then extensive additional analysis would be required. This additional analysis could support additional NEPA documentation and an operating permit from the State of Colorado, both of which could provide opportunities for additional public input.

Table 4–53 presents the modeled total concentrations of hazardous and criteria air pollutants released from all of the proposed processing at each site and compares them to existing Federal and State air pollution standards. The Industrial Source Complex air dispersion model ISC3 was used to develop these estimates (see Appendix D, Section D.4). The types of air pollutants differ by site because of differences in the chemical constituents of the residue materials and in the chemical reactants required for the various processes. These concentrations are based on the maximum predicted releases at each site that are associated with managing all residues and scrub alloy.

Table 4–52 Risks Due to Accidents with Scrub Alloy

	Accident Scenario	*Offsite Public Maximally Exposed Individual Risk (Probability of a Latent Cancer Fatality)*	*Offsite Public Population Risk (Number of Latent Cancer or Traffic Fatalities)*	*Noninvolved Onsite Worker Risk (Probability of a Latent Cancer Fatality)*
Alternative 1 (No Action)				
Repackage at Rocky Flats	Earthquake (Bldg. 707)	1.4×10^{-8}	0.00026	1.4×10^{-7}
	Composite	1.5×10^{-8}	0.00028	1.5×10^{-7}
Alternative 2 (without Plutonium Separation)				
Calcine and Vitrify at Rocky Flats	Earthquake (Bldg. 707)	8.5×10^{-9}	0.00016	8.2×10^{-8}
	Composite	9.4×10^{-9}	0.00017	9.1×10^{-8}
Alternative 3 (with Plutonium Separation)				
Preprocess at Rocky Flats	**Room Fire (Bldg. 371)**	**8.1×10^{-10}**	**9.6×10^{-6}**	**5.0×10^{-9}**
	Composite	**1.6×10^{-9}**	**0.000018**	**9.6×10^{-9}**
Transport to Savannah River Site	**Traffic Fatality**	**N/A**	**0.0006 [a]**	
	Radioactive Release	**N/A**	**4.3×10^{-8}**	**N/A**
Purex at Savannah River Site	**Earthquake (H-Canyon)**	**1.9×10^{-8}**	**0.00082**	**9.9×10^{-6}**
	Composite	**2.9×10^{-8}**	**0.0013**	**9.9×10^{-6}**

N/A = not applicable

[a] This risk is due to the mechanical impact of a potential accident, not cancer due to radiation. This risk includes members of the public and transportation workers.

Note: The risks due to the preferred processing option are presented in bold type.

Table 4–53 Air Quality Impacts from Process Emissions

Site	Pollutant	Modeled Onsite Concentration ($\mu g/m^3$)	Averaging Time	Most Stringent Regulations or Guidelines ($\mu g/m^3$)[a]
Criteria Air Pollutants				
Rocky Flats	Nitrogen dioxide[b]	0.008	Annual	100
Savannah River Site	Nitrogen dioxide[b]	0.3	Annual	100
Hazardous Chemicals				
Rocky Flats	Carbon tetrachloride	0.002	Annual	N/A
Rocky Flats	Hydrochloric acid	0.00006	Annual	N/A
Savannah River Site	Phosphoric acid	0.02[d]	24-hour	25
Savannah River Site	Nitric acid	7[d]	24-hour	125
Savannah River Site	Gaseous fluorides[c]	0.04[d]	24-hour	2.9

N/A = not available
[a] Federal and State standards.
[b] Nitrogen oxide potentially released.
[c] Hydrofluoric acid and calcium fluoride potentially released.
[d] Values are estimated 8-hour onsite concentrations.

For Rocky Flats, nitrogen oxide (NO_x) is the only criteria pollutant expected to be released. Modeled ambient air concentrations of this pollutant are compared to the annual standard for nitrogen dioxide (NO_2). For the Savannah River Site, nitrogen oxide emissions are also compared to the annual standard for nitrogen dioxide. In addition, emissions of the hazardous air pollutants nitric acid, hydrofluoric acid, calcium fluoride, and phosphoric acid at the Savannah River Site are compared to the 24-hour standards for nitric acid, gaseous fluorides, and phosphoric acid. The Los Alamos National Laboratory is not included in the table because no hazardous chemicals and only a very small quantity of criteria air pollutants would be released to the atmosphere due to the very limited processing that would take place at that site under any of the processing options.

The modeled ambient air concentrations used in this analysis are conservative estimates—onsite concentrations are used for all contaminants and 8-hour averaging times for hazardous air pollutant concentrations are used instead of the 24-hour State standards. The modeled concentrations are very small in comparison to the standards. Therefore, the air quality impacts due to managing plutonium residues and scrub alloy would be low under any combination of processing options.

In addition to the releases of criteria pollutants from processing facilities, the shipment of residues and scrub alloy between sites would also contribute small amounts of criteria pollutants. The impacts of these mobile sources of pollutants on air quality would be very low. See the Cumulative Impacts discussion in Section 4.25.4 for additional information.

No form Clean Air Act conformity determination is required for the proposed action because only the Rocky Flats Environmental technology Site is located in a non-attainment area and the processing technologies being considered at Rocky Flats, as well as at the Savannah River Site and the Los Alamos National Laboratory, do not emit sufficient quantities of criteria air pollutants to trigger a conformity determination.

4.13 Water Quality

None of the processing options at any of the sites would discharge untreated process effluents to surface water or ground water. Thus, there would be no impact on water quality at any of the three sites under incident-free conditions.

In the event of a major earthquake or an airplane crash at a facility that is processing plutonium residues or scrub alloy, radioactive material might be released into surface waters. The amount of material that may be released from the facility to the surface water and subsequently flow offsite would be very small. A traffic accident involving a truck carrying containers of plutonium residues or scrub alloy would have no impact on water quality because the containers are all designed to contain the material, even if the containers are submerged in water after the traffic accident.

4.14 Impacts of Post-Processing Transportation and Storage

The impacts of post-processing transportation and storage of the products and wastes generated from processing the Rocky Flats plutonium residues and scrub alloy are analyzed in other EISs prepared by DOE.

The environmental impacts of transporting the transuranic waste generated during processing of the plutonium residues are included in the *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement* (DOE 1997h). Further NEPA review would be needed before transuranic wastes from scrub alloy could be disposed of at WIPP.

Low-level and possibly low-level mixed waste would also be generated as a result of processing the residues and scrub alloy. The environmental impacts of transporting these wastes are included in the *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (DOE 1997d).

Impacts from transportation and storage of plutonium metal and oxides, which would be produced by processing residues and scrub alloy with plutonium separation (Alternative 3), are described in the *Storage and Disposition of Weapons-Usable Fissile Materials Programmatic Environmental Impact Statement* (Storage and Disposition Programmatic EIS) (DOE 1996a). If Alternative 3 (processing with plutonium separation) is implemented for the electrorefining and molten salt extraction residues, the resulting plutonium product would have special management requirements not addressed in the Storage and Disposition Programmatic EIS. These residues have a high americium content, and the non-Purex separation processes bring considered for this category would not ensure the removal of the americium from the plutonium. Because americium emits gamma radiation, shielded containers would be required for storage and transportation of this mixture of plutonium and americium. Also, worker radiation exposures from storage and transportation of this material probably would be higher than those estimated in the Storage and Disposition Programmatic EIS for storage and transportation of weapons-usable plutonium.

DOE plans to consolidate the storage of weapon-usable plutonium by upgrading existing and planned facilities at the Pantex Plant in Texas and the Savannah River Site in South Carolina. After certain conditions are met, most plutonium now stored at Rocky Flats would be moved to the Pantex Plant and the Savannah River Site (DOE 1997g). The transportation and storage of this plutonium will be analyzed in the *Surplus Plutonium Disposition EIS,* which is in preparation (DOE 1997e).

4.15 Impacts of Disposal/Disposition of Products and Wastes

The impacts of disposal and/or disposition of the products and wastes generated from processing the Rocky Flats plutonium residues and scrub alloy are analyzed in other EISs prepared by DOE.

Products and wastes that result from processing the residues and scrub alloy according to the No Action Alternative would be stored at Rocky Flats until decisions are made concerning their disposition. Accordingly, no disposal impacts can be estimated at this time.

If the residues and scrub alloy are processed according to the Process without Plutonium Separation Alternative, the residual product is a transuranic waste that meets the WIPP waste acceptance criteria. The environmental impacts of disposing of the transuranic waste from the residues are included in the *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement* (DOE 1997h). Further NEPA review would be needed before transuranic wastes from scrub alloy could be disposed of at WIPP.

Secondary wastes classified as low-level or low-level mixed waste may also be generated as a result of the processes to stabilize the residues and scrub alloy. The environmental impacts of disposing of these secondary wastes are included in the *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (DOE 1997d).

If the residues and scrub alloy are processed according to the Process with Plutonium Separation Alternative, two principal products would result: (1) plutonium metal or plutonium oxide that contains greater than 50 percent plutonium and (2) transuranic waste. In addition, secondary wastes classified as low-level or low-level mixed waste may be generated during the process. Further, additional waste streams are generated when processing takes place at the Savannah River Site.

Decisions have not yet been made concerning the disposition of the plutonium metal and plutonium oxide separated from the residues and scrub alloy. However, current DOE policy would ensure that any plutonium separated and/or stabilized under this EIS would not be used for nuclear explosive purposes (DOE 1994e). The environmental impacts of further stabilization of this material or its conversion into a mixed oxide fuel would be determined in the Surplus Plutonium Disposition EIS currently in preparation (DOE 1997e). No environmental impact statement has yet been published on the disposal of stabilized plutonium or irradiated mixed oxide fuel in a national geologic repository. The impacts of disposing of transuranic waste resulting from processing of the residues are analyzed in the *Waste Isolation Pilot Plant Disposal Phase Final Supplemental Environmental Impact Statement* (DOE 1997h). The environmental impacts of disposing of most of the low-level and low-level mixed secondary wastes generated in the processing of residues and scrub alloy are included in the *Final Waste Management Programmatic Environmental Impact Statement for Managing Treatment, Storage, and Disposal of Radioactive and Hazardous Waste* (DOE 1997d).

Two additional waste streams would be generated at the Savannah River Site if the residues or scrub alloy are processed by the mediated electrochemical process or the Purex process. These processes produce a waste that is sent to the high-level waste tank farm and mixed with other high-level wastes. When this waste is processed, part of it is sent to the Defense Waste Processing Facility to be vitrified as high-level waste and another fraction is sent to the Saltstone Manufacturing and Disposal Facility to be solidified as low-level waste. The high-level waste fraction of this waste would be disposed of in the national geologic repository for defense high-level waste and spent nuclear fuel. The environmental impacts of disposing of the high-level waste fraction of this material will be addressed with other high-level waste. The impacts of disposing of saltstone at the Savannah River Site are addressed in the *Final Supplemental Environmental Impact Statement, Defense Waste Processing Facility* (DOE 1994c).

4.16 ENVIRONMENTAL JUSTICE

As discussed in Appendix F, Executive Order 12898 directs Federal agencies to address disproportionately high and adverse health or environmental effects of alternatives on minority populations and low-income populations. The Executive Order does not alter prevailing statutory interpretations under NEPA or existing case law. Regulations prepared by the Council on Environmental Quality (the Council) remain the foundation for the preparation of environmental documentation in compliance with NEPA (40 CFR Parts 1500 through 1508). As discussed previously, the alternatives would have no significant adverse or beneficial environmental

effects on the general population. Nor would the alternatives have any significant effects on any particular group within the general population including minority populations or low-income populations.

Chapter 3 and Appendix F describe the distributions of minority and low-income populations in the vicinity of the three candidate processing sites and potential intersite transportation routes. Analyses described elsewhere in this chapter predict only minimal risks to health and safety from the management of plutonium residues and scrub alloy currently stored at Rocky Flats. Analyses of risks from incident-free operations and from accidents under all alternatives yield estimates that are much less than 1. Because none of the alternatives would cause high and adverse consequences to the population at large, no minority or low-income populations would be expected to experience disproportionate high and adverse consequences.

4.17 Costs, Processing Durations, and Uncertainties

This section summarizes total costs, associated processing durations, and uncertainties for the Minimum Cost and Preferred Management Approaches. Detailed supporting data and calculations for the individual processing options are presented in Appendix G. All costs are presented in undiscounted 1997 dollars.

The costs are presented in three ways:

- Allocable program costs, including costs incurred or planned to be incurred in support of the plutonium residues program independent of any decisions made in this EIS
- Out-of-pocket costs that depend on the selected management approach, including all site overheads and indirect costs
- Incremental out-of-pocket costs for each management approach compared to the No Action Alternative.

All costs for individual management approaches are rolled-up totals from six individual cost categories:

- Facilities and Equipment Costs
- Labor costs
- Transuranic waste costs
- Low-level waste costs at Rocky Flats and Los Alamos National Laboratory
- Other materials storage, shipping, and disposal costs, including costs at the Savannah River Site
- Costs related to delaying the closure of Rocky Flats.

DOE estimates that the minimum cost management approach has an allocable cost of about $485 million. About $180 million of this cost has been or will be incurred at Rocky Flats in support of the plutonium residues program independent of any decisions in this EIS. Another $20 million will be incurred at Rocky Flats or Los Alamos National Laboratory in fiscal year 1998 for development and testing of the processing technologies independent of any decisions in this EIS. The remaining $285 million is allocable to individual processing options (including site overheads and indirect costs) at the various sites. **Table 4–54** shows these costs. Allocable common costs at Rocky Flats are based on a charge of $30 million per building or module used in a management approach. This charge covers facilities upgrades, compliance with DOE Orders or Defense Nuclear Facilities Safety Board recommendations, operational readiness reviews, start-up, standard equipment and supplies, documentation, and so forth. Between five and seven buildings or modules at Rocky Flats (e.g., Building 707 Module A, Building 707 Module B, Building 371 Room 3701) would be required for each management approach. Where appropriate, itemized equipment costs for equipment used in multiple processes are added to the common cost total. No common costs are allocated for activities at the Savannah River Site or Los Alamos National Laboratory in the minimum cost management approach. Decommissioning costs at all three sites are considered to be part of site-wide programs outside the scope of this EIS.

Table 4–54 Costs of the Minimum Cost Processing Options[a]

Material Category	Minimum Cost Processing Option	Approx. Cost, Excluding Common Costs ($M)	DOE Preferred Processing Option
Incinerator Ash	Vitrify at Rocky Flats	89	Yes
Sand, Slag, and Crucible	Vitrify at Rocky Flats	17	No
Inorganic Ash	Vitrify at Rocky Flats	8	Yes
Graphite Fines	Vitrify at Rocky Flats	6	Yes
Electrorefining and Molten Salt Extraction Salts	Three options have about the same (minimum) cost: 1) Pyro-Oxidize and Salt Distill at Rocky Flats, 2) Pyro-Oxidize at Rocky Flats and Salt Distill at Los Alamos National Laboratory, or 3) Salt Scrub at Rocky Flats and Purex at the Savannah River Site F-Canyon.	83	Yes (Salt Distill at Rocky Flats)
Direct Oxide Reduction Salts	Salt Scrub at Rocky Flats and Purex at the Savannah River Site F-Canyon	14	No
Combustibles	Shred and Blend down at Rocky Flats	4	No
Plutonium Fluorides	Repackage at Rocky Flats and Purex at the Savannah River Site F-Canyon	24	Yes
Filter Media	Shred and Blend Down at Rocky Flats	9	TBD
Sludge Residues	Blend Down at Rocky Flats	3	TBD
Glass Residues	Blend Down at Rocky Flats	1	No
Graphite Residues	Repackage at Rocky Flats	3	Yes
Inorganic Residues	Repackage at Rocky Flats	1	Yes
Scrub Alloy	Repackage at Rocky Flats and Purex at the Savannah River Site F-Canyon	21	Yes
Total Individual Costs[b]		~285	
Common Costs at Rocky Flats		~180	
Development Costs at Rocky Flats and Los Alamos National Laboratory		~20	
Total		~485	

[a] Excluding processing options which would generate stabilized residues without variances for disposal in WIPP and options involving incineration at Rocky Flats.
[b] Because of round-off, the sum of the individual costs does not add up exactly to the total cost given on this line.
TBD=To be determined. DOE has not yet selected preferred processing options for filters or sludges.

Most of the technology development required for the program is underway at Rocky Flats or Los Alamos National Laboratory pursuant to guidance from the Defense Nuclear Facilities Safety Board or other DOE programs and would continue independent of the Record of Decision in this EIS. For fiscal year 1998, the largest itemized development and testing costs are estimated to be for fluidized bed incineration ($10 million), catalytic chemical oxidation ($2 million), mediated electrochemical oxidation ($2 million), salt distillation ($2 million), and sonic wash ($1 million). Of these, only salt distillation is among the preferred processing options.

The $285 million in costs chargeable to individual processing options is based on the most conservative or most proven approach to a particular processing and waste handling technology. Processing costs are based on facilities and equipment that are (or would be) up-and-running for this program rather than on developmental technologies. Site overheads and indirect costs, including costs for inter- and intra-site

coordination, shipping, and management, are included in the out-of-pocket cost estimate. Cost and processing duration uncertainties are discussed separately at the end of this section.

More than 75 percent of the individually allocable costs would be due to the management of ash and salt residues. Furnace vitrification at Rocky Flats is the least expensive approach for managing the ash (including graphite fines and sand, slag, and crucible) while salt scrub at Rocky Flats for Purex processing at the Savannah River Site F-Canyon, is the least expensive option for managing the salts. Pyro-oxidation of electrorefining and molten salt extraction salts at Rocky Flats for distillation at either Rocky Flats or Los Alamos National Laboratory is similar in cost to Purex processing at the Savannah River Site F-Canyon but subject to greater technical and economic uncertainty. The least expensive option for managing the plutonium fluorides and scrub alloy is Purex processing at the Savannah River Site F-Canyon. Processing options that include plutonium separation (e.g., Purex and salt distillation) also include a charge for storing and disposing of the refined plutonium.

In contrast to the minimum cost management approach, the preferred management approach has an additional $16 million in itemized equipment costs and an additional $20 million in out-of-pocket costs for labor, waste processing, etc. (**Table 4-55**). The only residue categories for which the preferred processing options are substantially more expensive than the minimum costs options are sand, slag, and crucible and direct oxide reduction salts. Purex processing of sand, slag, and crucible at the Savannah River Site F-Canyon is about $19 million more costly than furnace vitrification at Rocky Flats. Processing and packaging the direct oxide reduction salts for water leach at Los Alamos National Laboratory is about $14 million more expensive than processing and packaging the salts for Purex processing at the Savannah River Site F-Canyon. The minimum cost processing option for molten salt extraction and electrorefining salts incurs more labor and waste processing costs than the preferred processing approach but could offset an equivalent expenditure for pyro-oxidation furnaces and distillation equipment (depending on how the $12 million cost for the pyro-oxidation furnaces is allocated). The total allocable cost in the preferred management approach is estimated at $520 million.

The No Action Alternative (excluding interim on-site storage) has an estimated total cost of about $406 million, of which $150 million is attributable to common costs at Rocky Flats, $12 million to itemized equipment, and $244 million to individual processing options. Adding interim on-site storage, which would be required for the materials above safeguards termination limits, increases the cost to almost $700 million, of which more than $500 million would be incremental and out-of-pocket.

Apart from interim on-site storage, the only large incremental costs under the No Action Alternative are those for specialized equipment, waste characterization and disposition, and a portion of the allocable labor. Costs for ongoing facilities and equipment upgrades, ongoing technology development, site support, existing indirect labor, program management, and so forth are being incurred or will be incurred at about the same level over the next few years independent of any decisions in this EIS. Incremental processing labor costs average only about 20 to 30 percent of allocable labor costs in most management approaches, so the incremental cost impact to DOE from selecting any of the broadly similar processing options is small. For example, DOE estimates that the difference in incremental costs between the minimum cost management approach and the preferred management approach could be as little as $15 to 20 million ($4 million for distillation equipment plus perhaps $10 to 15 million for variable processing labor and waste-related costs). These differences are well within the level of uncertainty in the cost estimating procedures and the technical and processing duration uncertainties associated with the individual processing options.

Table 4–55 Costs of the Preferred Processing Options

Material Category	Preferred Processing Option	Approx. Cost, Excluding Common Costs ($M)	Increment Over Minimum Cost Processing Option ($M)
Incinerator Ash	Vitrify at Rocky Flats	89	0
Sand, Slag, and Crucible	Repackage at Rocky Flats and Purex at the Savannah River Site F-Canyon	36	19
Inorganic Ash	Vitrify at Rocky Flats	8	0
Graphite Fines	Vitrify at Rocky Flats	6	0
Electrorefining and Molten Salt Extraction Salts	Pyro-oxidize and Salt Distill at Rocky Flats	70	(13)[a]
Direct Oxide Reduction Salts	Pyro-oxidation at Rocky Flats and Water Leach at Los Alamos National Laboratory	28	14
Aqueous Contaminated Combustibles	Neutralize/dry at Rocky Flats	2	1
Organic Contaminated Combustibles	Thermal Desorption/Steam Passivation at Rocky Flats	3	1
Dry Contaminated Combustibles	Repackage at Rocky Flats	1	0
Plutonium Fluorides	Repackage at Rocky Flats and Purex at the Savannah River Site F-Canyon	24	0
Filter Media	To Be Determined (assume Blend Down at Rocky Flats for cost analysis)	9	0
Sludge Residues	To Be Determined (assume Blend Down at Rocky Flats for cost analysis)	3	0
Glass Residues	Neutralize/dry at Rocky Flats	1	0
Graphite Residues	Repackage at Rocky Flats	3	0
Inorganic Residues	Repackage at Rocky Flats	1	0
Scrub Alloy	Repackage at Rocky Flats and Purex at the Savannah River Site F-Canyon	21	0
Total Individual Costs[b]		~304	~20
Common Costs	At Rocky Flats	~196	~16
Development Costs	At Rocky Flats and Los Alamos National Laboratory	~20	0
Total		~520	~35

[a] Offsets more than equivalent costs in pyro-oxidation and distillation equipment in preferred alternative.
[b] Because of round-off, the sum of the individual costs do not add up exactly to the total cost given on this line.

Most combinations of processing options would require 3 to 7 years of processing time at Rocky Flats. The processing at the Savannah River Site would run concurrently with other ongoing programs. The maximum time required at Los Alamos National Laboratory would be less than 1 year. DOE has not yet decided when various activities would take place at each site in each management approach. In general, however, the combination of relatively brief durations, the low Federal discount rate, and the general similarity of most options (excluding, for example, such high-cost options as ash and salt blending at Rocky Flats or mediated electrochemical oxidation at Savannah River Site's H-Canyon) suggests that discounted costs would have very little value in differentiating one option or set of options from another. The absence of discounted costs, arising from the absence of integrated management schedules, is thus of very little decisional significance.

Several factors contribute to the cost relationships outlined in this section. First, in general, the shorter the duration of processing, the lower the costs. Second, processing options that demand highly specific large-scale equipment (e.g., mediated electrochemical oxidation) or facilities that would not otherwise be used (e.g., Building 776 for thermal destruction) are never among the least costly options. Third, the results depend

on the use of TRUPACT-II loadings at 2,800 fissile gram-equivalence. If TRUPACT-II loadings are reduced, the minimum cost program excludes blend down and favors separation. Fourth, to the extent blend down is among the minimum cost options, it is a result of the relatively small quantities of plutonium in the residue, and the low generation of secondary transuranic waste and low-level waste.

The estimated time required at Rocky Flats to complete processing operations under either the preferred management approach or the minimum cost management approach is just under 4 years. Management approaches constructed around maximum use of the Savannah River Site could reduce the duration at Rocky Flats to about 2½ years, but only at an additional cost of more than $100 million. Management approaches that depend on blend down for the ash and salt residues would increase costs by more than $200 million and extend operations at Rocky Flats well beyond 2010. The estimated time required at the Savannah River Site to complete processing operations cannot be estimated since this depends on canyon processing schedules established for materials outside the present EIS.

The costs and management approaches discussed in this section do not adjust for technical or processing duration uncertainty. **Table 4-56** shows the processing options for the major residue categories according to their technical uncertainty. The low-uncertainty processing options are nearly free of technical uncertainty. The moderate-uncertainty processing options are riskier than the low-uncertainty processing options. The high-uncertainty processing options are at the boundary of technical acceptability and would carry very substantial costs if they are implemented and subsequently fail.

Table 4–56 Technical Uncertainties for Processing Options

Residue	*Low Uncertainty*	*Moderate Uncertainty*	*High Uncertainty*
Ash	Blend down, Purex at the Savannah River Site	Vitrification, Mediated Electrochemical Oxidation at the Savannah River Site, Calcine and Cement, Cement	
Salt	Blend down, Purex at the Savannah River Site	Pyro-oxidize (electrorefining salts), Water Leach, Salt Scrub at Rocky Flats for the purpose of Purex processing at the Savannah River Site	Pyro-oxidize (molten salt extraction and direct oxide reduction salts), distillation (electrorefining, molten salt extraction salts)
Combustibles	Blend down, Neutralize/Dry, Repackage, Incinerate	Mediated Electrochemical Oxidation, Sonic Wash, Thermal Desorption, Catalytic Chemical Oxidation	
Fluoride	Blend down, Purex at the Savannah River Site	Acid Dissolution	
Filter Media	Blend down, Neutralize/Dry, Incinerate	Vitrification, Mediated Electrochemical Oxidation, Sonic Wash	
Sludge	Blend down, Filter/Dry	Vitrification, Sonic Wash, Acid Dissolution	
Glass	Blend down, Neutralize/Dry	Vitrification, Mediated Electrochemical Oxidation	
Graphite	Blend down, Repackage	Vitrification, Mediated Electrochemical Oxidation at the Savannah River Site, Cement	
Inorganics	Blend down, Repackage	Vitrification, Mediated Electrochemical Oxidation, Mediated Electrochemical Oxidation at the Savannah River Site, Sonic Wash	
Scrub Alloy	Purex at the Savannah River Site, Repackage	Calcine and Vitrify	

Among the preferred processing options, distillation of molten salt extraction salts carries the highest technical and economic uncertainty. Salt distillation would produce an americium-rich mixture of plutonium and americium oxides which would emit relatively high levels of gamma radiation. These oxides could be designated for shipment to the Savannah River Site under future decisions to be made under the *Surplus Plutonium Disposition EIS*, which is in preparation (see Chapter 1, Section 1.6.4). Containers complying with

DOE-STD-3013-096 and existing facilities at the Savannah River Site cannot adequately shield the gamma radiation from the americium. The result could be a requirement to construct costly remote-handling and storage facilities. Alternatively, the salts could be scrubbed at Rocky Flats for Purex processing at the Savannah River Site. Although salt scrub is considered a low-uncertainty process in general, scrubbing of less pure salts or salts that have absorbed moisture during storage creates moderate to high technical uncertainties. A small but non-trivial portion of the salts at Rocky Flats could be in these categories. Development work on scrubbing off-specification salts would likely be required prior to or in parallel with the scrubbing operations. Finally, if the salts are pyro-oxidized in preparation for distillation, the option to scrub for Purex processing is foreclosed. Thus, short-term stabilization (i.e., pyro-oxidation) may limit the processing path to distillation or blend down. Blend down is technically proven, but would add more than $150 million to total costs and would extend processing operations at Rocky Flats for at least 12 years.

Of the other processing options, pyro-oxidation of direct oxide reduction salts and distillation of electrorefining salts also carry high uncertainties. Pyro-oxidation of direct oxide reduction salts as a precursor to distillation (not pyro-oxidation as a stand-alone process) is unproven using the existing technologies at Rocky Flats. Salt distillation (for all three salt categories) is unproven at the scale proposed for the residues in this program. Ash vitrification is among the more uncertain of the moderate uncertainty options but is not a high uncertainty option. The preferred processing option to ash vitrification includes a calcination stage ahead of the vitrification stage. This increases the cost of vitrification but reduces the uncertainty. Optimization studies are underway to determine if calcination can be bypassed without affecting the acceptability of the waste form.

Certain processing technologies may have low or moderate technical uncertainty but may also have high processing duration uncertainty, as outlined below. For each processing technology, the estimated time beyond the Record of Decision is provided. No delays due to general facilities or equipment upgrades are envisioned.

- **Cementation**—Rocky Flats would have to install or remodel gloveboxes to provide additional area for the curing stage. The time required to be fully operational is estimated at 1 year.

- **Catalytic Chemical Oxidation**—Catalytic chemical oxidation has been demonstrated commercially but not as a production process at the scale or characteristics required for the plutonium residues. The time required to demonstrate a consistent process and develop procedures and supporting analyses is estimated at 4 years.

- **Thermal Destruction**—Thermal destruction (i.e., fluidized bed incineration), while demonstrated in previous Rocky Flats operations and at other sites, has not been demonstrated under current Clean Air Act standards. Additionally, the designated building (Building 776) has high programmatic uncertainty due to its condition and schedule for decommissioning. Because of the requirement to identify and permit a new or restarted facility at Rocky Flats and develop procedures and supporting analyses, the process would not be available for an estimated 4 years. DOE does not consider thermal destruction to be a reasonable processing option.

- **Sonic Wash**—Sonic washing has been demonstrated with residue-type material at a bench scale. The time required to demonstrate a consistent full-scale process and develop the procedures and supporting analyses is estimated at 2 years.

- **Acid Dissolution**—Acid dissolution for processing plutonium fluorides or sludges is a proven process but the capabilities for it are not currently available at Rocky Flats. Also, this process would take place in the same area of Building 371 as the neutralize/dry process for combustibles (including combustibles below safeguard termination limits). Because the acid dissolution of fluorides or sludges would be required to follow all combustibles processing, it might not be able to start for 4 years.

- **Mediated Electrochemical Oxidation (Rocky Flats)**—The mediated electrochemical oxidation technology has been demonstrated for radioactive materials, although not in DOE production operations. Equipment would have to be installed in Building 371 adjacent to the liquid treatment facilities. Requirements for these treatment facilities by higher priority residues (e.g., combustibles) would delay the start of operations by at least 4 years.

- **Mediated Electrochemical Oxidation (Savannah River Site)**—Installation of the new dissolvers, start-up tests, etc. are estimated to require 2 years from the Record of Decision at the Savannah River Site. In the case of H-Canyon, decontamination and decommissioning of existing equipment and facilities prior to installation of the mediated electrochemical oxidation equipment is estimated to require an additional 2 years.

- **Salt Distillation**—Salt distillation has been demonstrated at a pilot scale at the Los Alamos National Laboratory with residue materials. Optimization studies are ongoing and final designs are not yet available. Capabilities for production-scale distillation could be available in 2 to 4 years at the Los Alamos National Laboratory and 2 years at Rocky Flats.

- **Water Leach (Rocky Flats)**—Water leaching is a well-demonstrated technology for dissolving chloride salts. The equipment required for water leaching would have to be installed in Building 371 adjacent to the liquid treatment facilities. Requirements for these treatment facilities by higher priority residues (e.g., combustibles) would delay the start of operations by at least 4 years.

- **Water Leach (Los Alamos National Laboratory)**—The capability for water leaching is installed and operational at Los Alamos National Laboratory on a limited scale. Additional capabilities are available using a similar aqueous dissolution process. If any other capabilities were necessary they could be available in 2 to 4 years.

Detailed, integrated schedules for processing all plutonium residues and scrub alloy are not available at this time. The development of such operational schedules is outside the scope of this EIS and would involve difficulties, as illustrated in the following example. Ideally, all processes requiring liquid processing at Rocky Flats would follow the processing of combustibles (including combustibles below safeguard termination limits) in Building 371. If the selected approach for managing plutonium fluoride residues is packaging at Rocky Flats for shipment to the Savannah River Site, fluoride packaging would follow the processing of wet combustibles but precede the processing of dry combustibles. This insertion of fluoride packaging into the Building 371 time-line would add three to six months to the total duration of operations at Rocky Flats compared to processing all the combustibles followed by fluoride packaging. The interruption might be necessary, however, to coordinate the processing windows of Rocky Flats and the Savannah River Site. Other processes that use the liquid processing capabilities of Building 371 would follow both the fluoride and the combustibles processes. Certain sequences could thus add time to the total processing duration at Rocky Flats. Depending on which processing options are selected, other integration issues and shipment constraints could be expected to result in additional extensions to the total processing duration.

4.18 SOCIOECONOMICS

The socioeconomic impacts from the management of Rocky Flats plutonium residues and scrub alloy depend on the management approach selected to manage all the materials. Socioeconomic impacts can only be estimated for management approaches (rather than individual options). As a practical matter, the processing options selected for the management of salts and ash determine essentially all of the socioeconomic impact. More specifically, the processing options that require the most labor and generate the most transuranic waste generate the greatest socioeconomic impacts.

Table 4–57 shows the estimated labor-related direct and indirect spending at Rocky Flats for each processing option in this EIS. Spending on common facilities and equipment upgrades, research and development, programmatic management, and other ongoing activities is excluded. Also excluded are costs relating to waste packages, shipping, fissile materials disposition and other off-site activities. Packaging residues for shipment to the Savannah River Site shifts the bulk of the spending to that site. Avoiding labor-intensive processing options, such as blend down, also minimizes spending at Rocky Flats. Note that while spending on individual processing options is frequently at an annualized rate of tens of millions of dollars per year, only processing options related to ash or salts take long enough for this spending to have a material impact.

The data in Table 4-57 only provide general guidance on the spending levels at each site. For example, while waste characterization expenditures take place at the site, it is unclear if ancillary expenditures, such as manufacture of the shipping and waste packaging equipment, take place within the region. It is also unclear where all the spending for the disposition of fissile materials would take place. Similarly, the charges for labor are fully burdened, indicating out-of-region expenditures for program management, certain fringes and benefits, supplies, etc. On the other hand, socioeconomic benefits attach to the ongoing site expenditures that are not part of the decision process in this EIS. For simplicity, the data in Table 4-57 are used as a proxy for regional spending subject to decision-making under this EIS.

4.18.1 The No Action Management Approach (No Action Alternative) at Rocky Flats

In the No Action Alternative, direct and indirect labor and waste-related spending at Rocky Flats is estimated at about $244 million.

Selection of an option under the No Action Alternative that leaves stabilized residues on site, however, implies extended post-processing storage at the Rocky Flats site. Maintaining the site in a surveillance mode for these stabilized residues is estimated to cost $20 to 23 million per year. This spending would be purely incremental and would exceed the incremental spending for processing the residues and characterizing the waste. Over the short-run, this would have very small regional socioeconomic impact but would delay the closure and dismantlement of the site. This delay could have long-term negative socioeconomic effects as alternative uses for the site are deferred.

4.18.2 Other Management Approaches at Rocky Flats

Except for management approaches that substantially extend the operation of Rocky Flats, especially those heavily based on blend down, the socioeconomic impact versus the No Action Alternative is very small. Given that the differential economic impact (excluding interim on-site storage) between almost any management approach and the No Action Alternative is less than $10 to 15 million per year, the effect on the Rocky Flats region would be very small. Management approaches that extend Rocky Flats' operation well into the next century would continue this modest economic gain for the region but at the expense of the timely shutdown and conversion of the site to other uses. The effect would be very small and could be negative.

At the other extreme are management approaches that include most or all of the options that have the shortest duration and lowest cost at Rocky Flats. These management approaches are built around the selection of options to pack the residues for shipment offsite. These management approaches could collectively reduce spending at Rocky Flats by $10 to 20 million per year for several years, depending upon the approach to downsizing Rocky Flats. The incremental and multiplied impact of a reduction of spending in this range is very small in a socioeconomic context. Shipping the maximum amount of residues to the Savannah River Site would not accelerate the closure of Rocky Flats.

Table 4–57 Estimated Spending at Rocky Flats[a]

Material	Process	Years[b]	Processing $M	Transuranic Characterization $M	Low-Level Waste Characterization $M	Total $M	Total $M/yr[c]
Incinerator Ash	Calcine & Cement	3.4	110	9	2	121	35
Incinerator Ash	Blend Down	2.9	52	43	1	96	33
Incinerator Ash	Furnace Vitrification	2.5	34	36	1	72	29
Incinerator Ash	Fusion->Purex at F-Canyon	1.7	43	4	0	48	28
Incinerator Ash	Fusion->Purex at H-Canyon	1.7	43	4	0	48	28
Incinerator Ash, Graphite Fines	Pack->MEO at F-Canyon	1.3	6	4	1	11	9
Incinerator Ash, Graphite Fines	Pack->MEO at H-Canyon	1.3	6	4	1	11	9
Sand, Slag & Crucible	Calcine & Cement	0.5	16	2	0	18	37
Sand, Slag & Crucible	Blend Down	1.9	30	9	0	39	21
Sand, Slag & Crucible	Furnace Vitrification	0.4	5	8	0	13	36
Sand, Slag & Crucible	Pack w/o Calcine->Purex at F-Canyon	0.4	1	1	0	2	5
Sand, Slag & Crucible	Pack w/o Calcine->Purex at H-Canyon	0.4	1	1	0	2	5
Inorganic Ash	Calcine & Cement	0.2	1	1	0	2	12
Inorganic Ash	Blend Down	0.7	3	1	0	4	5
Inorganic Ash	Furnace Vitrification	0.1	1	1	0	1	11
Graphite Fines	Cement	0.3	9	1	0	10	35
Graphite Fines	Furnace Vitrification	0.2	3	2	0	5	25
Graphite Fines	Blend Down	0.2	4	4	0	8	35
Pyro Salts (Electrorefining, Molten Salt Extraction)	Pyro-Oxidize	1.5	19	4	1	23	15
Pyro Salts (Electrorefining, Molten Salt Extraction)	Blend Down	11.9	113	85	1	198	17
Pyro Salts (Electrorefining, Molten Salt Extraction)	Salt Scrub->Purex at F-Canyon	1.6	24	9	1	34	21
Pyro Salts (Electrorefining, Molten Salt Extraction)	Salt Scrub->Purex at H-Canyon	1.6	24	9	1	34	21
Pyro Salts (Electrorefining, Molten Salt Extraction)	Distillation	2.8	27	4	1	32	12
Pyro Salts (Electrorefining, Molten Salt Extraction)	Water Leach	2.7	105	93	22	219	81
Pyro Salts (Electrorefining, Molten Salt Extraction)	Pyrox->LANL Distill	2.8	26	4	1	31	11
Pyro Salts (Direct Oxide Reduction)	Pyro-Oxidize	0.2	1	5	0	6	30
Pyro Salts (Direct Oxide Reduction)	Blend Down	1.5	14	11	0	26	17

Material	Process	Years[b]	Processing $M	Transuranic Characterization $M	Low-Level Waste Characterization $M	Total $M	Total $M/yr[c]
Pyro Salts (Direct Oxide Reduction)	Salt Scrub->Purex at F-Canyon	0.2	3	1	0	4	21
Pyro Salts (Direct Oxide Reduction)	Salt Scrub->Purex at H-Canyon	0.2	3	1	0	4	21
Pyro Salts (Direct Oxide Reduction)	Water Leach	0.4	15	12	3	29	77
Pyro Salts (Direct Oxide Reduction)	Pyrox->LANL Water Leach	0.4	4	5	0	9	21
Combustibles (Aqueous)	Neutralize/Dry	0.2	2	0	0	2	13
Combustibles (Aqueous)	Blend Down	0.0	1	1	0	1	49
Combustibles (Aqueous)	MEO	0.4	2	5	1	8	19
Combustibles (Aqueous)	Sonic Washing	0.2	2	2	0	4	24
Combustibles (Aqueous)	Incineration	0.2	1	1	0	2	13
Combustibles (Aqueous)	Catalytic Chemical Oxidation	0.5	7	5	1	13	24
Combustibles (Organic)	Thermal Desorption	0.5	3	0	0	3	6
Combustibles (Organic)	Blend Down	0.0	0	0	0	0	23
Combustibles (Organic)	MEO	0.3	1	1	0	2	7
Combustibles (Organic)	Sonic Washing	0.1	2	0	0	2	15
Combustibles (Organic)	Incineration	0.1	1	0	0	1	9
Combustibles (Organic)	Catalytic Chemical Oxidation	0.4	5	1	0	6	15
Combustibles (Dry)	Repackage	0.0	0	0	0	0	21
Combustibles (Dry)	Blend Down	0.0	0	1	0	1	41
Combustibles (Dry)	MEO	0.2	1	3	1	5	21
Combustibles (Dry)	Sonic Washing	0.1	1	1	0	2	25
Combustibles (Dry)	Incineration	0.1	1	1	0	1	14
Combustibles (Dry)	Catalytic Chemical Oxidation	0.3	4	3	1	8	25
Fluorides	Acid Dissolution	0.6	13	2	1	16	28
Fluorides	Blend Down	1.8	23	22	0	46	25
Fluorides	Pack->Purex at F-Canyon	0.2	0	0	0	1	4
Fluorides	Pack->Purex at H-Canyon	0.2	0	0	0	1	4
Filter Media (High-Efficiency Particulate Air)	Neutralize/Dry	0.7	7	1	0	8	11
Filter Media (High-Efficiency Particulate Air)	Furnace Vitrification	0.3	4	5	0	9	36
Filter Media (High-Efficiency Particulate Air)	MEO	0.5	8	13	3	24	50
Filter Media (High-Efficiency Particulate Air)	Sonic Washing	1.2	21	5	0	26	22
Filter Media (High-Efficiency Particulate Air)	Incineration	1.7	11	4	0	15	9
Filter Media (Ful Flo)	Neutralize/Dry	0.1	1	1	0	3	18
Filter Media (Ful Flo)	MEO	0.1	2	6	1	9	87
Filter Media (Ful Flo)	Sonic Washing	0.3	4	2	0	7	27

Material	Process	Years[b]	Processing $M	Transuranic Characterization $M	Low-Level Waste Characterization $M	Total $M	Total $M/yr[c]
Filter Media (Ful Flo)	Incineration	0.4	3	2	0	4	12
Filter Media (All)	Blend Down	0.4	6	2	0	8	22
Sludge	Filter/Dry	0.5	3	0	0	3	7
Sludge	Blend Down	0.1	1	1	0	3	37
Sludge	Furnace Vitrification	0.1	1	1	0	3	37
Sludge	Acid Dissolution	1.0	14	4	1	19	19
Glass	Neutralize/Dry	0.0	0	0	0	0	9
Glass	Blend Down	0.0	0	0	0	1	33
Glass	Furnace Vitrification	0.0	0	0	0	0	36
Glass	MEO	0.0	0	1	0	2	65
Glass	Sonic Washing	0.0	1	0	0	1	19
Graphite	Repackage	0.3	1	1	0	2	9
Graphite	Blend Down	0.3	4	4	0	8	30
Graphite	Furnace Vitrification	0.3	4	4	0	8	31
Graphite	MEO	0.5	8	14	3	25	48
Graphite	Pack->MEO at F-Canyon	0.5	1	1	0	1	3
Graphite	Pack->MEO at H-Canyon	0.5	1	1	0	1	3
Graphite	Cement	0.4	12	5	0	17	46
Inorganic Residues	Repackage	0.0	0	0	0	0	10
Inorganic Residues	Blend Down	0.0	1	1	0	2	35
Inorganic Residues	Furnace Vitrification	0.0	1	1	0	2	32
Inorganic Residues	MEO	0.1	2	3	1	6	73
Inorganic Residues	Pack->MEO at F-Canyon	0.1	0	0	0	0	5
Inorganic Residues	Pack->MEO at H-Canyon	0.1	0	0	0	0	5
Scrub Alloy	Repackage	0.1	0	0	0	1	6
Scrub Alloy	Calcine, Vitrify	2.5	41	19	0	60	24
Scrub Alloy	Pack->Purex at F-Canyon	0.1	0	0	0	1	6
Scrub Alloy	Pack->Purex at H-Canyon	0.1	0	0	0	1	6

MEO = mediated electrochemical oxidation. LANL = Los Alamos National Laboratory.
[a] Excluding common facilities and equipment, interim on-site storage, waste packages and shipping, and other minor cost categories.
[b] Durations below three weeks round to 0.0. No durations are less than 1 week.
[c] Annualized rate. Most processing options require less than 1 year.

4.18.3 Management Approaches at the Savannah River Site

The preferred management approach includes Purex processing at F-Canyon of sand, slag, and crucible residues, fluorides residues, and scrub alloy. Collectively, these materials would increase spending at the Savannah River Site by perhaps $15 million per year compared to the No Action Alternative. If the materials were processed at the Savannah River Site H-Canyon, spending would increase by about twice as much. If all the materials that could be shipped to the Savannah River Site were shipped there in the maximum labor cost configuration for the Savannah River Site, the incremental labor allocable to the Savannah River Site would be about $30 million per year over a longer period. The majority of these costs would be incurred for processing ash and salts. Costs for Purex processing at H-Canyon would be extended for several years longer. Costs for mediated electrochemical oxidation at H-Canyon would be $20 million higher than at F-Canyon for a 2-year decontamination and decommissioning phase and then would be similar.

The addition of an incremental $15 million per year for some number of years, although not large, would be noticeable in the Savannah River Site regional economic area. The Savannah River Site accounts for about 7 percent of regional economic area employment, versus 3/10 of 1 percent for Rocky Flats. Assuming all of the incremental hires at the Savannah River Site were recruited from currently unemployed people in the 15-county regional economic area, the unemployment rate would decline by more than 1/10 of 1 percentage point. Income in the six-county region of influence would increase by more than 1/10 of 1 percent for each of the years in which the processing activities took place. The site, the regional economic area, and the region of influence could easily accommodate all of these income-related benefits since the increase would be only a small percentage of the reductions in jobs and income experienced in the area due to reductions in site staffing in the 1990s. The net effect would be one of restoring some of the economic and socioeconomic benefits associated with the site rather than adding new benefits in an otherwise stable area.

The one potentially important variation on the Savannah River Site impacts would be if shipments of Rocky Flats plutonium residues and scrub alloy were responsible for extending the operations at one of the canyons. This EIS assumes that the Rocky Flats plutonium residues and scrub alloy can be processed incrementally with other materials that make up the baseline canyon operations plan. If Rocky Flats plutonium residues and scrub alloy processing were responsible for extending canyon operations, then the extension of canyon operations would be fully charged to the Rocky Flats program. Canyon operations costs exceed $3.2 million per month. If the processing of Rocky Flats materials were also responsible for deferring the shutdown of a canyon, it would generate even higher costs for continued surveillance and maintenance. The socioeconomic impacts of extended canyon operations would be several times greater than in the maximum processing cases noted above. The duration would be much shorter, however. The regional socioeconomic impacts would be large and positive due to manpower requirements, but those effects would be brief.

4.18.4 Management Approaches at Los Alamos National Laboratory

Shipments of residues to Los Alamos National Laboratory for processing would have no measurable socioeconomic impact in the Los Alamos National Laboratory regional economic area or region of influence.

4.19 Materials, Utilities, and Energy

Tables 4–58 and **4–59** show materials, utilities, and energy associated with each of the processing options for Rocky Flats (SAIC 1997b) and the Savannah River Site (WSRC 1997), respectively. Similar data for Los Alamos National Laboratory are not available. At Rocky Flats, all processes except fluidized bed incineration would be powered exclusively by electricity. The fluidized bed incineration processing option would also use methanol. The gas volumes do not include the nitrogen volume used in the nitrogen boxes.

Table 4–58 Rocky Flats—Materials, Utilities, and Energy

		Elec. (MWh)	*Steam (kg)*	*Water (thousands of liters)*	*Acid (thousands of liters)*	*Nitrogen (thousands of cubic feet)*	*Argon (thousands of cubic feet)*	*Air (thousands of cubic feet)*	*Methanol (kg)*
Incinerator Ash	Calcine & cement	209	0	8,883	0	391	0	0	0
Incinerator Ash	Blending	128	0	698	0	0	55	5,520	0
Incinerator Ash	Furnace Vitrification	326	0	0	0	786	0	0	0
Incinerator Ash	Fusion->PX-F	162	0	0	0	280	0	16,773	0
Incinerator Ash	Fusion->PX-H	162	0	0	0	280	0	16,773	0
Incin. Ash, w/ G.F.	Pack->MEO-F	130	0	0	0	225	0	13,478	0
Incin. Ash, w/G.F.	Pack->MEO-H	130	0	0	0	225	0	13,478	0
SS&C w/ Inorg. Ash	Calcine & cement	76	0	3,226	0	142	0	0	0
SS&C w/ Inorg. Ash	Blending	46	0	254	0	0	20	2,005	0
SS&C w/ Inorg. Ash	Furnace Vitrification	118	0	0	0	286	0	0	0
SS&C	Pack w/o Calc->PX-F	5	0	0	0	0	0	0	0
SS&C	Pack w/o Calc->PX-H	5	0	0	0	0	0	0	0
Graphite Fines	Cement	13	0	568	0	25	0	0	0
Graphite Fines	Furnace Vitrification	21	0	0	0	50	0	0	0
Graphite Fines	Blending	8	0	45	0	0	4	353	0
Pyro Salts (ER, MSE)	Pyro-oxidize	264	0	2,073	0	0	197	19,679	0
Pyro Salts (ER, MSE)	Blending	368	0	2,012	0	0	159	15,929	0
Pyro Salts (ER, MSE)	Salt Scrub->PX-F	324	0	2,689	0	0	255	25,530	0
Pyro Salts (ER, MSE)	Salt Scrub->PX-H	324	0	2,689	0	0	255	25,530	0
Pyro Salts (ER, MSE)	Distillation	332	0	2,689	0	0	256	25,530	0
Pyro Salts (ER, MSE)	Water Leach	283	97	8,894	14,699	0	139	30,250	0
Pyro Salts (ER, MSE)	Pyrox->LANL distill	168	0	1,343	0	0	128	12,765	0
Pyro Salts (DOR)	Pyro-oxidize	33	0	262	0	0	25	2,485	0
Pyro Salts (DOR)	Blending	47	0	254	0	0	20	2,011	0
Pyro Salts (DOR)	Salt Scrub->PX-F	41	0	339	0	0	32	3,224	0
Pyro Salts (DOR)	Salt Scrub->PX-H	41	0	339	0	0	32	3,224	0
Pyro Salts (DOR)	Water Leach	36	12	1,123	1,856	0	18	3,820	0
Pyro Salts (DOR)	Pyrox->LANL distill	21	0	170	0	0	16	1,612	0
Pyro Salts (DOR)	Pyrox->LANL W Leach	21	0	170	0	0	16	1,613	0
Combustibles (Aq.)	Neutralize/Dry	0	0	0	0	0	0	124	0
Combustibles (Aq.)	Blending	0	0	0	0	0	0	0	0
Combustibles (Aq.)	MEO	7	10	828	5	0	0	589	0

		Elec. (MWh)	Steam (kg)	Water (thousands of liters)	Acid (thousands of liters)	Nitrogen (thousands of cubic feet)	Argon (thousands of cubic feet)	Air (thousands of cubic feet)	Methanol (kg)
Combustibles (Aq.)	Sonic Washing	5	13	739	0	8	0	0	0
Combustibles (Aq.)	Incineration	7	0	243	0	4	0	385	0
Combustibles (Aq.)	CCO	19	36	1,608	13	0	0	5,654	0
Combustibles (Org.)	Thermal Desorption	3	10	0	0	0	0	0	0
Combustibles (Org.)	Blending	0	0	0	0	0	0	0	0
Combustibles (Org.)	MEO	4	6	534	3	0	0	380	0
Combustibles (Org.)	Sonic Washing	3	9	476	0	5	0	0	0
Combustibles (Org.)	Incineration	4	0	157	0	2	0	248	0
Combustibles (Org.)	CCO	12	23	1,037	8	0	0	3,647	0
Combustibles (Dry)	Repackage	0	0	0	0	0	0	0	0
Combustibles (Dry)	Blending	0	0	0	0	0	0	0	0
Combustibles (Dry)	MEO	3	5	393	3	0	0	279	0
Combustibles (Dry)	Sonic Washing	2	6	350	0	4	0	0	0
Combustibles (Dry)	Incineration	3	0	115	0	2	0	182	0
Combustibles (Dry)	CCO	9	17	762	6	0	0	2,680	0
Fluorides	Acid Dissolution	61	16	1,224	8	0	0	6,629	0
Fluorides	Blending	35	0	0	0	0	0	0	0
Fluorides	Pack->PX-F	1	0	0	0	0	0	0	0
Fluorides	Pack->PX-H	1	0	0	0	0	0	0	0
Filter Media (HEPA)	Neutralize/Dry	4	0	0	0	0	0	887	0
Filter Media (HEPA)	Furnace Vitrification	25	0	0	0	0	0	0	0
Filter Media (HEPA)	MEO	23	35	3,016	18	0	0	2,148	0
Filter Media (HEPA)	Sonic Washing	17	45	2,486	0	29	0	0	0
Filter Media (HEPA)	Incineration	51	0	1,819	0	29	0	2,881	4
Filter Media (Ful Flo)	Neutralize/Dry	2	0	0	0	0	0	388	0
Filter Media (Ful Flo)	MEO	10	15	1,319	8	0	0	939	0
Filter Media (Ful Flo)	Sonic Washing	8	20	1,088	0	13	0	0	0
Filter Media (Ful Flo)	Incineration	22	0	796	0	12	0	1,260	2
Filter Media (All)	Blending	7	0	0	0	0	0	0	0
Sludge	Filter/Dry	4	0	0	0	0	0	734	0
Sludge	Blending	1	0	0	0	0	0	0	0
Sludge	Furnace Vitrification	11	0	0	0	0	0	0	0
Sludge	Acid Dissolution	69	19	1,387	11	0	0	7,508	0

		Elec. (MWh)	Steam (kg)	Water (thousands of liters)	Acid (thousands of liters)	Nitrogen (thousands of cubic feet)	Argon (thousands of cubic feet)	Air (thousands of cubic feet)	Methanol (kg)
Glass	Neutralize/Dry	0	0	0	0	0	0	65	0
Glass	Blending	0	0	0	0	0	0	0	0
Glass	Furnace Vitrification	2	0	0	0	0	0	0	0
Glass	MEO	2	2	220	0	0	0	151	0
Glass	Sonic Washing	1	3	182	0	2	0	0	0
Graphite	Repackage	4	0	0	0	0	0	0	0
Graphite	Blending	5	0	0	0	0	0	0	0
Graphite	Furnace Vitrification	38	0	0	0	0	0	0	0
Graphite	MEO	28	43	3,688	23	0	0	2,625	0
Graphite	Pack->MEO-F	4	0	0	0	0	0	0	0
Graphite	Pack->MEO-H	4	0	0	0	0	0	0	0
Graphite	Cement	25	0	1,061	0	47	0	0	0
Inorganic Residues	Repackage	0	0	0	0	0	0	0	0
Inorganic Residues	Blending	1	0	0	0	0	0	0	0
Inorganic Residues	Furnace Vitrification	7	0	0	0	0	0	0	0
Inorganic Residues	MEO	5	8	705	4	0	0	501	0
Inorganic Residues	Pack->MEO-F	1	0	0	0	0	0	0	0
Inorganic Residues	Pack->MEO-H	1	0	0	0	0	0	0	0
Scrub Alloy	Repackage	2	0	0	0	0	0	0	0
Scrub Alloy	Calcine, Vitrify	365	0	0	0	879	0	0	0
Scrub Alloy	Pack->PX-F	1	0	0	0	0	0	0	0
Scrub Alloy	Pack->PX-H	1	0	0	0	0	0	0	0

PX-F = Purex at F-Canyon PX-H = Purex at H-Canyon MEO = mediated electrochemical oxidation SS&C = sand, slag, and crucible G.F. = graphite fines
ER = electrorefining MSE = molten salt extraction LANL = Los Alamos National Laboratory DOR = direct oxide reduction CCO = catalytic chemical oxidation
HEPA = high-efficiency particulate air

Table 4–59 Savannah River Site—Materials, Utilities, and Energy

		Electricity (MWh)	Steam (kg)	Water (thousands of liters)	Fuel (liters)
Incinerator Ash	Purex-F	1,197	855	14,250	3,021
Incinerator Ash	Purex-H	4,731	3,420	57,000	11,970
Incinerator Ash, w/ G.F.	MEO-F	697	492	8,200	1,771
Incinerator Ash, w/ G.F.	MEO-H	697	492	8,200	1,771
SS&C	Purex-F	152	113	1,715	774
SS&C	Purex-H	493	359	6,240	1,232
Pyro Salts (ER, MSE)	Purex-F	227	166	2,760	1,159
Pyro Salts (ER, MSE)	Purex-H	569	411	6,850	1,439
Pyro Salts (DOR)	Purex-F	30	22	360	151
Pyro Salts (DOR)	Purex-H	79	57	950	200
Fluorides	Purex-F	112	84	1,330	566
Fluorides	Purex-H	332	242	4,200	840
Graphite	MEO-F	125	91	1,440	314
Graphite	MEO-H	125	91	1,440	314
Inorganic Residues	MEO-F	31	23	350	79
Inorganic Residues	MEO-H	31	23	350	79
Scrub Alloy	Purex-F	60	43	720	302
Scrub Alloy	Purex-H	179	130	2,160	454

G.F. = graphite fines MEO = mediated electrochemical oxidation SS&C = sand, slag, and crucible ER = electrorefining MSE = molten salt extraction
DOR = direct oxide reduction

At the Savannah River Site, electricity and fuel oil would be used. At each site, the total consumption of materials, utilities, and energy is consistent with the overall requirements for other inputs (i.e., processing for ash and salts require the greatest amounts of materials, utilities, and energy). The consumption requirements for all other residues are comparatively small.

In dollar terms, the costs for the materials, utilities, and energy would be very small. The cost for electricity in the most energy-intensive processing at any site (Purex processing of fused ash at Savannah River Site's H-Canyon) is in the $100,000 range. No other process requires more than a small fraction of that figure for any material, utility, or energy. For example, the 7.8 megawatt hours of electricity required for water leach of direct oxide reduction salt reduction at Los Alamos National Laboratory would cost less than $500. The total program cost for materials, utilities, and energy is likely to be no more than a few hundred thousand dollars.

4.20 Impacts of the No Action Alternative

As discussed in Chapter 2 of this EIS, DOE has identified processing options for each category or subcategory of plutonium residue and scrub alloy under Alternative 1 (the No Action Alternative). The impacts of these no action processing options are presented for each material category and subcategory in Sections 4.2 through 4.11, with each section being devoted to one material category. The impacts of the No Action Alternative were calculated by aggregating the appropriate impacts from the sets of impacts in Sections 4.2 through 4.11. All the processes in the No Action Alternative would take place at Rocky Flats, so there would be no transportation impacts in this alternative.

4.20.1 Products and Wastes

The No Action Alternative would generate stabilized residues, transuranic waste, and low-level waste. This alternative would not generate high-level waste, separated plutonium, or saltstone. The estimated amounts of the solid plutonium-bearing products and wastes are presented and compared to the onsite storage capacities in **Table 4–60**. The stabilized residues and transuranic waste would be placed in pipe components inside 210-L (55-gal) drums as shown in Figure 2-13. The largest amount of material would be stabilized residues, most of which would be placed in safe, secure storage at Rocky Flats for an indefinite period of time. About 900 drums of the stabilized residues could be disposed of in WIPP because variances from the safeguard termination limits have been approved. The transuranic waste would be placed in safe, secure storage at Rocky Flats until WIPP is ready to receive it. Assuming WIPP opens on schedule, the storage capacity at Rocky Flats will be more than adequate.

Table 4–60 Products and Wastes from the No Action Alternative

	Stabilized Residues (Drums)	Transuranic Waste (Drums)	Low-Level Waste (Drums)
Generation	10,300	3,500	7,600
Onsite Storage Capacity	13,400[a]	13,400[a]	21,800

[a] This storage capacity is for both the stabilized residues and transuranic waste combined.

The low-level waste would probably be placed in standard 210-L (55-gal) waste drums. The low-level waste would be disposed of in one of the offsite disposal facilities routinely used by Rocky Flats, so the onsite storage capacity would probably not be necessary.

4.20.2 Public and Occupational Health and Safety Impacts

This section describes the radiological and hazardous chemical impacts which might result from the No Action Alternative associated with the management of all Rocky Flats plutonium residues and scrub alloy. These

impacts are presented for incident-free operations and postulated accident scenarios, respectively. The detailed site analyses are presented in Appendix D.

No construction of new facilities is included in this alternative, but DOE may need to modify certain existing facilities at Rocky Flats. Standard site mitigation measures during any modifications would ensure that any radiological or hazardous chemical releases would be extremely small. Worker exposures to contaminated material would be limited to ensure that doses are maintained as low as reasonably achievable.

4.20.2.1 Incident-Free Operations

- **Radiological Impacts**—The radiological impacts to the public and the workers associated with incident-free implementation of the No Action Alternative are presented in **Table 4–61**. The impacts are those that are anticipated to occur as a result of process operations over whatever time period is necessary to process the entire inventory of residues and scrub alloy. The post-processing storage of the stabilized residues and transuranic wastes would also produce impacts, but these are very small compared to the impacts due to processing.

Table 4–61 Radiological Impacts Due to Incident-Free Implementation of the No Action Alternative

Offsite Public Maximally Exposed Individual		Offsite Public Population	
Dose[a] (mrem)	Probability of a Latent Cancer Fatality	Dose (person-rem)	Number of Latent Cancer Fatalities
0.00047	2.4×10^{-13}	0.012	6.0×10^{-6}
Maximally Exposed Individual Involved Worker		**Involved Worker Population**	
Dose (mrem per year)	Probability of a Latent Cancer Fatality per year	Dose (person-rem)	Number of Latent Cancer Fatalities
2,000	0.0008	782	0.31

[a] The doses to the maximally exposed individual for each material category are additive because the maximum receptor location was determined to be the same for every material, regardless of whether the release location is Building 371 or Building 707 at Rocky Flats. These two buildings are near each other.

The estimated total public maximally exposed individual dose is 0.00047 mrem, which applies to a hypothetical individual who lives downwind at the site boundary. This individual's chance of incurring a latent cancer fatality due to this alternative would be less than one in one billion.

The total public population radiation dose is 0.012 person-rem. During incident-free storage, no release of radioactive material would occur, so the impact on the public would be equal to zero.

The total involved worker population radiation dose would be approximately 782 person-rem, which would cause 0.31 additional latent cancer fatalities among the workers directly involved in the operations. Onsite workers who are not involved with the actual processing of the residues are designated as "noninvolved workers." The impacts to these workers would be much smaller than the impacts to the involved workers. During the post-processing storage period, inspections of the storage facility would expose the involved worker population to very small incremental additions to the processing dose.

- **Hazardous Chemical Impacts**—The impacts of hazardous chemical releases associated with incident-free implementation of the No Action Alternative are presented in **Table 4–62**. Carbon tetrachloride is no longer used at Rocky Flats, but is present in small amounts in some of the residues. The probability of excess latent cancer incidence for the offsite maximally exposed individual as a result of exposure to carbon tetrachloride is 8×10^{-11}. This hypothetical individual's chance of incurring a latent cancer would be increased by less than one in one billion.

Table 4–62 Chemical Impacts Due to Incident-Free Implementation of the No Action Alternative

Offsite Public Maximally Exposed Individual[a]		Offsite Public Population
Probability of Cancer Incidence	Hazard Index	Number of Cancer Incidences
8×10^{-11}	0	<1[b]
Maximally Exposed Individual Involved Worker		**Involved Worker Population**
Probability of Cancer Incidence	Hazard Index	Number of Cancer Incidences
4×10^{-9}	0	<1[c]

[a] Only carcinogenic chemicals are released from the process; therefore, only cancer health risks are evaluated. The Hazard Index is equal to zero.
[b] In a population of 2.4 million individuals living within 80 km (50 mi) of Rocky Flats.
[c] Based on the extremely conservative assumption that the entire Rocky Flats workforce of approximately 4,600 workers would be exposed to maximally exposed individual concentration.

Carbon tetrachloride is a carcinogen that produces toxic effects in the central nervous system, pulmonary system, gastrointestinal system, and other systems in humans (Sax and Lewis 1987). The compound is an eye and skin irritant and damages the liver, kidneys, and lungs (Lewis 1991). The liver is the primary target organ for carbon tetrachloride toxicity (EPA 1991a). Less than one latent cancer is expected to occur in the offsite population of 2.4 million individuals living within an 80-km (50-mi)radius of Rocky Flats. The maximally exposed individual worker probability of excess latent cancer incidence is 4×10^{-9}. This hypothetical individual's risk of incurring a latent cancer would be increased by less than one in one hundred million. If all site workers were exposed to the maximally exposed individual concentration of carbon tetrachloride, which is an extremely conservative and unrealistic assumption, less than 1 excess latent cancer fatality would be expected to occur in the workforce population.

4.20.2.2 Accidents

The potential radiological impacts to the public and the noninvolved onsite workers due to accidents under the No Action Alternative are summarized and presented in this section. These impacts were derived directly from the sets of impacts for all the material categories presented in Sections 4.2 through 4.11. The detailed analysis of onsite accidents, with the associated assumptions, is presented in Appendix D, Section D.3.

In any accident scenario the individuals most likely to be hurt are the involved workers. The risk to these workers would be due to both radiological and non-radiological effects. In a fire the involved workers could be exposed to airborne radioactive material, in addition to the smoke and heat of the fire. In an explosion, there could be flying debris and containment barriers could be broken, exposing workers to airborne radioactive material. Most spills would not have a major effect on involved workers because they would clean up the spill, wearing protective clothing and respirators as necessary. An accidental criticality could expose involved workers to large doses of prompt penetrating radiation, which could cause death in a short period of time. The earthquake and aircraft crash accident scenarios present very severe non-radiological effects to the involved workers. In these scenarios, the workers are likely to be hurt or killed from the collapse of the building or the impact of the aircraft crash before they could be evacuated.

The maximum number of involved workers at risk is estimated to be equal to the number of workers who would be working on plutonium residues or scrub alloy at any one time in each of the processing buildings at each of the three sites. Buildings 707 and 371 at Rocky Flats would each have about 100 involved workers inside, which is more involved workers than any facility at either of the other two sites. Thus, if an earthquake strong enough to collapse Building 707 and damage Building 371 hits Rocky Flats, then approximately 200 involved workers would be at risk of death or injury due to activities associated with plutonium residues and scrub alloy.

The maximum consequences for the public and a noninvolved onsite worker if DOE decides to implement the No Action Alternative are presented in **Table 4–63**. The public maximally exposed individual is a hypothetical individual who resides at the site boundary in the downwind direction. The public population is defined as the residential population within a radius of 80 km (50 mi). A noninvolved onsite worker is defined as an individual worker who is located 100 m (328 ft) or more downwind from the release point when an accidental release of radioactive material occurs. The highest consequences to all three receptors would occur if a major earthquake strong enough to cause the collapse of Buildling 707 occurs during pyro-oxidation of the salt residues. The frequency of this earthquake is estimated to be 0.0018 per year.

Table 4–63 Maximum Accident Consequences in the No Action Alternative

Residue, Processing Option, and Location	*Accident Frequency (per year)*	*Offsite Public Maximally Exposed Individual Consequences*		*Offsite Public Population Consequences*		*Noninvolved Onsite Worker Consequences*	
		Dose (mrem)	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*	*Dose (mrem)*	*Probability of a Latent Cancer Fatality*
Salt Residues, Pyro-Oxidation at Rocky Flats	0.0018	16,700	0.0084	293,000	147	188,000	0.15

Differences exist between the Rocky Flats Cumulative Impacts Document (DOC 1997a) for the 1996 Baseline and this EIS in terms of the maximum accident consequences. Several factors are responsible for the differences between the two documents, and are provided below in approximate order of importance.

1. The Cumulative Impacts Document used the median value for weather conditions and this EIS uses the 95th percentile. For the earthquake accident scenario, the 95th percentile yields a calculated value of 293,000 person-rem for the population and the 50th percentile yields a calculated value of 7,000 person-rem for the population.

2. The Cumulative Impacts Document used the MACCS computer code (also used for the other Rocky Flats EISs) and this EIS uses the GENII computer code.

3. The Cumulative Impacts Document used the actual material known to be in each building, and calculated the amount of dispersible material based upon conversion of plutonium metal to oxides, amount of oxides present, amount of residues present (with associated americium amounts) and amount of transuranic and low level waste present. This EIS used a much simpler approach, in that it used two IDCs, 409 and 410, both molten salt extraction salts containing the maximum quantity of americium, as the worst case scenario, and assumed a 5-day supply to be present in Building 707 upon collapse from an earthquake.

The approach taken in this EIS does not affect the validity of the Finding of No Significant Impact decision of the Residue Stabilization Environmental Assessment, because this EIS uses the worst case approach instead of the median approach.

The aggregation of all the risks due to accidents in the No Action Alternative to the public and a noninvolved onsite worker are presented in **Table 4–64**. The increase in the probability of a latent cancer fatality to the public maximally exposed individual is estimated to be 0.000023. This individual's chance of incurring a latent cancer fatality would be increased by less than one in ten thousand. The increase in latent cancer fatalities in the public population within 80 km (50 mi) of Rocky Flats is estimated to be 0.41, less than one latent cancer fatality. The increase in the probability of a latent cancer fatality to the noninvolved onsite worker is estimated to be 0.00041. This individual's chance of incurring a latent cancer fatality would be

increased by less than one in one thousand. More than 95 percent of the latent cancer fatality accident risks for the No Action Alternative are attributable to the salt residues.

Table 4–64 Risks Due to Accidents in the No Action Alternative

Offsite Public Maximally Exposed Individual Risk (Probability of a Latent Cancer Fatality)	*Offsite Public Population Risk (Number of Latent Cancer Fatalities)*	*Onsite Noninvolved Worker Risk (Probability of a Latent Cancer Fatality)*
0.000023	0.41	0.00041

4.20.2.3 Mitigation Measures

All the environmental impacts in the No Action Alternative would be low, and specific mitigation measures would not be necessary. Nevertheless, DOE would maintain all public and worker exposures, both direct exposures and indirect exposures via airborne emissions, as low as reasonably achievable. As low as reasonably achievable is a long-standing DOE policy to control or manage radiation exposures and releases of radioactive material to the environment as low as social, technical, economic, practical, and public policy considerations permit. As low as reasonably achievable is not a dose limit but rather a process that has as its objective the attainment of dose levels as far below the applicable limits as practical.

4.21 Impacts of the Preferred Management Approach

As discussed in Chapter 2, DOE has identified a variety of processing options for each category or subcategory of plutonium residue and scrub alloy. The impacts of all the processing options for each material category and subcategory are presented in Sections 4.2 through 4.11, with each section being devoted to one material category. The impacts of the Preferred Management Approach were calculated by aggregating the appropriate impacts from Sections 4.2 through 4.11. Some processes in the Preferred Management Approach would take place at sites other than Rocky Flats, so transportation impacts would exist in this management approach.

As discussed in Chapter 2, DOE has identified preferred processing options for most, but not all, of the residue categories. The preferred processing options have been identified for ash residues, pyrochemical salt residues, combustible residues, plutonium fluoride residues, glass residues, graphite residues, inorganic residues, and scrub alloy. A preferred processing option will be specified for the other two residue categories (filter media residues and sludge residues) in the final EIS. Until the preferred processing options are specified for these two categories, the total impacts of the Preferred Management Approach are expressed as ranges. The low and high ends of each impact range reflect the aggregates of the lowest and highest estimates, respectively, of the impacts among the processing options for the filter media and sludge residues in the Proposed Action, except that thermal destruction is not allowed in this management approach, because DOE does not consider it to be a reasonable processing option.

4.21.1 Products and Wastes

The Preferred Management Approach would generate high-level waste, transuranic waste, saltstone, low-level waste, and separated plutonium in the form of a metal and/or an oxide. The estimated amounts of the solid plutonium-bearing products and wastes are presented and compared to the onsite storage capacities in **Table 4–65**. The stabilized residues and transuranic waste would be placed in pipe components inside 210-L (55-gal) drums as shown in Figure 2-13. The transuranic waste would be placed in safe, secure storage until WIPP is ready to receive it. The 900 drums of stabilized residues would not meet the safeguards termination limits, but DOE has decided to grant variances to these limits for these residues. Thus, DOE would dispose of these residues in WIPP along with the transuranic waste. Assuming WIPP opens on schedule, the transuranic waste storage capacity at Rocky Flats will be more than adequate.

Table 4–65 Products and Wastes from the Preferred Management Approach[a]

DOE Site	Stabilized Residues (Drums)	Transuranic Waste (Drums)	High-Level Waste (Canisters of Glass)	Separated Plutonium (kg)	Low-Level Waste (Drums)	Saltstone (cubic yards)
Rocky Flats Generation	900	8,900–11,300	0	881–1,016	4,500–11,600	0
Onsite Storage Capacity	13,400[b]	13,400[b]	0	12,900[c]	21,800	0
Savannah River Site Generation	0	47	<6	469	200	600
Onsite Storage Capacity	0	74,600	2,286	10,000[d]	(e)	(e)
Los Alamos National Laboratory Generation	0	2,200	0	188	5,100	0
Onsite Storage Capacity	0	116,900	0	2,700[f]	(e)	0

[a] Some values are given as ranges because preferred processing options have not yet been selected for filter and sludge residues. Refer to the text.
[b] This storage capacity is for both the stabilized residues and transuranic waste combined.
[c] This is the amount of plutonium that was stored at Rocky Flats as of September 1994. DOE has analyzed the shipment of the plutonium to the Savannah River Site and the Pantex Plant in the Storage and Disposition of Weapons-Usable Fissile Materials Environmental Impact Statement (DOE 1996a).
[d] Capacity of the new Actinide Packaging and Storage Facility (DOE 1997g).
[e] The site routinely disposes of this waste onsite.
[f] This is the amount of plutonium that was stored at the Los Alamos National Laboratory as of September 1994 (DOE 1996a).

The low-level waste would probably be placed in standard 210-L (55-gal) waste drums. The low-level waste at Rocky Flats would be disposed of in one of the offsite disposal facilities routinely used by Rocky Flats. The Savannah River Site and Los Alamos National Laboratory would use their onsite low-level waste disposal facilities. The plutonium would be ready for disposition in accordance with decisions to be reached on the Surplus Plutonium Disposition EIS (DOE 1997e). The plutonium separated at the Savannah River Site would be stored securely in the Actinide Packaging and Storage Facility. No increase in proliferation risk would result and this plutonium would not be used for nuclear explosive purposes. The high-level waste would be stored at the Savannah River Site until a geologic repository is ready to receive it. The saltstone would be disposed of at the Savannah River Site in concrete vaults.

4.21.2 Public and Occupational Health and Safety Impacts

This section describes the radiological and hazardous chemical impacts which could result from the Preferred Management Approach associated with the management of all Rocky Flats plutonium residues and scrub alloy. These impacts are presented for incident-free operations and postulated accident scenarios, respectively. The detailed site and transportation analyses are presented in Appendices D and E, respectively.

If DOE decides to implement the Preferred Management Approach, then DOE would make 39 shipments to the Savannah River Site and 13 shipments to the Los Alamos National Laboratory. The total round-trip highway distance would be about 223,000 kilometers (138,000 miles).

No construction of new facilities is included in this management approach but DOE may need to modify certain existing facilities. Standard mitigation measures during modifications would ensure that any radiological or hazardous chemical releases would be extremely small. Worker exposures to contaminated material would be limited to ensure that doses are maintained as low as reasonably achievable.

4.21.2.1 Incident-Free Operations

- **Radiological Impacts**—The radiological impacts to the public and the workers associated with incident-free implementation of the Preferred Management Approach are presented in **Table 4–66**. The impacts are those which are anticipated to occur as a result of process operations and transportation over whatever time period is necessary to process the entire inventory of plutonium residues and scrub alloy.

Table 4–66 Radiological Impacts Due to Incident-Free Implementation of the Preferred Management Approach[a]

Offsite Public Maximally Exposed Individual		*Offsite Public Population*	
Dose (mrem)	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*
11	5.5×10^{-6}	4.3	0.0022
Maximally Exposed Individual Involved Worker		*Involved Worker Population*	
Dose (mrem per year)	*Probability of a Latent Cancer Fatality per year*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*
2,000	0.00080	774–827	0.31–0.33

[a] Some values are given as ranges because preferred processing options have not yet been selected for filter and sludge residues. Refer to the beginning of Section 4.3.

The length of time necessary to process all the material will depend on which options DOE decides to implement. The post-processing storage of the high-level waste, transuranic waste, and plutonium would also produce impacts, but these are very small compared to the impacts due to processing.

The estimated total public maximally exposed individual dose, as shown in Table 4–66, is 11 mrem, which applies to a hypothetical member of the public stuck in traffic next to a safe secure trailer for one-half hour. See discussion in Section 4.2.2.1 regarding the conservative nature of this analysis. This individual's chance of incurring a latent cancer fatality due to this management approach would be 5.5×10^{-6}, or less than one chance in one hundred thousand. The public maximally exposed individual near any of the sites would be a hypothetical individual who lives downwind at the site boundary. The highest estimated total dose for this maximally exposed individual would be 5.7×10^{-4} mrem at the Savannah River Site. This individual's chance of incurring a latent cancer fatality due to this management approach would be less than one in one billion.

The total public population radiation dose, as shown in Table 4–66, would be 4.3 person-rem. During incident-free storage, no release of radioactive material would occur, so the impact on the public would be equal to zero. The highest public population radiation dose (excluding transportation) was determined to be 0.062 person-rem to the population surrounding the Savannah River Site, which would cause far less than one additional latent cancer fatality to this population. During incident-free storage, there would be no release of radioactive material, so the impact on the public would be equal to zero.

The total involved worker population radiation dose would range from 774 to 827 person-rem, which would cause 0.31 to 0.33 additional latent cancer fatalities among the workers directly involved in the operations. Onsite workers who are not involved with the actual processing of the residues are designated as noninvolved workers. The impacts to these workers would be much smaller than the impacts to the involved workers. During the post-processing storage period, inspections of the storage facility would expose the involved worker population to very small incremental additions beyond the processing dose.

❒ **Hazardous Chemical Impacts**—The impacts of hazardous chemical releases associated with incident-free implementation of the Preferred Management Approach are presented in **Table 4–67**. Carbon tetrachloride is no longer used at Rocky Flats, but is present in small amounts in some of the residues. The probability of excess latent cancer incidence for the offsite maximally exposed individual as a result of exposure to carbon tetrachloride would be less than about 2×10^{-10}. This hypothetical individual's chance of incurring a latent cancer would be increased by less than one in one billion. Less than one latent cancer incidence is expected to occur in the offsite population of 2.4 million individuals living within an 80-km (50-m) radius of Rocky Flats. The Hazard Index of 0.03 suggests that noncancer adverse health effects are not expected in the offsite population following exposure to phosphoric acid, hydrochloric acid, ammonium nitrate, and fluorides.

Table 4–67 Chemical Impacts Due to Incident-Free Implementation of the Preferred Management Approach[a]

Offsite Public Maximally Exposed Individual		*Offsite Public Population*
Probability of Cancer Incidence	*Hazard Index*	*Number of Cancer Incidences or Fatalities*
3×10^{-11} to 2×10^{-10}	0.03	<1
Maximally Exposed Involved Individual Worker		*Involved Worker Population*
Probability of Cancer Incidence	*Hazard Index*	*Number of Cancer Incidences or Fatalities*
4×10^{-9} to 1×10^{-8}	0.5	<1

[a] Values are given as ranges because preferred processing options have not yet been selected for filter and sludge residues. Refer to the text near the beginning of Section 4.3.

The maximally exposed individual worker probability of excess latent cancer incidence would be less than about 1.1×10^{-8}. This hypothetical individual's chance of incurring a latent cancer would be increased by less than one in ten million. If all site workers were exposed to the maximally exposed individual concentration of carbon tetrachloride, which is an extremely conservative and unrealistic assumption, less than 1 excess latent cancer would be expected to occur in the workforce population. The Hazard Index of 0.5 suggests that noncancer adverse health effects are not expected in the involved worker population.

4.21.2.2 Accidents

The potential radiological impacts to the public and the noninvolved onsite workers due to accidents under the Preferred Management Approach are summarized and presented in this section. These impacts were derived directly from the sets of impacts for all the material categories presented in Sections 4.2 through 4.11. The detailed analysis of onsite accidents, with the associated assumptions, is presented in Appendix D, Section D.3. The detailed analysis of transportation accidents, with the associated assumptions, is presented in Appendix E, Sections E.5 and E.6.

In any accident scenario the individuals most likely to be hurt are the involved workers. The risk to these workers would be due to both radiological and non-radiological effects. In a fire the involved workers could be exposed to airborne radioactive material, in addition to the smoke and heat of the fire. In an explosion, there could be flying debris and containment barriers could be broken, exposing workers to airborne radioactive material. Most spills would not have a major effect on involved workers because they would clean up the spill, wearing protective clothing and respirators as necessary. An accidental criticality could expose involved workers to large doses of prompt penetrating radiation, which could cause death in a short period of time. The earthquake and aircraft crash accident scenarios present very severe non-radiological effects to the involved workers. In these scenarios, the workers are likely to be hurt or killed from the collapse of the building or the impact of the aircraft crash before they could be evacuated.

The maximum number of involved workers at risk is estimated to be equal to the number of workers who would be working on plutonium residues or scrub alloy at any one time in each of the processing buildings at each of the three sites. Buildings 707 and 371 at Rocky Flats would each have about 100 involved workers inside, which is more involved workers than any facility at either of the other two sites. Thus, if an earthquake strong enough to collapse Building 707 and damage Building 371 hits Rocky Flats, then approximately 200 involved workers would be at risk of death or injury due to activities associated with plutonium residues and scrub alloy.

The maximum consequences for the public and a noninvolved onsite worker if DOE decides to implement the Preferred Management Approach, are presented in **Table 4–68**. The public maximally exposed individual is a hypothetical individual who resides at the site boundary in the downwind direction. The public population is defined as the residential population within a radius of 80 km (50 mi). A noninvolved onsite worker is defined as an individual worker who is located 100 m (328 ft) or more downwind from the release point when an accidental release of radioactive material occurs. The highest consequence to the public maximally exposed individual and the non-involved onsite worker would occur if a major earthquake strong enough to breach Technical Area 55 Building PF-4 occurs during the processing of direct oxide reduction salts with the water leach process at Los Alamos National Laboratory. The highest consequence to the public population would occur if a major earthquake strong enough to collapse Building 707 occurs during the process of electrorefining and molten salt extraction salts with the salt distillation process at Rocky Flats.

Table 4–68 Maximum Accident Consequences in the Preferred Management Approach

Residue, Processing Option, and Location	Accident Frequency (per year)	Offsite Public Maximally Exposed Individual Consequences		Offsite Public Population Consequences		Noninvolved Onsite Worker Consequences	
		Dose (mrem)	Probability of a Latent Cancer Fatality	Dose (person-rem)	Number of Latent Cancer Fatalities	Dose (mrem)	Probability of a Latent Cancer Fatality
Direct Oxide Reduction Salts Water Leach at Los Alamos National Laboratory	0.0005	15,100	0.0076	19,800	9.9	163,000	0.13
Electrorefining and Molten Salt Extraction Salts Distillation at Rocky Flats	0.0018	9,000	0.0045	158,000	79	101,000	0.081

The aggregation of all the risks due to accidents in the Preferred Management Approach to the public and an onsite worker are presented in **Table 4–69**. The increase in the probability of a latent cancer fatality to the public maximally exposed individual is estimated to be in the range of 0.0000259 to 0.0000264. This individual's chance of incurring a latent cancer fatality would be increased by less than one in ten thousand. The increase in latent cancer fatalities in the public population within 80 km (50 mi) of Rocky Flats, the Savannah River Site, and Los Alamos National Laboratory is estimated to be in the range of 0.46 to 0.47, less than one latent cancer fatality. The increase in the probability of a latent cancer fatality to the noninvolved onsite worker is estimated to be in the range of 0.00045 to 0.00046. This individual's chance of incurring a latent cancer fatality would be increased by less than one in one thousand. More than 80 percent of the latent cancer fatality accident risks for the Preferred Management Approach are attributable to the salt residues.

Table 4–69 Risks Due to Accidents in the Preferred Management Approach

Offsite Public Maximally Exposed Individual Risk (Probability of a Latent Cancer Fatality)	Offsite Public Population Risk (Number of Latent Cancer or Traffic Fatalities)	Noninvolved Onsite Worker Risk (Probability of a Latent Cancer Fatality)
0.0000302 to 0.0000306	0.467 to 0.475	0.000538 to 0.000543

[a] Values are given as ranges because preferred processing options have not yet been selected for filter and sludge residues. Refer to the text near the beginning of Section 4.3.

4.21.2.3 Mitigation Measures

All the environmental impacts in the Preferred Management Approach would be low and within regulatory limits, so specific mitigation measures would not be necessary. Nevertheless, DOE would maintain all public and worker exposures, both direct exposures and indirect exposures via airborne emissions, as low as reasonably achievable. As low as reasonably achievable is a long-standing DOE policy to control or manage radiation exposures and releases of radioactive material to the environment as low as social, technical, economic, practical, and public policy considerations permit. As low as reasonably achievable is not a dose limit but rather a process that has as its objective the attainment of dose levels as far below the applicable limits as practical.

4.22 Comparison of the Impacts of the Management Approaches

As discussed in Chapter 2, Section 2.5, eight management approaches have been constructed by selecting a processing option for each of the 15 material categories and/or subcategories. The primary impacts of the eight management approaches are presented in **Table 4-70**. These impacts have been derived from the impacts presented for each material category in Sections 4.2 through 4.11.

4.22.1 Products and Wastes

The amounts of solid plutonium-bearing products and wastes that would be generated under each of the management approaches are compared in **Figures 4–1** through **4-5**. The bars for the Preferred Management Approach are shown as ranges because DOE has not yet identified a preferred processing option for all the residues. The primary product of the No Action Alternative would be approximately 10,300 drums of stabilized residues, most of which would have to be stored at Rocky Flats indefinitely. DOE has not identified any options for disposition or disposal of most of these stabilized residues. Under the Preferred Management Approach, DOE would generate about 900 drums of stabilized residues at Rocky Flats. DOE believes that these 900 drums of stabilized residues would be acceptable for disposal in WIPP because variances from the safeguards termination limits have been approved.

As shown in Figure 4–2, DOE would generate the most transuranic waste under the Processing at Rocky Flats without Plutonium Separation Management Approach. DOE would generate substantially more transuranic waste under the Preferred Management Approach than under the No Action Alternative.

Figure 4–3 shows the amounts of high-level waste that would be generated at the Savannah River Site. This site would use site-specific facilities to separate plutonium from the residues and scrub alloy, generating high-level waste in the process. As shown in Figure 4-3, three management approaches would require the generation of more high-level waste than the Preferred Management Approach. As discussed in Section 4.25, the amounts of high-level waste shown in Figure 4–3 are all very small compared to the amounts that will be generated at the site by existing operations.

Figure 4–4 shows the amounts of plutonium that could be separated from the plutonium residues and scrub alloy. Two of the management approaches do not involve any plutonium separation. Under the Preferred Management Approach, DOE would separate roughly half of the plutonium that could be separated under the Maximum Plutonium Separation Management Approach. If any plutonium is separated, it would be placed in safe, secure storage until DOE makes decisions on its disposition. Under no circumstances, however, would DOE use this plutonium for nuclear explosive purposes.

As shown in Figure 4–5, DOE could generate as much as 20,000 drums of low-level waste. Under the Preferred Management Approach, DOE would generate between 9,800 and 16,900 drums, depending on DOE's final processing choices in the Preferred Management Approach. In all cases, the low-level waste would be disposed of in a disposal site on a routine basis.

Table 4–70 Impacts of the Management Approaches

Impact	Management Approaches							
	No Action	Preferred[a]	Minimize Total Process Duration at Rocky Flats	Minimize Cost	Conduct all Processes at Rocky Flats	Conduct Fewest Actions at Rocky Flats	Process with Maximum Plutonium Separation	Process without Plutonium Separation
Products and Wastes								
Stabilized Residues (drums)	10,300	**900**	0	700	900	900	0	900
Transuranic Waste (drums)	3,500	**11,200 - 13,600**	5,800	11,200	15,400	6,900	9,900	31,000
High-Level Waste (canisters)	0	**< 6**	37	4	0	34	43	0
Separated Plutonium (kilograms)[b]	0	**1,538–1,673**	2,467	1,348	1,204	2,512	2,786	0
Low-Level Waste (drums)	7,600	**9,800–16,900**	5,500	5,000	10,200	11,200	20,000	4,500
Public and Occupational Health and Safety								
Incident-Free Radiological Risk to the Public Maximally Exposed Individual (Probability of a Latent Cancer Fatality)	2.4×10^{-10}	**5.5×10^{-6}**	5.5×10^{-6}	5.5×10^{-6}	2.4×10^{-10}	5.5×10^{-6}	5.5×10^{-6}	2.4×10^{-10}
Incident-Free Radiological Risk to the Public Population (Latent Cancer Fatalities)	6.0×10^{-6}	**0.0022**	0.0089	0.0021	6.2×10^{-6}	0.0074	0.0078	3.9×10^{-6}
Incident-Free Radiological Risk to the Maximally Exposed Individual Worker (Probability of a Latent Cancer Fatality per year)	0.0008	**0.0008**	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
Incident-Free Radiological Risk to the Worker Population (Latent Cancer Fatalities)	0.31	**0.31– 0.33**	0.37	0.31	0.36	0.33	0.37	0.66
Incident-Free Worker Hazard Index[c]	0	**0.5**	2.0	0.6	0	1.5	1.6	0
Accident Risk to the Public Maximally Exposed Individual (Probability of a Latent Cancer Fatality)	0.000023	**0.000030–0.000031**	0.000018	0.000017	0.000024	0.000050	0.000031	0.000027
Accident Risk to the Public Population (Latent Cancer or Traffic Fatalities)	0.41	**0.47–0.48**	0.34	0.31	0.43	0.53	0.50	0.47
Accident Risk to the Noninvolved Onsite Worker (Probability of a Latent Cancer Fatality)	0.00041	**0.00054**	0.00039	0.00035	0.00042	0.00090	0.00059	0.00046

Impact	Management Approaches							
	No Action	*Preferred*[a]	*Minimize Total Process Duration at Rocky Flats*	*Minimize Cost*	*Conduct all Processes at Rocky Flats*	*Conduct Fewest Actions at Rocky Flats*	*Process with Maximum Plutonium Separation*	*Process without Plutonium Separation*
Other Impacts								
Intersite Round-Trip Transportation (1,000 kilometers)[d]	0	**223**	847	204	0	786	815	0
Cost (million $)[e]	633[f]	**520**[g]	670	483	628	645	816	718
Processing Duration at Rocky Flats (years)[h]	7.1	**3.6**	2.5	4.0	6.4	3.8	3.5	13.4
Air Quality Impacts	Very small (See Sections 4.12 and 4.25)	**Very small (See Sections 4.12 and 4.25)**	Very small (See Sections 4.12 and 4.25)	Very small (See Sections 4.12 and 4.25)	Very small (See Sections 4.12 and 4.25)	Very small (See Sections 4.12 and 4.25)	Very small (See Sections 4.12 and 4.25)	Very small (See Sections 4.12 and 4.25)
Proliferation Risk	See note i	**See note j**	See note j	See note j	See note j	See note j	See note j	See note j

[a] These impacts may be expressed as ranges because DOE has not yet selected a processing option for some residues.
[b] To convert to pounds, multiply by 2.2.
[c] The Hazard Index indicates the potential for noncancer health effects. When this index is greater than one, the potential for adverse health effects exists.
[d] To convert thousands of kilometers to thousands of miles, multiply by 0.62.
[e] Undiscounted 1997 Dollars. Fully allocated including all site overheads, common facility costs, and technology development costs.
[f] Of which $426 million is attributable to facilities costs and processing costs and $207 million is attributable to interim onsite storage at Rocky Flats from 2001 through 2015 plus offsite shipping. Assumes no safeguards termination limit variances.
[g] Assumes safeguards termination limit variances and no onsite interim storage for neutralize/dry for aqueous combustibles, thermal desorption/steam passivation for organic combustibles, repackaging for dry combustibles, neutralize/dry for glass, repackaging for graphite, and repackaging for inorganics. Assumes blend down for filter media and furnace vitrification for sludge.
[h] Assumes all processes at different buildings or modules at Rocky Flats are conducted concurrently. Canyon processing at the Savannah River Site depends on schedules for materials in programs outside the scope of this EIS. Processing duration at Los Alamos National Laboratory is 0.75 years in the Preferred and Maximum Separation Management Approaches and zero in the others.
[i] The plutonium residues and scrub alloy would be left in forms that cannot be disposed of due to proliferation concerns (except for any material disposed of through use of safeguards termination limit variances).
[j] The plutonium residues and scrub alloy would be managed and placed in forms that can be disposed of or dispositioned in a manner that supports U.S. nuclear weapons nonproliferation policy.

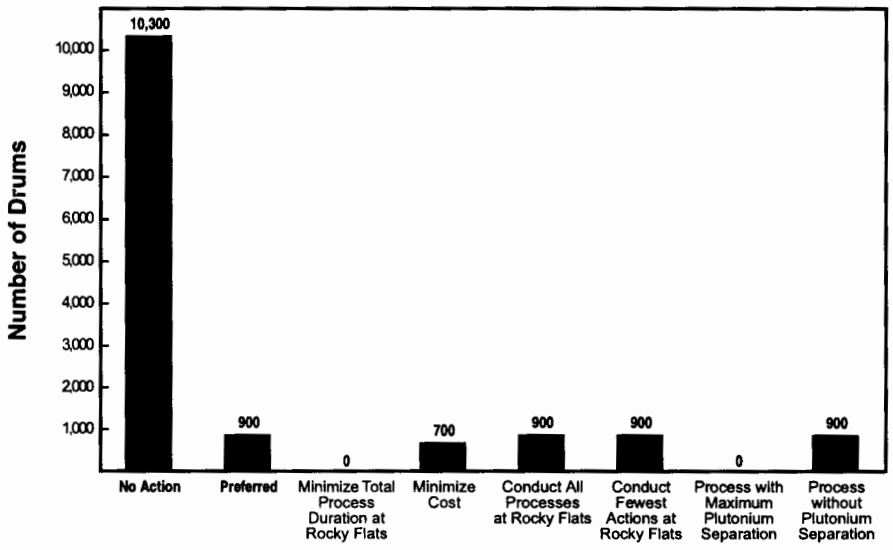

Figure 4–1 Stabilized Residues Generated Under Each Management Approach

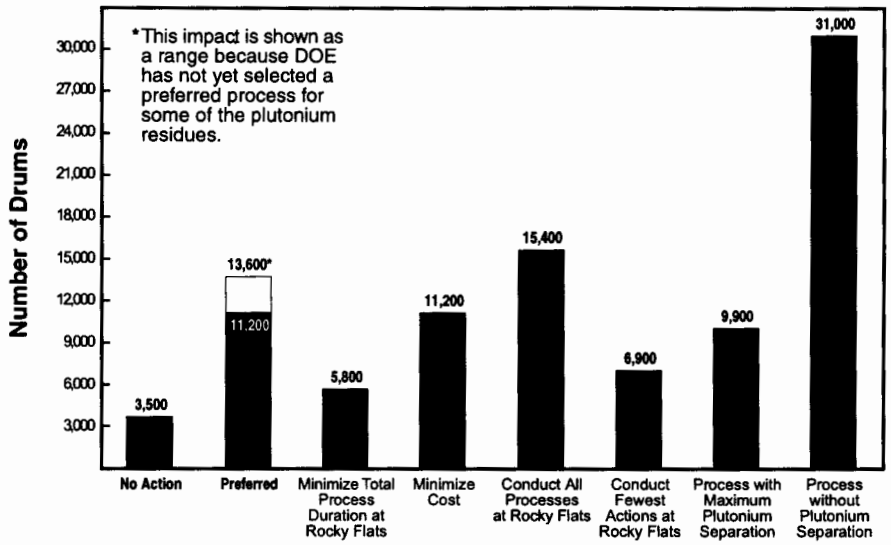

Figure 4–2 Transuranic Waste Generated Under Each Management Approach

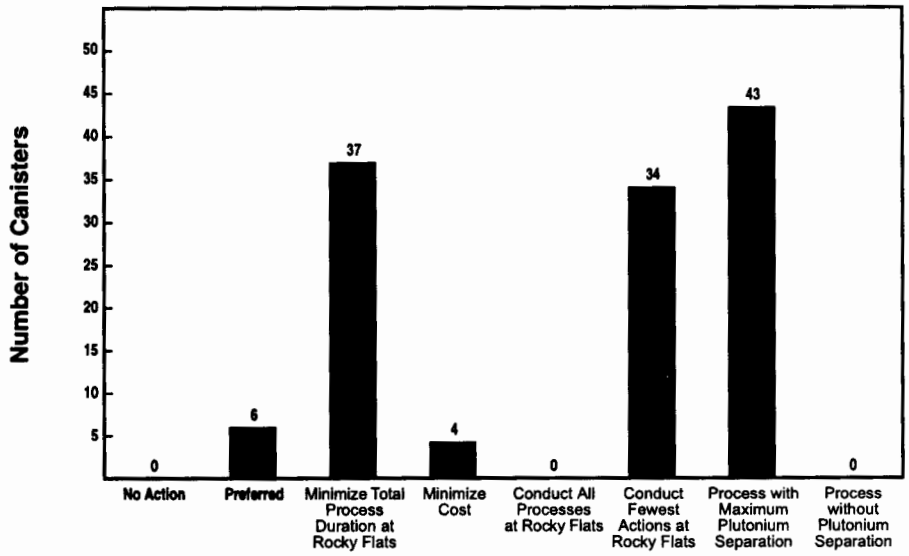

Figure 4–3 High-Level Waste Generated Under Each Management Approach

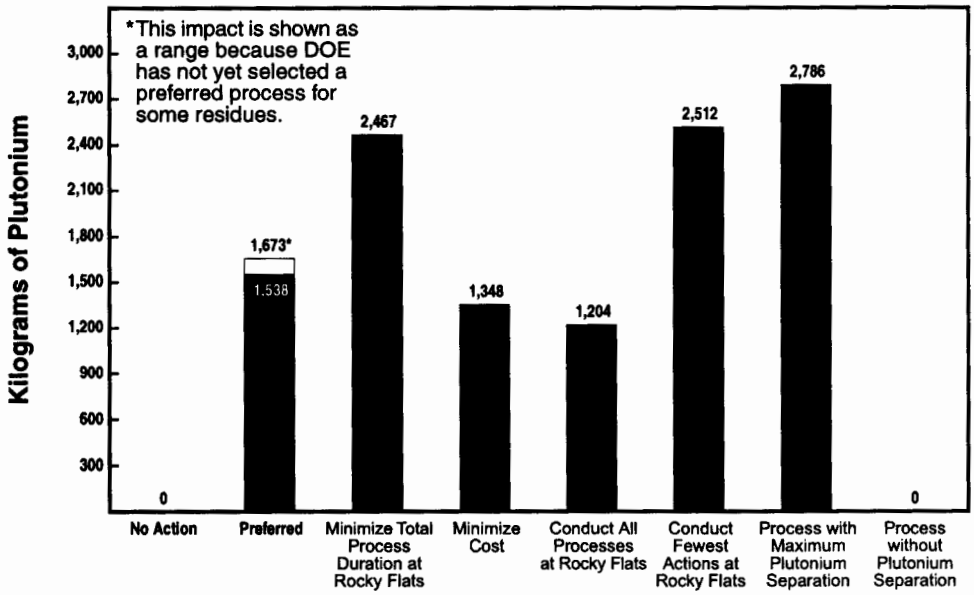

Figure 4–4 Plutonium Separated Under Each Management Approach

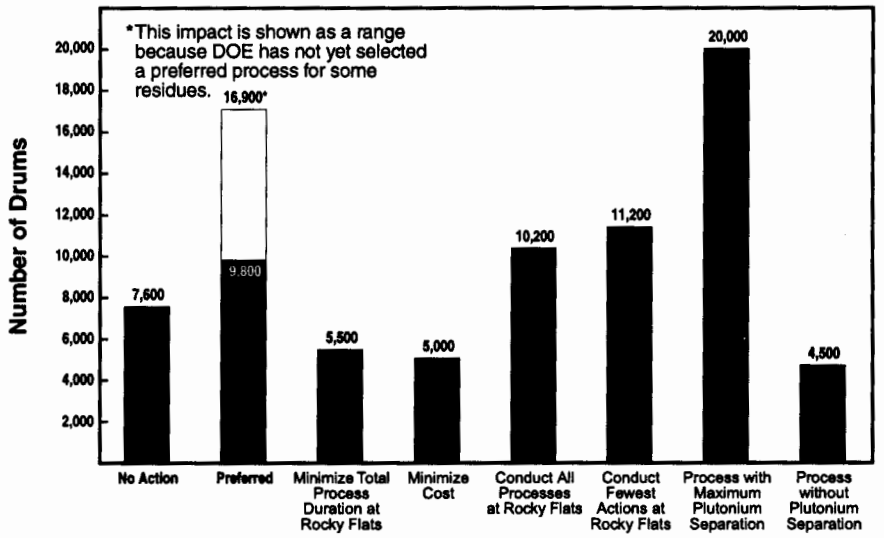

Figure 4–5 Low-Level Waste Generated Under Each Management Approach

4.22.2 Public and Occupational Health and Safety Impacts

All of the management approaches present low risks to the public and to workers. The risk numbers are so low that DOE would expect far less than one additional latent cancer fatality to occur in the general public as a result of radiation exposure, no matter which management approach is selected. Nevertheless, differences exist between the risks presented by the eight management approaches and these could be of interest to government officials and members of the public. **Figures 4–6** through **4-13** display the risk comparisons for the public and workers under both incident-free and accident conditions.

As shown in Figure 4–6, the management approaches transporting intersite would involve greater risk to the public maximally exposed individual than the management approaches without intersite transportation. See Section 4.2.2.1 regarding the conservative nature of this analysis. The greatest chance that this hypothetical individual would incur a latent cancer fatality would be about 5.5×10^{-6}, or less than one chance in one hundred thousand. As shown in Figure 4–7, three management approaches present risks of about 0.008 additional latent cancer fatalities, while the Preferred Management Approach presents a risk of only 0.0022 additional latent cancer fatalities. In all cases the estimated risks are so low that no member of the public would be likely to incur a latent cancer fatality due to incident-free operations.

As shown in Figure 4–8, all the management approaches are equal in terms of the risk to the maximally exposed individual involved worker. This is because DOE applied the same conservative assumption across the board for this part of the analysis. As shown in Figure 4–9, most of the management approaches would cause between 0.3 and 0.4 additional latent cancer fatalities among the worker population. Only the Process without Plutonium Separation Management Approach would cause a noticeably greater risk to the work force.

As shown in Figure 4–10, the Hazard Index would be greater than one for three of the management approaches. This means than the involved workers could incur small noncancer adverse health effects due to exposure to hazardous chemicals under these management approaches. The Hazard Index for the Preferred Management Approach is safely below one.

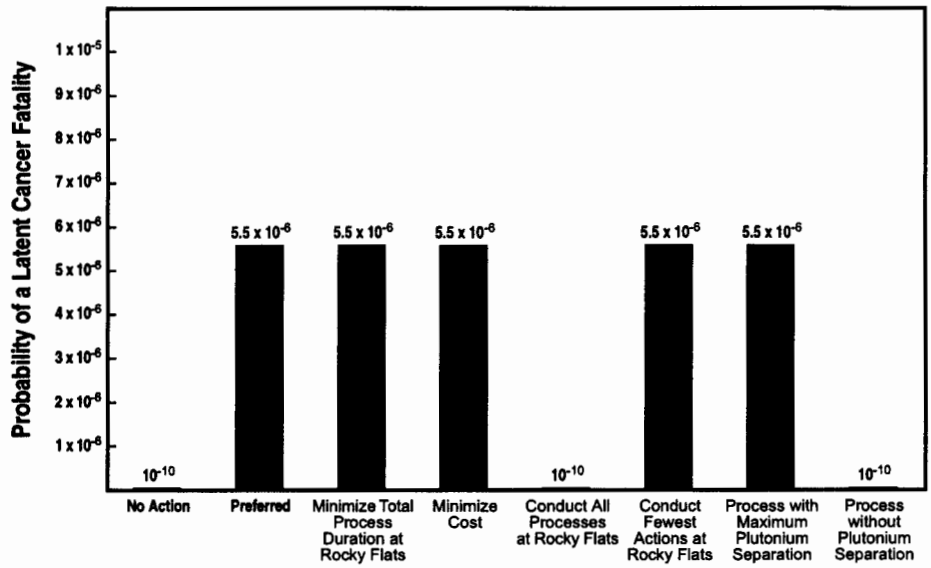

Figure 4–6 Incident-Free Radiological Risk to the Public Maximally Exposed Individual Under Each Management Approach

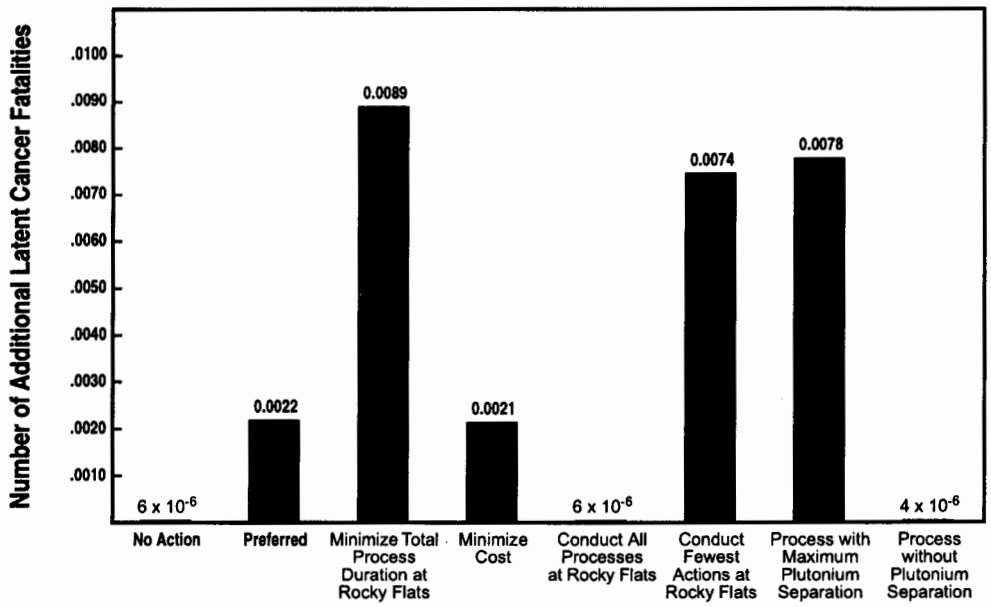

Figure 4–7 Incident-Free Radiological Risk to the Public Population Under Each Management Approach

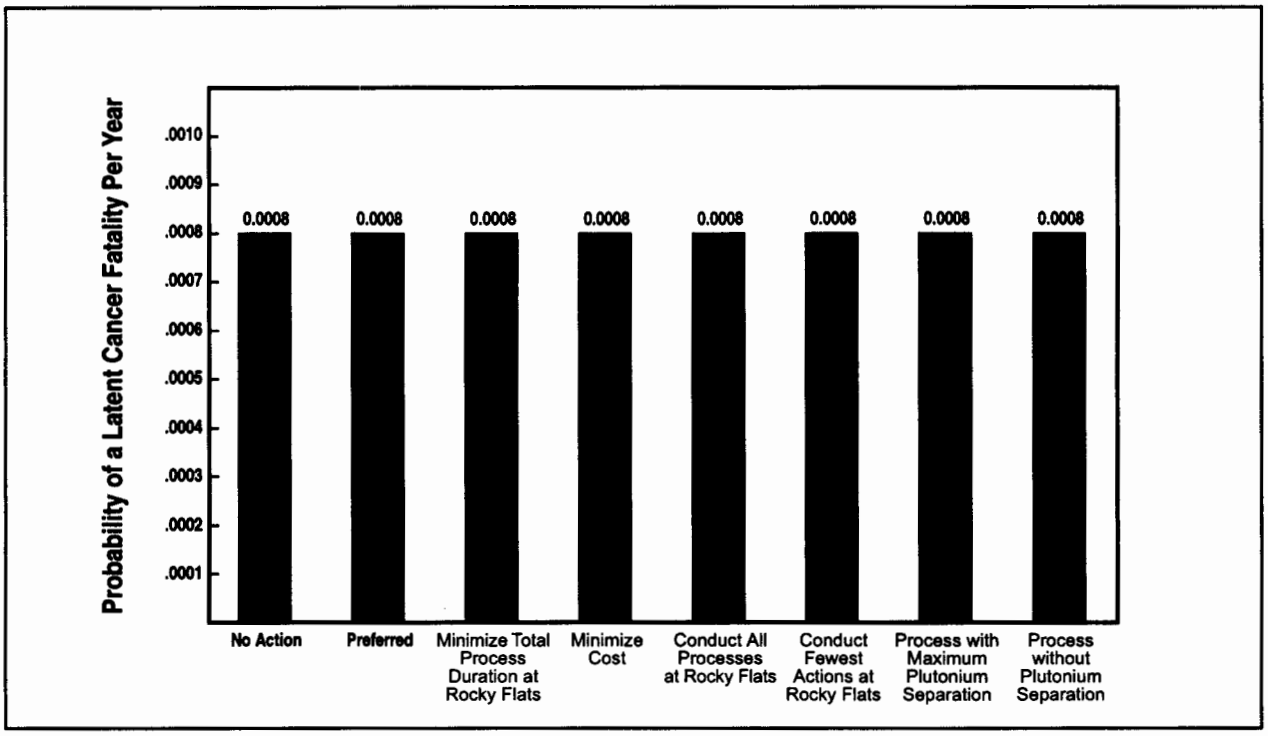

Figure 4–8 Incident-Free Radiological Risk to the Maximally Exposed Individual Worker Under Each Management Approach

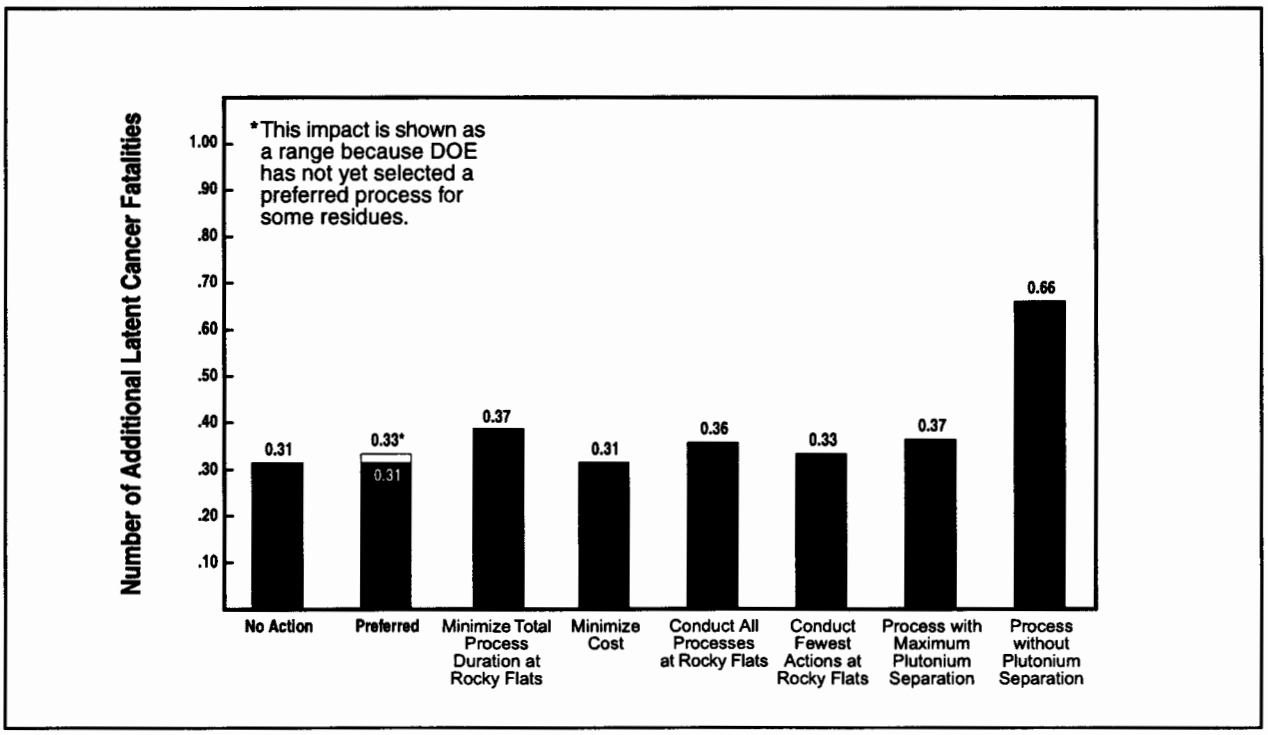

Figure 4–9 Incident-Free Radiological Risk to the Worker Population Under Each Management Approach

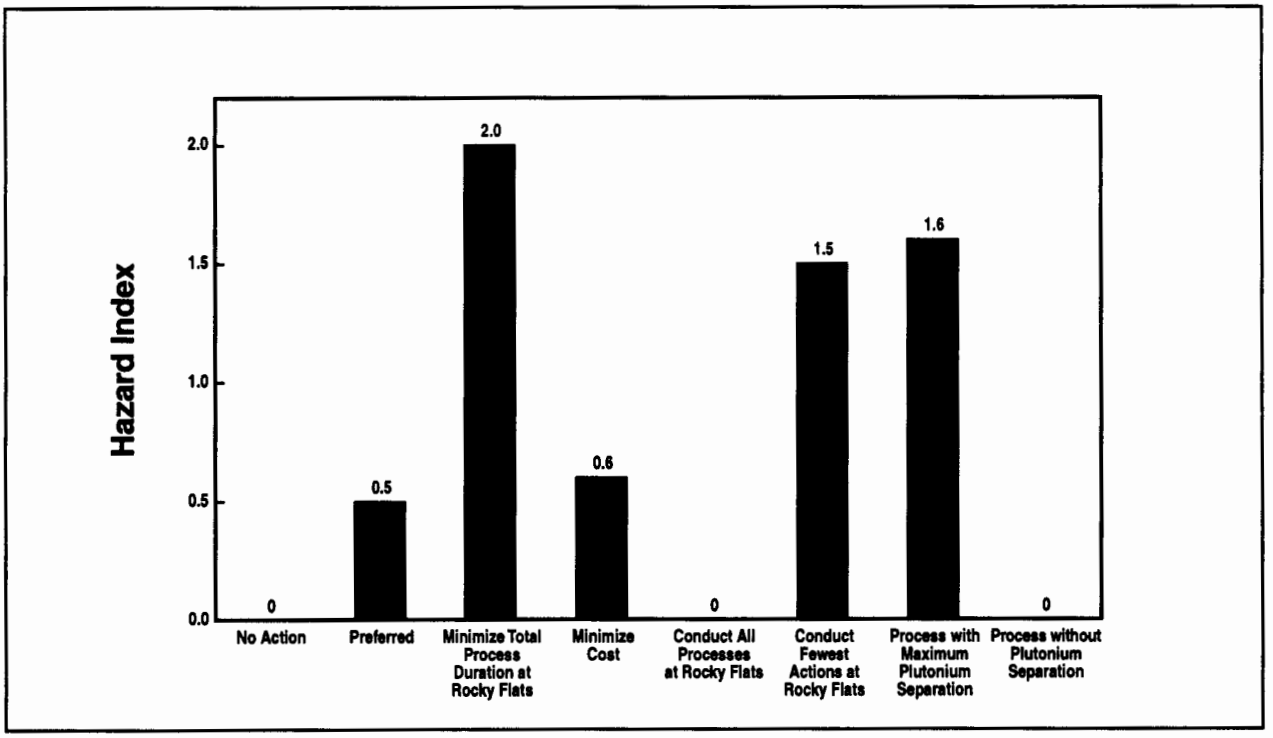

Figure 4–10 Incident-Free Worker Hazard Index Under Each Management Approach

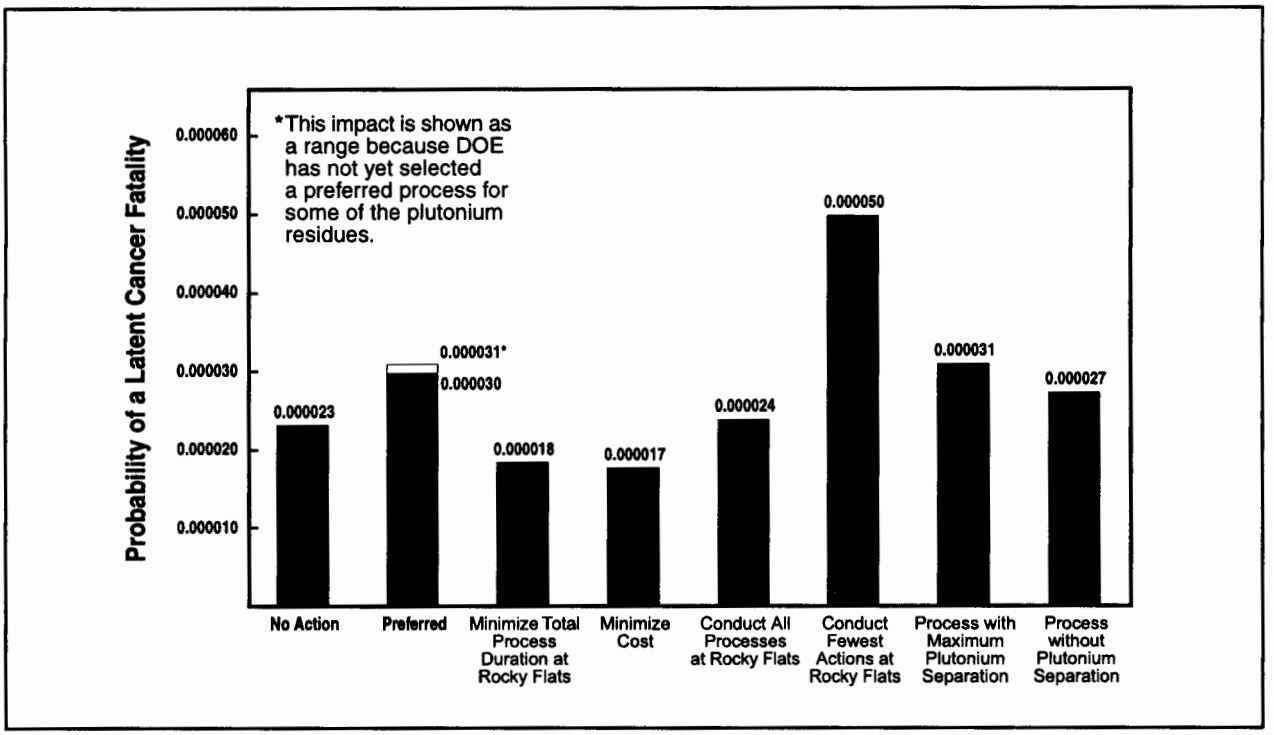

Figure 4–11 Accident Risk to the Public Maximally Exposed Individual Under Each Management Approach

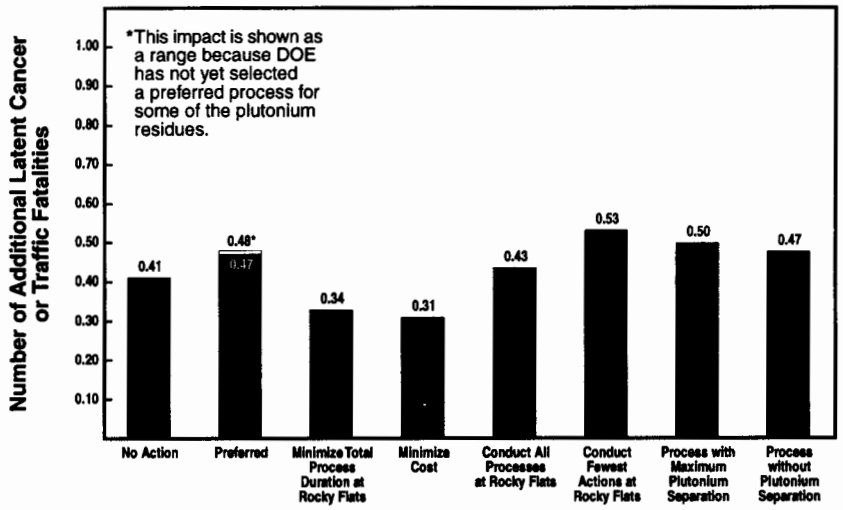

Figure 4–12 Accident Risk to the Public Population Under Each Management Approach

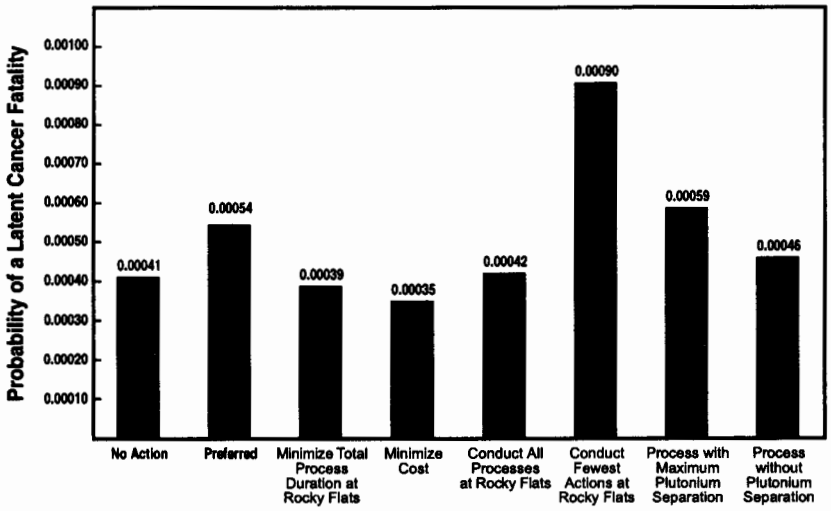

Figure 4–13 Accident Risk to the Noninvolved Onsite Worker Under Each Management Approach

As shown in Figures 4–11, 4–12, and 4–13, the risks due to onsite and transportation accidents do not vary greatly among any of the management approaches. In general, the Minimize Total Process Duration at Rocky Flats and Minimize Cost Management Approaches present somewhat lower accident risks than the rest of the management approaches, but all the accident risks are very low.

4.22.3 Other Impacts

Five of the management approaches involve intersite transportation of plutonium residues and/or scrub alloy. **Figure 4-14** compares the amounts of intersite transportation that would be required under each management approach. Three of the management approaches would require about 800,000 km (500,000 mi) of intersite transportation, while the Preferred Management Approach would require about 223,000 km (138,000 mi).

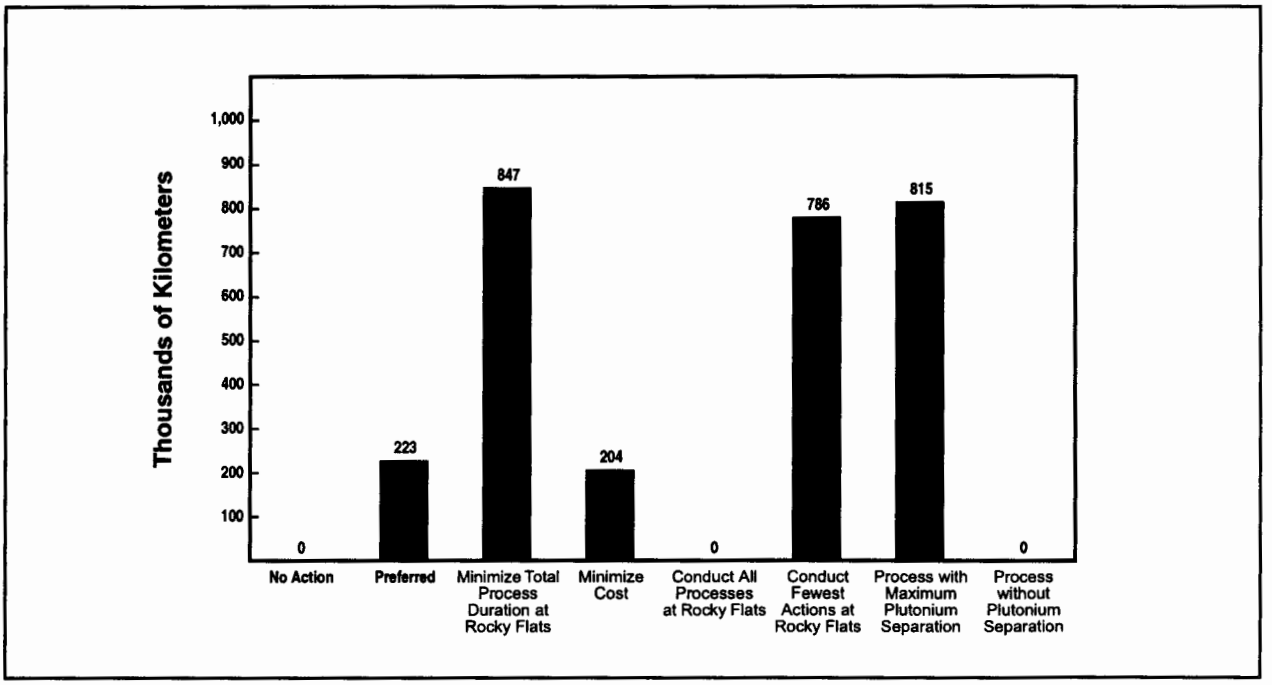

Figure 4–14 Intersite Round-Trip Transportation Required Under Each Management Approach

The cost comparison is presented in **Figure 4-15**. Cost estimates range from $483 million for the Minimum Cost Management Approach to $816 million for the Processing with Maximum Plutonium Separation Management Approach. The Preferred Management Approach has the second lowest estimated cost ($520 million).

4.23 Range of Impacts at Each Site

As discussed in Chapter 2, DOE has identified a variety of options for each category or subcategory of plutonium residue and scrub alloy under Alternative 1 (No Action) and Alternative 2 (the Proposed Action). The impacts of all the options are presented for each residue category and subcategory in Sections 4.2 through 4.11, with each section being devoted to one residue category.

All the residues can be processed at Rocky Flats and portions of the residues can be processed at the Savannah River Site or Los Alamos National Laboratory. Sections 4.23.1 through 4.23.3 present the range of impacts that could result from the processing option associated with the management of certain plutonium residues and scrub alloy at Rocky Flats, the Savannah River Site, and Los Alamos National Laboratory, respectively. The low end of the range for all impacts at the Savannah River Site and at Los Alamos National Laboratory is zero; this would result if all processing were to take place at Rocky Flats or at Rocky Flats and only one other site.

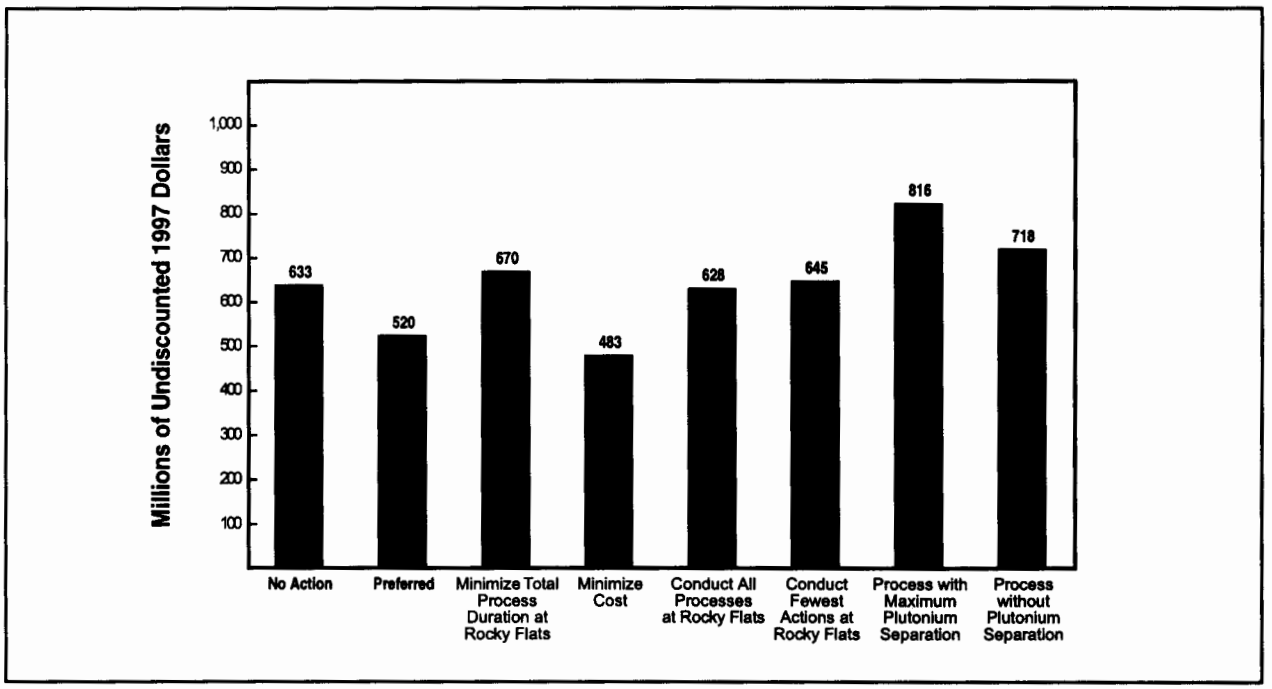

Figure 4–15 Cost of Each Management Approach

4.23.1 Rocky Flats Environmental Technology Site

4.23.1.1 Products and Wastes

The processing options at Rocky Flats would generate stabilized residues, transuranic waste, low-level waste, and separated plutonium (with americium included) in the form of an oxide. Considering all possible processing options, the minimum and maximum estimated amounts of the solid plutonium-bearing products and wastes that could be generated from plutonium residues and scrub alloy at Rocky Flats are presented in **Table 4–71**. The transuranic waste would be placed in safe, secure storage until WIPP is ready to receive it. The low-level waste would be disposed of in one of the offsite disposal facilities routinely used by Rocky Flats.

Table 4–71 Range of Products and Wastes at Rocky Flats

Stabilized Residues (Drums)	*Transuranic Waste (Drums)*	*Separated Plutonium (kg)*[a]	*Low-Level Waste (Drums)*
0 to 10,300	2,300 to 39,600	0 to 1,477	4,200 to 58,600

[a] To convert to pounds, multiply by 2.2.

4.23.1.2 Public and Occupational Health and Safety Impacts

This section describes the range of radiological and hazardous chemical impacts which could result from the various processing options associated with the management of Rocky Flats plutonium residues and scrub alloy at Rocky Flats. These impacts are presented for incident-free operations and postulated accident scenarios, respectively. Detailed analyses associated with these impacts are presented in Appendix D.

No construction of new facilities is required for any of the alternatives, but DOE may need to modify certain existing facilities. Mitigation measures during modifications would ensure that any radiological or hazardous chemical releases would be extremely small. Worker exposures to contaminated material would be limited to assure that doses are maintained as low as reasonably achievable.

4.23.1.2.1 Incident-Free Operations

❒ **Radiological Impacts**—The range of radiological impacts to the public and the workers associated with incident-free implementation of the various processing options at Rocky Flats is presented in **Table 4–72**. The impacts are those which are anticipated to occur as a result of process operations over whatever time period is necessary to process the entire inventory of plutonium residues and scrub alloy. The length of time necessary to process all the plutonium residues and scrub alloy will depend on which options DOE decides to implement. The post-processing storage of the high-level waste, transuranic waste, and plutonium would also produce impacts, but these are very small compared to the impacts due to processing.

Table 4–72 Range of Radiological Impacts Due to Incident-Free Operations at Rocky Flats

Offsite Public Maximally Exposed Individual		*Offsite Public Population*	
Dose (mrem)	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*
0.00014 to 0.0011	7.0×10^{-11} to 5.5×10^{-10}	0.0054 to 0.025	2.7×10^{-6} to 0.000012
Maximally Exposed Individual Involved Worker		*Involved Worker Population*	
Dose (mrem per year)	*Probability of a Latent Cancer Fatality per year*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*
2,000	0.0008	477 to 2,060	0.19 to 0.82

The public maximally exposed individual at Rocky Flats would be a hypothetical individual who lives downwind at the site boundary. As shown in Table 4–72, the estimated total dose for this maximally exposed individual could range from 0.00014 mrem to 0.0011 mrem. This individual's chance of incurring a latent cancer fatality due to process operations would be less than one in one billion.

The total public population radiation dose, as shown in Table 4–72, could range from 0.0054 person-rem to 0.025 person-rem. During incident-free storage, no release of radioactive material would occur, so the impact on the public would be equal to zero.

The total involved worker population radiation dose would range from 477 person-rem to 2,060 person-rem, which would cause 0.19 to 0.82 additional latent cancer fatalities among the workers directly involved in the operations. Onsite workers who are not involved with the actual processing of the residues are designated as noninvolved workers. The impacts to these workers would be much smaller than the impacts to the involved workers. During the post-processing storage period, inspections of the storage facility would expose the involved worker population to very small incremental additions.

❒ **Hazardous Chemical Impacts**—The range of impacts of hazardous chemical releases associated with incident-free implementation of the various processing options at Rocky Flats is presented in **Table 4–73**. The probability of excess latent cancer incidence for the offsite population maximally exposed individual resulting from releases of carbon tetrachloride ranges from 0 to 3×10^{-10}. This hypothetical individual's chance of incurring a latent cancer would be increased by less than one in one billion. From zero to less than one latent cancer incidence is expected to occur in the offsite population of 2.4 million individuals living within an 80-km (50-mi) radius of Rocky Flats. The Hazard Index value of 0.006 resulting from releases of hydrochloric acid suggests that noncancer adverse health effects are not expected in the offsite population.

Table 4–73 Range of Chemical Impacts at Rocky Flats

Offsite Public Maximally Exposed Individual		*Offsite Public Population*
Probability of Cancer Incidence	*Hazard Index*	*Number of Cancer Incidences or Fatalities*
0 to 3×10^{-10}	0 to 0.006	0 to <1
Maximally Exposed Individual Worker		*Worker Population*
Probability of Cancer Incidence	*Hazard Index*	*Number of Cancer Incidences or Fatalities*
0 to 1×10^{-8}	0 to 0.2	0 to <1

The maximally exposed individual involved worker probability of excess latent cancer incidence ranges from 0 to 1×10^{-8}. This hypothetical individual's chance of incurring a latent cancer would be increased by less than one in ten million. If all site workers were exposed to the maximally exposed individual concentration of carbon tetrachloride, which is an extremely conservative and unrealistic assumption, less than 1 excess latent cancer would be expected to occur in the workforce population. The Hazard Index value of 0.2 suggests that noncancer adverse health effects are not expected in the involved worker population as a result of exposure to hydrochloric acid. Hydrochloric acid at sufficiently high concentrations may be toxic following ingestion and inhalation exposure. The compound is a strong eye, skin, and mucous membrane irritant.

4.23.1.2.2 Accidents

The range of radiological impacts to the public and the noninvolved onsite workers due to accidents during the implementation of the various processing options for plutonium residues and scrub alloy at Rocky Flats is presented in **Table 4–74**. The length of time necessary to process all the residues and scrub alloy will depend on which options DOE decides to implement.

Table 4–74 Range of Radiological Impacts[a] Due to Accidents at Rocky Flats

Offsite Public Maximally Exposed Individual Risk	*Offsite Public Population Risk*	*Noninvolved Onsite Worker Maximally Exposed Individual Risk*
Probability of a Latent Cancer Fatality	*Number of Latent Cancer Fatalities*	*Probability of a Latent Cancer Fatality*
0.0000029 to 0.000028	0.035 to 0.50	0.000030 to 0.00050

[a] The impacts are given as risks, which are additive, rather than consequences, which are not additive for accidents.

The public maximally exposed individual at Rocky Flats would be a hypothetical individual who lives downwind at the site boundary. The public population is defined as the residential population within a radius of 80 km (50 mi). A noninvolved onsite worker is defined as an individual worker who is located 100 m (328 ft) or more downwind from the release point when an accidental release of radioactive material occurs.

The estimated risk of a latent cancer fatality for the maximally exposed individual could range from 0.0000029 to 0.000028. This individual's chance of incurring a latent cancer fatality due to an accident during process operations would be increased by less than one in ten thousand. The estimated risk of latent cancer fatalities for the general population could be in the range of 0.035 to 0.50. This accident risk is not expected to cause one additional latent cancer fatality in the population living near Rocky Flats. The noninvolved onsite worker risk is in the range of 0.000030 to 0.00050. This noninvolved onsite worker's chance of incurring a latent cancer fatality due to an accident during process operations would be increased by less than one in ten thousand.

4.23.2 Savannah River Site

4.23.2.1 Products and Wastes

The processing options at the Savannah River Site would generate high-level waste, transuranic waste, saltstone, low-level waste, and separated plutonium in the form of a metal and/or an oxide. The americium from the residues would go into the high-level waste. Considering all possible processing options, the minimum and maximum estimated amounts of the solid plutonium-bearing products and wastes that could be generated from plutonium residues and scrub alloy at the Savannah River Site are presented in **Table 4–75**. The transuranic waste would be placed in safe, secure storage until WIPP is ready to receive it. The high-level waste canisters would be stored onsite until a geologic repository is ready to receive them. The separated plutonium would be stored onsite until a decision is made on its disposition. The low-level waste and saltstone would be disposed of in the onsite disposal facilities at the Savannah River Site.

Table 4–75 Range of Products and Wastes at the Savannah River Site

Transuranic Waste (Drums)	*High-Level Waste (Canisters of Glass)*	*Separated Plutonium (kg)*[a]	*Low-Level Waste (Drums)*	*Saltstone (cubic yards)*
0 to 500	0 to 45	0 to 2,563	0 to 1,100	0 to 3,300

[a] To convert to pounds, multiply by 2.2.

4.23.2.2 Public and Occupational Health and Safety Impacts

This section describes the range of radiological and hazardous chemical impacts which could result from the various processing options associated with the management of certain Rocky Flats residues and scrub alloy at the Savannah River Site. These impacts are presented for incident-free operations and postulated accident scenarios, respectively. Detailed analyses associated with these impacts are presented in Appendix D.

No construction of new facilities is required for any of the alternatives, but DOE may need to modify certain existing facilities. Mitigation measures during modifications would ensure that any radiological or hazardous chemical releases would be extremely small. Worker exposures to contaminated material would be limited to assure that doses are maintained as low as reasonably achievable.

4.23.2.2.1 Incident-Free Operations

- **Radiological Impacts**—The range of radiological impacts to the public and the workers associated with incident-free implementation of the various processing options at the Savannah River Site is presented in **Table 4–76**. The impacts are those which are anticipated to occur as a result of process operations over whatever time period is necessary to process the applicable inventory of residues and scrub alloy. The length of time necessary to process the residues and scrub alloy will depend on which options DOE decides to implement. The post-processing storage of the high-level waste, transuranic waste, and plutonium would also produce impacts, but these are very small compared to the impacts due to processing.

Table 4–76 Range of Radiological Impacts Due to Incident-Free Operations at the Savannah River Site

Offsite Public Maximally Exposed Individual		*Offsite Public Population*	
Dose (mrem)	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*
0 to 0.0054	0 to 1.7×10^{-6}	0 to 0.38	0 to 0.00019
Maximally Exposed Individual Involved Worker		*Involved Worker Population*	
Dose (mrem per year)	*Probability of a Latent Cancer Fatality per year*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*
0 to 2,000	0 to 0.00080	0 to 469	0 to 0.19

The public maximally exposed individual at the Savannah River Site would be a hypothetical individual who lives downwind at the site boundary. As shown in Table 4–76, the estimated total dose for this maximally exposed individual could range from 0 mrem to 0.0034 mrem. This individual's chance of incurring a latent cancer fatality due to process operations would be less than one in one-hundred million.

The total public population radiation dose, as shown in Table 4–76, could range from 0 person-rem to 0.38 person-rem. During incident-free storage, no release of radioactive material would occur, so the impact on the public would be equal to zero.

The total involved worker population radiation dose would range from 0 to approximately 469 person-rem, which would cause 0 to 0.19 additional latent cancer fatalities among the workers directly involved in the operations. Onsite workers who are not involved with the actual processing of the residues are designated as noninvolved workers. The impacts to these workers would be much smaller than the impacts to the involved workers. During the post-processing storage period, inspections of the storage facility would expose the involved worker population to very small incremental additions.

- **Hazardous Chemical Impacts**—The range of impacts of hazardous chemical releases associated with incident-free implementation of the various processing options at the Savannah River Site is presented in **Table 4–77**. No carcinogenic chemicals are expected to be released from the processing of plutonium residues and scrub alloy at the Savannah River Site; therefore, maximally exposed individual cancer probability and population cancer incidences were not evaluated for the offsite population or workers. The Hazard Index range of 0 to 0.2 suggests that noncancer adverse health effects are not expected in the offsite population as a result of releases of phosphoric acid, ammonium nitrate, and fluorides. The Hazard Index range of 0 to 2.7 indicates that onsite workers may experience adverse noncancer health effects if exposed to the estimated releases of the process hazardous chemicals for long periods of time.

Table 4–77 Range of Chemical Impacts at the Savannah River Site

Offsite Public Maximally Exposed Individual		*Offsite Public Population*
Probability of Cancer Incidence	*Hazard Index*	*Number of Cancer Incidences*
N/A	0 to 0.2	N/A
Maximally Exposed Individual Involved Worker		*Involved Worker Population*
Probability of Cancer Incidence	*Hazard Index*	*Number of Cancer Incidences*
N/A	0 to 2.7	N/A

N/A = not applicable

4.23.2.2.2 Accidents

The range of radiological impacts to the public and the noninvolved onsite workers due to accidents during the implementation of the various processing options for plutonium residues and scrub alloy at the Savannah River Site is presented in **Table 4–78**. The length of time necessary to process all the residues and scrub alloy will depend on which options DOE decides to implement.

Table 4–78 Range of Radiological Impacts[a] Due to Accidents at the Savannah River Site

Offsite Public Maximally Exposed Individual Risk	*Offsite Public Population Risk*	*Noninvolved Onsite Worker Maximally Exposed Individual Risk*
Probability of a Latent Cancer Fatality	*Number of Latent Cancer Fatalities*	*Probability of a Latent Cancer Fatality*
0 to 2.4×10^{-7}	0 to 0.011	0 to 0.000078

[a] The impacts are given as risks, which are additive, rather than consequences, which are not additive for accidents.

The public maximally exposed individual at the Savannah River Site would be a hypothetical individual who lives downwind at the site boundary. The public population is defined as the residential population within a radius of 80 km (50 mi). A noninvolved onsite worker is defined as an individual worker who is located 100 m (328 ft) or more downwind from the release point when an accidental release of radioactive material occurs.

The estimated risk of a latent cancer fatality for the maximally exposed individual could range from 0 to 2.4×10^{-7}. This individual's chance of incurring a latent cancer fatality due to an accident during process operations would be increased by less than one in one million. The estimated risk of latent cancer fatalities for the general population could be in the range of 0 to 0.011. The noninvolved onsite worker risk is in the range of 0 to 0.000078. This onsite worker's chance of incurring a latent cancer fatality due to an accident during process operations would be increased by less than one in ten thousand.

4.23.3 Los Alamos National Laboratory

4.23.3.1 Products and Wastes

The processing options at Los Alamos National Laboratory would generate high-level waste, transuranic waste, and low-level waste, and would also produce separated plutonium (with americium included) in the form of an oxide. Considering all possible processing options, the minimum and maximum estimated amounts of the solid plutonium-bearing products and wastes that could be generated from plutonium residues and scrub alloy at the Los Alamos National Laboratory are presented in **Table 4–79**. The transuranic waste would be placed in safe, secure storage until WIPP is ready to receive it. The low-level waste would be disposed of at the onsite disposal facilities at Los Alamos National Laboratory.

Table 4–79 Range of Products and Wastes at Los Alamos National Laboratory

Transuranic Waste (Drums)	*Separated Plutonium (kg)*[a]	*Low-Level Waste (Drums)*
0 to 2,700	0 to 1,069	0 to 6,100

[a] To convert to pounds, multiply by 2.2.

4.23.3.2 Public and Occupational Health and Safety Impacts

This section describes the range of radiological and hazardous chemical impacts which could result from the processing options associated with the management of certain Rocky Flats residues at the Los Alamos National Laboratory. These impacts are presented for incident-free operations and postulated accident scenarios, respectively. Detailed analyses associated with these impacts are presented in Appendix D.

No construction of new facilities is required for any of the alternatives, but DOE may need to modify certain existing facilities. Mitigation measures during modifications would ensure that any radiological or hazardous chemical releases would be extremely small. Worker exposures to contaminated material would be limited to assure that doses are maintained as low as reasonably achievable.

4.23.3.2.1 Incident-Free Operations

- **Radiological Impacts**—The range of radiological impacts to the public and the workers associated with incident-free implementation of applicable processing options at Los Alamos National Laboratory is presented in **Table 4–80**. The impacts are those which are anticipated to occur as a result of process operations over whatever time period is necessary to process the inventory of applicable residues. The length of time necessary to process the residues will depend on which option(s) DOE decides to implement. The post-processing storage of the high-level waste, transuranic waste, and plutonium would also produce impacts, but these are very small compared to the impacts due to processing.

Table 4–80 Radiological Impacts Due to Incident-Free Operations at Los Alamos National Laboratory

Offsite Public Maximally Exposed Individual		Offsite Public Population	
Dose (mrem)	Probability of a Latent Cancer Fatality	Dose (person-rem)	Number of Latent Cancer Fatalities
0 to 0.00032	0 to 1.6×10^{-10}	0 to 0.00095	0 to 4.8×10^{-7}
Maximally Exposed Individual Involved Worker		Involved Worker Population	
Dose (mrem per year)	Probability of a Latent Cancer Fatality per year	Dose (person-rem)	Number of Latent Cancer Fatalities
0 to 2,000	0 to 0.00080	0 to 29	0 to 0.012

The public maximally exposed individual at Los Alamos National Laboratory would be a hypothetical individual who lives downwind at the site boundary. As shown in Table 4–80, the estimated total dose for this maximally exposed individual could range from 0 mrem to 0.00032 mrem. This individual's chance of incurring a latent cancer fatality due to process operations would be less than one in one-billion.

The total public population radiation dose, as shown in Table 4–80, could range from 0 person-rem to 0.00095 person-rem. During incident-free storage, no release of radioactive material would occur, so the impact on the public would be equal to zero.

The total involved worker population radiation dose would range from 0 person-rem to approximately 29 person-rem, which would cause 0 to 0.012 additional latent cancer fatalities among the workers directly involved in the operations. Onsite workers who are not involved with the actual processing of the residues are designated as noninvolved workers. The impacts to these workers would be much smaller than the impacts to the involved workers. During the post-processing storage period, inspections of the storage facility would expose the involved worker population to very small incremental additions.

- **Hazardous Chemical Impacts**—No hazardous chemicals are expected to be released from the proposed processing of plutonium residues at Los Alamos National Laboratory under the various processing options evaluated in this EIS because no hazardous chemicals are reported to be used in these operations.

4.23.3.2.2 Accidents

The range of radiological impacts to the public and the noninvolved onsite workers due to accidents during the implementation of the various processing options for plutonium residues at Los Alamos National Laboratory is presented in **Table 4–81**. The length of time necessary to process all the residues will depend on which options DOE decides to implement.

Table 4–81 Range of Radiological Impacts[a] Due to Accidents at Los Alamos National Laboratory

Offsite Public Maximally Exposed Individual Risk	Offsite Public Population Risk	Noninvolved Onsite Worker Maximally Exposed Individual Risk
Probability of a Latent Cancer Fatality	Number of Latent Cancer Fatalities	Probability of a Latent Cancer Fatality
0 to 0.000023	0 to 0.030	0 to 0.00039

[a] The impacts are given as risks, which are additive, rather than consequences, which are not additive for accidents.

The public maximally exposed individual at the Los Alamos National Laboratory would be a hypothetical individual who lives downwind at the site boundary. The public population is defined as the residential population within a radius of 80 km (50 mi). A noninvolved onsite worker is defined as an individual worker

who is located 100 m (328 ft) or more downwind from the release point when an accidental release of radioactive material occurs.

The estimated risk of a latent cancer fatality for the maximally exposed individual could range from 0 to 0.000023. This individual's chance of incurring a latent cancer fatality due to an accident during process operations would be increased by less than one in ten thousand. The estimated risk of latent cancer fatalities for the general population could be in the range of 0 to 0.030. The noninvolved onsite worker risk is in the range of 0 to 0.00039. This noninvolved onsite worker's chance of incurring a latent cancer fatality due to an accident during process operations would be increased by less than one in one thousand.

4.24 Range of Intersite Transportation Impacts

As discussed in Chapter 2, DOE has identified a variety of options under Alternative 3, Process with Plutonium Separation, that would require transporting plutonium residues or scrub alloy from Rocky Flats to either the Savannah River Site or Los Alamos National Laboratory. Considering all the options, the number of truck shipments from Rocky Flats to the Savannah River Site could range from zero to 208. Similarly, the number of truck shipments from Rocky Flats to Los Alamos National Laboratory could range from zero to 62. The detailed analysis of the intersite transportation impacts are presented in Appendix E, Sections E.5 and E.6.

The range of radiological impacts due to incident-free transportation is presented in **Table 4–82**. These results are all based on the conservative assumption that the dose rate is 10 mrem per hour at 2 m (6.6 ft) from the side of the truck. See Section 4.2.2.1 for additional information on the conservative nature of the transportation analyses. For every impact, the low end of the range is always zero because options involve no transportation. The high end of each range is always very low, which indicates that DOE would expect no latent cancer fatalities from any combination of transportation options.

Table 4–82 Range of Radiological Impacts Due to Incident-Free Transportation

	Public Maximally Exposed Individual		*Public Population*	
Destination	*Dose (mrem)*	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*
Savannah River Site	0 to 11	0 to 5.5×10^{-6}	0 to 21	0 to 0.011
Los Alamos National Laboratory	0 to 11	0 to 5.5×10^{-6}	0 to 1.7	0 to 0.00085
	Maximally Exposed Individual Transport Worker		*Transport Worker Population*	
Destination	*Dose (mrem per year)*	*Probability of a Latent Cancer Fatality per year*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*
Savannah River Site	0 to 100	0 to 0.000040	0 to 32	0 to 0.013
Los Alamos National Laboratory	0 to 100	0 to 0.000040	0 to 2.6	0 to 0.0010

The only chemical impact would be latent cancer fatalities due to vehicle exhaust. The vehicle exhaust gases from the maximum number of truck shipments (round-trip) to the Savannah River Site and Los Alamos National Laboratory could cause 0.0027 and 0.00028 latent cancer fatalities, respectively.

The potential impacts due to transportation accidents are presented in **Table 4–83**. For every impact, the low end of the range is always zero because some options involve no transportation. The table shows that the risk of prompt death due to the trauma of a traffic accident is much greater than the risk due to radiological exposure following an accident. The highest risk is 0.021, which means that there would be about a 2-percent chance of one traffic fatality if DOE decides to make all 208 possible truck shipments to the Savannah River Site.

Table 4–83 Range of Risks Due to Transportation Accidents

Destination	Public Population Radiological Risk	Public and Worker Trauma Risk
	Number of Latent Cancer Fatalities	Probability of One Traffic Fatality
Savannah River Site	0 to 8.4×10^{-6}	0 to 0.021
Los Alamos National Laboratory	0 to 3.7×10^{-7}	0 to 0.00046

4.25 Key Cumulative Impacts at the Potential Processing Sites and During Intersite Transportation for Rocky Flats Plutonium Residues and Scrub Alloy

All of the potential processing sites for the Rocky Flats plutonium residues and scrub alloy have facilities unrelated to the management of these materials. These other facilities may continue to operate throughout the same period during which the residues and scrub alloy are processed (approximately 5 to 10 years). Impacts from operation of the plutonium residue and scrub alloy processing facilities would be cumulative with the impacts of existing and planned facilities or actions such as environmental restoration and waste management activities which are unrelated to processing and management of the residues and scrub alloy.

This section presents the cumulative impacts at each of the three sites that may process residues and scrub alloy. It also presents the cumulative impacts of transporting these materials for potential processing at the Savannah River Site and at Los Alamos National Laboratory. To obtain the cumulative site impacts, the range of impacts from processing the residues and scrub alloy at each site are added to the impacts from existing and planned actions unrelated to residue or scrub alloy processing. The impacts from existing and planned actions are taken from the information presented in the Waste Management Programmatic Environmental Impact Statement (DOE 1997d). Cumulative impacts from transportation are derived from information given in Section 4.24 and Appendix E.

In compliance with the Clean Air Act (42 U.S.C. 7401), EPA has promulgated National Ambient Air Quality Standards for six criteria air pollutants (40 CFR Part 50): carbon monoxide (CO), sulfur dioxide (SO_2), particles with an aerodynamic diameter less than or equal to a nominal 10 micrometers (PM_{10}), ozone (O_3), nitrogen dioxide (NO_2), and lead (Pb). These pollutants are regulated both in terms of annual production in tons per year and in terms of ambient concentrations emanating from point and mobile sources. Unlike the other five criteria air pollutants, ozone is not a direct emission but is formed in the atmosphere through a complex reaction of ozone precursor pollutants, sunlight, and temperature. Ozone precursor pollutants include nitrogen oxides (NO_X) and nonmethane hydrocarbons, which include the class of compounds known as volatile organic compounds.

Criteria air pollutants can be emitted from equipment used to modify facilities, vehicles from workers traveling to and from the site, from operation and maintenance of processing facilities, and from Safe Secure Trailers used to transport plutonium residues and scrub alloy from Rocky Flats to the Savannah River Site and Los Alamos National Laboratory. In this EIS, DOE considers that the implementation of mitigation measures would effectively prevent emissions of criteria air pollutants during facility modifications. Although new equipment may be added to existing facilities, no new facilities would be constructed for any of the options. DOE has also considered that no increase in criteria air pollutants emitted by vehicles driven by workers traveling to and from each site because the number of workers at each site would not change dramatically due to the implementation of any processes described in the EIS (see Section 4.18).

4.25.1 Cumulative Impacts at the Rocky Flats Environmental Technology Site

Aside from the continuation of existing operation and waste management activities at Rocky Flats, reasonably foreseeable future actions at Rocky Flats include the transfer of certain Nuclear Weapons Complex nonnuclear

functions from Rocky Flats to other sites (DOE 1993a) and environmental restoration activities. **Tables 4–84** and **4–85** identify the ranges of cumulative impacts resulting from the management of the plutonium residues and scrub alloy addressed in this EIS, other future actions, and current activities. Future and ongoing cleanup actions include remediation of contaminated groundwater, solidification and disposition of solar pond sludge, and decontamination and decommissioning of facilities.

Table 4–84 Rocky Flats Cumulative Radiological Impacts

Impact Category	Notes	Impacts of Existing Operations	Plutonium Residue and Scrub Alloy Impacts			Impacts of Other Reasonably Foreseeable Future Actions[a]	Cumulative Impacts[b]		
			Min.	Max.	Preferred[c]		Min.[d]	Max.[e]	Preferred
Waste Generation									
Stabilized Residues (drums)		0	0	15,100	900	0	0	15,100	900
Transuranic Waste (cubic meters)	1	11,200	400	8,100	2,400	(f)	11,600	19,300	13,600
Low-Level Waste (cubic meters)	2	137,000	900	11,900	2,400	(f)	138,000	149,000	139,400
Low-Level Mixed Waste (cubic meters)	3	401,000	0	0	0	(f)	401,000	401,000	401,000
Offsite Population									
Collective dose, 10 years (person-rem)	4	1.6	0.0054	0.025	0.0085	(f)	1.6	1.6	1.6
Number of latent cancer fatalities from collective dose	5	0.00080	2.7×10^{-6}	0.000012	4.2×10^{-6}	(f)	0.00080	0.00081	0.00080
Offsite Maximally Exposed Individual									
Annual dose, atmospheric releases (mrem)	6	0.00047	0.00014	0.0011	0.00027	(f)	0.00061	0.0016	0.00074
Probability of a latent cancer fatality	7	2.3×10^{-10}	7.0×10^{-11}	5.5×10^{-10}	1.4×10^{-10}	(f)	3.0×10^{-10}	7.8×10^{-10}	3.7×10^{-10}
Worker Population									
Collective dose, 10 years (person-rem)	8	2,650	477	2,060	765	(f)	3,130	4,710	3,420
Number of latent cancer fatalities from collective dose	9	1.1	0.19	0.82	0.31	(f)	1.3	1.9	1.4

[a] Other reasonably foreseeable future actions include the transfer of nonnuclear functions from Rocky Flats to other sites (DOE 1993a).
[b] Impacts of existing operations, combined impacts from processing Rocky Flats plutonium residues and scrub alloy, and impacts of other reasonably foreseeable future actions. Existing operations include those associated with the preferred alternative for combined waste management as given in Table 11.15-2 of the Waste Management Programmatic Environmental Impact Statement (DOE 1997d).
[c] Highest possible (most conservative) values are presented because preferred processing options for filter and sludge residues have not yet been selected.
[d] Cumulative impacts, including minimum combined impacts from processing Rocky Flats plutonium residues and scrub alloy.
[e] Cumulative impacts, including maximum combined impacts from processing Rocky Flats plutonium residues and scrub alloy.
[f] The impacts due to other reasonably foreseeable future actions is included in the column of impacts due to existing operations.

Notes:
(1) Data for existing operations from Table 1.6-2 and Section 11.15.2 of DOE 1997d.
(2) Data for existing operations from Table 1.6-2 and Section 11.15.2 of DOE 1997d.
(3) Data for existing operations from Table 1.6-2 and Section 11.15.2 of DOE 1997d.
(4) Assumes all facilities operate concurrently for the same 10-year period.
(5) Assumes 0.0005 latent cancer fatalities per person-rem.
(6) Based on (DOE 1994d) for existing operations, which contains releases for the year 1992. Cumulative impacts conservatively assume all facilities operate simultaneously and that the total radiological doses to the maximally exposed individual from processing residues and scrub alloy are received in 1 year.
(7) Assumes 5×10^{-7} latent cancer fatalities per mrem.
(8) Assumes that all facilities operate concurrently for the same 10-year period. The dose is based on (1) the 1996 dose to workers of 263 person-rem (DOE 1997a), and (2) the 10-year dose of 24 person-rem associated with waste management activities (DOE 1997d).
(9) Assumes 0.0004 latent cancer fatalities per person-rem.

Table 4–85 Cumulative Hazardous Chemical Impacts at Rocky Flats

Impact Category	Impacts of Existing Operations	Plutonium Residue and Scrub Alloy Impacts			Impacts of Other Reasonably Foreseeable Future Actions	Cumulative Impacts		
		Min.	Max.	Preferred		Min.	Max.	Preferred
Offsite Population Number of cancer incidences from chemical exposure	< 1	0	< 1[a]	< 1[a]	©	< 1	< 1	< 1
Offsite Maximally Exposed Individual Probability of cancer incidence from chemical exposure	2×10^{-6}	0	3×10^{-10}	2×10^{-10}	©	2×10^{-6}	2×10^{-6}	2×10^{-6}
Hazard Index	0.0012[b]	0	0.006	0	©	0.0012	0.0072	0.0012
Worker Population Number of cancer incidences from chemical exposure	< 1	0	< 1[a]	< 1[a]	©	< 1	< 1	< 1
Worker Maximally Exposed Individual Probability of cancer incidence from chemical exposure	9×10^{-7}	0	1.4×10^{-8}	1.1×10^{-8}	©	9×10^{-7}	9.1×10^{-7}	9.1×10^{-7}
Hazard Index	0.013[b]	0	0.2	0	©	0.013	0.21	0.013

[a] The sum of potential excess cancers from all proposed actions at the site is far less than one.
[b] From DOE 1996a.
[c] The impacts due to other reasonably foreseeable future actions are included in the column of impacts due to existing operations.

- **Products and Wastes**—As shown in Table 4–84, existing operations at Rocky Flats will manage approximately 11,200 m^3 (395,500 ft^3) of transuranic waste. The minimum and maximum amounts of transuranic waste to be generated from managing plutonium residues and scrub alloy are given in Table 4–71 in terms of numbers of drums. To compare the two, the numbers of drums from Table 4–71 were converted to cubic meters (4.8 drums per cubic meter), and then listed in Table 4–84. The maximum estimated volume of transuranic waste from plutonium residues and scrub alloy is 8,100 m^3 (286,000 ft^3), which would represent a major increase over the 11,200 m^3 (395,500 ft^3) from existing operations.

  As shown in Table 4–84, existing operations at Rocky flats will manage approximately 137,000 m^3 (4,840,000 ft^3) of low-level waste. The minimum and maximum amounts of low-level waste to be generated from managing plutonium residues and scrub alloy are given in Table 4–71 in terms of numbers of drums. These values were converted to cubic meters and then listed in Table 4–84. The maximum estimated volume from plutonium residues and scrub alloy is 11,900 m^3 (420,000 ft^3), which would represent an increase of less than 10 percent of the 137,000 m^3 (4,840,000 ft^3) from existing operations.

  Table 4–84 also shows that the largest volume of waste at Rocky Flats is low-level mixed waste. DOE has estimated that existing operations will generate more than 400,000 m^3 (14,000,000 ft^3) of low-level mixed waste, while the processing of plutonium residues and scrub alloy is not expected to generate any low-level mixed waste.

- **Radiological Impacts**—As identified in Table 4–84, the radioactive releases that would result from processing the Rocky Flats plutonium residues and scrub alloy would not noticeably increase the radiation dose or the associated number of latent cancer fatalities in the offsite population. In addition, the radiation

dose to the maximally exposed offsite individual would remain well below the DOE regulatory limit of 10 mrem per year from atmospheric releases (DOE Order 5400.5). The radiation dose to the involved worker population could increase by as much as 78 percent of the dose from existing operations over the 10-year processing periods. However, doses to individual involved workers will be kept below the regulatory limit of 5,000 mrem per year (10 CFR Part 835). Furthermore, as low as reasonably achievable principles will be exercised to maintain individual worker doses below the DOE Administrative Control Level of 2,000 mrem per year (DOE 1994a). Each DOE site also maintains its own Administrative Control Level, but for the sake of consistency, DOE used the 2,000 mrem per year level throughout this EIS. Transportation workers (e.g., drivers) will be held to an annual limit of 100 mrem per year because they are not certified radiation workers. All worker doses are routinely monitored, and if any individual worker's dose approaches the annual limit, he or she would be rotated into another job.

- **Hazardous Chemical Impacts**—As shown in Table 4–85, the existing baseline concentration of carbon tetrachloride at Rocky Flats results in higher maximally exposed individual cancer risks for the offsite public and onsite workers than the carbon tetrachloride potentially released from residue processing. The cumulative maximally exposed individual cancer risks would hardly be affected by the implementation of any set of processing options in this EIS. Population cancer incidences are estimated to be less than one. The maximum values of the ranges of cumulative impacts for noncancer health effects are the same as those estimated for the processing of plutonium residues and scrub alloy.

- **Air Quality Impacts**—Rocky Flats is in a nonattainment area where State standards for concentrations of criteria air pollutants are exceeded for particulates, carbon monoxide, and ozone. Section 176© of the 1990 Clean Air Act amendments requires that all Federal actions conform with the applicable State Implementation Plan. EPA has implemented rules that establish the criteria and procedures governing the determination of conformity for all Federal actions in nonattainment and maintenance areas. Since the area in which Rocky Flats is located is considered a nonattainment area, proposed actions at this site need to be evaluated for applicability of the conformity regulations.

  The processing of plutonium residues and scrub alloy at Rocky Flats could involve releases of nitrogen oxide. As presented in Section 4.12, the modeled onsite annual concentration of nitrogen dioxide at the site is 0.008 $\mu g/m^3$. The baseline concentration is 4.14 $\mu g/m^3$ (see Table 3.1–4). Adding the baseline concentration to the modeled processing release produces a total concentration of 4.15 $\mu g/m^3$. This concentration is much lower than the annual standard of 100 $\mu g/m^3$, which indicates that the cumulative impacts of potential onsite releases from processing and the existing baseline should not be of concern with respect to air quality at Rocky Flats.

  Airborne emissions associated with the transportation of residues and scrub alloy to the Savannah River Site and Los Alamos National Laboratory dominate those associated with processing activities at Rocky Flats. Transportation emissions have been estimated based on Safe Secure Trailer shipments of material from Rocky Flats. These emissions are approximately 800 kg/year (1,760 lb/yr) for nitrogen dioxide, 97 kg/year (213 lb/year) for hydrocarbons (assumed to be volatile organic chemicals), and 390 kg/year (860 lb/year) for carbon monoxide. These emissions are a small fraction of the total emissions from transportation emissions in the Denver area and are less than the applicability levels of 90,700 kg/year (200,000 lb/year) for volatile organic chemicals, nitrogen dioxide, and carbon monoxide for the Denver area (40 CFR Part 51; 40 CFR Part 93). Emissions of PM_{10} consist primarily of re-entrainment of road dust and emissions from diesel-powered Safe Secure Trailers and are expected to be a small fraction of total emissions from vehicles in the Denver area. Therefore, no further analysis of conformity at Rocky Flats is required.

4.25.2 Cumulative Impacts at the Savannah River Site

Aside from the continuation of existing operations and the activities addressed in this EIS, reasonably foreseeable future actions at the Savannah River Site include continued management of spent nuclear fuels (DOE 1995f), tritium supply and recycling (DOE 1995a), transfer of Nuclear Weapons Complex nonnuclear functions to the Savannah River Site (DOE 1993a), processing of F-Canyon plutonium solutions to plutonium metal (DOE 1994a), interim management of nuclear materials (DOE 1995b), operation of the Defense Waste Processing Facility (DOE 1994c), other site projects for the management of waste (including environmental restoration activities) (DOE 1995e), storage and disposition of weapons-usable fissile materials (DOE 1996a), stockpile stewardship and management (DOE 1996f), and disposition of surplus highly enriched uranium (DOE 1995c).

Tables 4–86 and **4–87** identify the ranges of cumulative impacts resulting from these other actions, the processing of Rocky Flats plutonium residues and scrub alloy, and current activities that include atmospheric radiological releases from the Vogtle Nuclear Power Plant, located near the Savannah River Site. Table 4–86 includes the impacts of the Savannah River Site managing aluminum-clad spent nuclear fuel, as recently analyzed and decided by DOE (DOE 1995e).

Table 4–86 Savannah River Site Cumulative Radiological Impacts

Impact Category	Notes	Impacts of Existing Operations	Plutonium Residue and Scrub Alloy Impacts			Impacts of Other Reasonably Foreseeable Future Actions[a]	Cumulative Impacts[b]		
			Min.	Max.	Preferred		Min.[c]	Max.[d]	Preferred
Waste Generation									
High-Level Waste (canisters)	1	4,600	0	44	4–6	(e)	4,600	4,644	4,605
Transuranic Waste (cubic meters)	2	82,100	0	300	9.8	(e)	82,100	82,400	82,110
Low-Level Waste (cubic meters)	3	3,000,000	0	200	42	(e)	3,000,000	3,000,000	3,000,000
Low-Level Mixed Waste (cubic meters)	4	11,000,000	0	0	0	(e)	11,000,000	11,000,000	11,000,000
Saltstone (cubic yards)	5	820,000	0	3,300	600	(e)	820,000	823,300	820,600
Offsite Population									
Collective dose, 10 years (person-rem)	6	68	0	0.38	0.062	2,900	3,000	3,000	3,000
Number of latent cancer fatalities from collective dose	7	0.034	0	0.00019	0.000031	1.5	1.5	1.5	1.5
Offsite Maximally Exposed Individual									
Annual dose, atmospheric releases (mrem)	8	0.14	0	0.003	0.001	3.8	3.9	3.9	3.9
Probability of a latent cancer fatality	9	7.0×10^{-8}	0	1.7×10^{-9}	2.8×10^{-10}	1.9×10^{-6}	2.0×10^{-6}	2.0×10^{-6}	2.0×10^{-6}

Impact Category	Notes	Impacts of Existing Operations	Plutonium Residue and Scrub Alloy Impacts			Impacts of Other Reasonably Foreseeable Future Actions[a]	Cumulative Impacts[b]		
			Min.	Max.	Preferred		Min.[c]	Max.[d]	Preferred
Worker Population									
Collective dose, 10 years (person-rem)	6	8,400	0	469	76	11,600	20,000	20,500	20,100
Number of latent cancer fatalities from collective dose	10	3.4	0	0.19	0.03	4.6	8	8.2	8

[a] Other reasonably foreseeable future actions include actions evaluated in EISs related to defense waste processing (DOE 1994b); tritium supply and recycle (DOE 1995a); spent nuclear fuel management, including spent nuclear fuel from foreign research reactors (DOE 1995f); other site-specific waste management actions, including environmental restoration activities (DOE 1995c); F-Canyon (DOE 1994b); interim management of nuclear materials (DOE 1995b); storage and disposition of weapons-usable fissile materials (DOE 1996a); stockpile stewardship and management (DOE 1996f); transfer of nonnuclear functions (DOE 1993a); and disposition of highly enriched uranium (DOE 1995c).

[b] Impacts of existing operations, combined impacts from processing Rocky Flats plutonium residues and scrub alloy, and impacts of other reasonably foreseeable future actions. Existing operations include those associated with the preferred alternative for combined waste management as given in Table 11.17-2 of the Waste Management Programmatic EIS (DOE 1997d).

[c] Cumulative impacts, including minimum combined impacts from processing Rocky Flats plutonium residues and scrub alloy.

[d] Cumulative impacts, including maximum combined impacts from processing Rocky Flats plutonium residues and scrub alloy.

[e] The waste generation due to other reasonably foreseeable future actions is included in the column of waste generation due to existing operations.

Notes:

(1) Data for existing operations from Table 1.6-2 of DOE 1997d.
(2) Data for existing operations from Tables 1.6-2 and B.5-3 of DOE 1997d.
(3) Data for existing operations from Tables 1.6-2 and B.5-1 of DOE 1997d.
(4) Data for existing operations from Tables 1.6-2 and B.5-2 of DOE 1997d.
(5) Data for existing operations from Table 5-5 of DOE 1994b.
(6) Assumes all facilities operate concurrently for the same 10-year period.
(7) Assumes 0.0005 latent cancer fatalities per person-rem.
(8) Based on (DOE 1994d) for existing operations, which contains releases for the year 1992. Cumulative impacts conservatively assume all facilities operate simultaneously and that the total radiological doses to the maximally exposed individual from processing residues and scrub alloy are received in 1 year.
(9) Assumes 5×10^{-7} latent cancer fatalities per mrem.
(10) Assumes 0.0004 latent cancer fatalities per person-rem.

Table 4–87 Cumulative Air Quality Impacts at the Savannah River Site

Pollutant	Modeled Onsite Concentration ($\mu g/m^3$)	Baseline Concentration ($\mu g/m^3$)	Total Concentration ($\mu g/m^3$)	Averaging Time	Most Stringent Regulations or Guidelines ($\mu g/m^3$)[a]
Nitrogen dioxide	0.3	5.7	6	Annual	100
Nitric acid	7	51	58	24-hour	125
Gaseous fluoride	0.04	1.04	1.08	24-hour	2.9
Phosphoric acid	0.02	0.462	0.482	24-hour	25

[a] Federal and State standards.

❒ **Products and Wastes**—As shown in Table 4–86, existing operations at the Savannah River Site will generate large volumes of high-level waste, transuranic waste, low-level waste, low-level mixed waste, and saltstone. Table 4–86 also lists the volumes of these wastes that could be generated from the processing of plutonium residues and scrub alloy. These values are from Table 4–75 and are converted from number of drums to cubic meters when necessary. The limited processing of plutonium residues and scrub alloy at the Savannah River Site would cause very small increases in the wastes to be managed at this site.

- **Radiological Impacts**—As identified in Table 4–86, the radioactive releases that would result from processing the Rocky Flats plutonium residues and scrub alloy at the Savannah River Site would not noticeably increase the radiation dose or the associated number of latent fatal cancers in the offsite population. In addition, the radiation dose to the maximally exposed offsite individual would remain well below the DOE regulatory limit of 10 mrem per year discussed in Section 4.25.1. The radiation dose to the involved worker population could increase by about 2 percent of the dose from existing operations and other reasonably foreseeable future actions over the 10-year processing periods. Doses to individual involved workers would be maintained below the limits discussed in Section 4.25.1.

- **Hazardous Chemical Impacts**—The cumulative releases of hazardous chemicals at the Savannah River Site are presented in the next subsection, under Air Quality Impacts. The modeled onsite concentration of each pollutant is the maximum that could result from processing plutonium residues and scrub alloy and the baseline concentration of each pollutant is due to existing operations. In each case the modeled onsite concentration is much smaller than the baseline concentration.

- **Air Quality Impacts**—The processing of plutonium residues and scrub alloy at the Savannah River Site would involve potential releases of nitrogen oxide, nitric acid, hydrogen fluoride, calcium fluoride, and phosphoric acid. The modeled onsite concentrations of these pollutants from Section 4.12 are presented in Table 4–87, along with baseline concentrations (from Table 3–12).

  Because the total concentrations are much lower than the applicable standards, the cumulative impacts of the Proposed Action and the existing baseline should not be of concern with respect to air quality at the Savannah River Site.

4.25.3 Cumulative Impacts at Los Alamos National Laboratory

Aside from the continuation of existing operations and from the activities addressed in this EIS (limited to the processing of pyrochemical salt residues), reasonably foreseeable future actions at Los Alamos National Laboratory include construction and operation of the dual-axis hydrodynamic test facility (DOE 1995d), medical isotope production project (DOE 1996d), stockpile stewardship and management (DOE 1996f), the transfer of nonnuclear functions (DOE 1993a), and environmental restoration activities. These actions were included as reasonably foreseeable actions for Los Alamos National Laboratory in the Waste Management Programmatic EIS (DOE 1997a).

- **Products and Wastes**—As shown in **Table 4–88**, existing operations at Los Alamos National Laboratory will generate large volumes of transuranic waste, low-level waste, and low-level mixed waste. Table 4–88 also lists the volumes of these waste that could be generated from the processing of pyrochemical salts. These values are from Table 4–79 and are converted from number of drums to cubic meters when necessary. The limited processing of plutonium residues at Los Alamos National Laboratory would cause very small increases in the wastes to be managed at this site.

Table 4–88 Los Alamos National Laboratory Cumulative Impacts

Impact Category	*Notes*	*Impacts of Existing Operations*	*Plutonium Residue and Scrub Alloy Impacts*			*Impacts of Other Reasonably Foreseeable Future Actions*[a]	*Cumulative Impacts*[b]		
			Min.	*Max.*	*Preferred*		*Min.*[c]	*Max.*[d]	*Preferred*
Waste Generation									
Transuranic Waste (cubic meters)	1	15,200	0	570	458	(e)	15,200	15,800	15,700
Low-Level Waste(cubic meters)	2	9,450,000	0	1,300	1,060	(e)	9,450,000	9,450,000	9,450,000
Low-Level Mixed Waste (cubic meters)	3	500,000	0	0	0	(e)	500,000	500,000	500,000

Impact Category	Notes	Impacts of Existing Operations	Plutonium Residue and Scrub Alloy Impacts			Impacts of Other Reasonably Foreseeable Future Actions[a]	Cumulative Impacts[b]		
			Min.	Max.	Preferred		Min.[c]	Max.[d]	Preferred
Offsite Population									
Collective dose, 10 years (person-rem)	4	16	0	0.00095	0.00024	5.7	22	22	22
Number of latent cancer fatalities from collective dose	5	0.0079	0	4.8×10^{-7}	1.2×10^{-7}	0.0029	0.011	0.011	0.011
Offsite Maximally Exposed Individual									
Annual dose, atmospheric releases (mrem)	6	7.9	0	0.00032	0.000083	0.020	7.9	7.9	7.9
Probability of a latent cancer fatality	7	4.0×10^{-6}	0	1.6×10^{-10}	4.2×10^{-11}	1.0×10^{-8}	4.0×10^{-6}	4.0×10^{-6}	4.0×10^{-6}
Worker Population									
Collective dose, 10 years (person-rem)	4	4,580	0	29	14	720	5,300	5,300	5,300
Number of latent cancer fatalities from collective dose	8	1.8	0	0.012	0.0056	0.29	2.1	2.1	2.1

[a] Other reasonably foreseeable future actions include actions evaluated in EISs related to dual-axis radiographic hydrodynamic test facility (DOE 1995d), medical isotope production (DOE 1996d), transfer of nonnuclear functions (DOE 1993a), and stockpile stewardship and management (DOE 1996f).

[b] Impacts of existing operations, combined impacts from processing Rocky Flats pyrochemical salts, and impacts of other reasonably foreseeable future actions. Existing operations include those associated with the preferred alternative for combined waste management as given in Table 11.9-2 of the Waste Management Programmatic Environmental Impact Statement (DOE 1997d).

[c] Cumulative impacts, including minimum combined impacts from processing Rocky Flats pyrochemical salts.

[d] Cumulative impacts, including maximum combined impacts from processing Rocky Flats pyrochemical salts.

[e] The waste generation due to other reasonably foreseeable future actions is included in the column of waste generation due to existing operations.

Notes:

(1) Data for existing operations from Tables 1.6-2 and B.5-3 of DOE 1997d.
(2) Data for existing operations from Tables 1.6-2 and B.5-1 of DOE 1997d.
(3) Data for existing operations from Tables 1.6-2 and B.5-2 of DOE 1997d.
(4) Assumes all facilities operate concurrently for the same 10-year period.
(5) Assumes 0.0005 latent cancer fatalities per person-rem.
(6) Based on (DOE 1994d) for existing operations, which contains releases for the year 1992. Cumulative impacts conservatively assume all facilities operate simultaneously and that the total radiological doses to the maximally exposed individual from processing Rocky Flats pyrochemical salts are received in 1 year.
(7) Assumes 5×10^{-7} latent cancer fatalities per mrem.
(8) Assumes 0.0004 latent cancer fatalities per person-rem.

- **Radiological Impacts**—As identified in Table 4–88, the radioactive releases that would result from processing the Rocky Flats pyrochemical salts at Los Alamos National Laboratory would cause very small increases in the radiation dose or the associated number of latent fatal cancers in the offsite population. In addition, the radiation dose to the maximally exposed offsite individual would remain below the DOE regulatory limit of 10 mrem per year discussed in Section 4.25.1. The radiation dose to the involved worker population could increase by less than 1 percent of the dose from existing operations and other reasonably foreseeable future actions over the 10-year processing periods. Doses to individual involved workers would be maintained below the limits discussed in Section 4.25.1.

- **Hazardous Chemical Impacts**—No hazardous chemicals would be released as the result of processing pyrochemical salts at the Los Alamos National Laboratory.

- **Air Quality Impacts**—For the Los Alamos National Laboratory, the emissions of air pollutants from the processing of pyrochemical salts would be very small because only limited processing would take place at this site. In addition, the baseline concentrations of criteria air pollutants and hazardous air pollutants are much smaller than the applicable standards (see Table 3.3–4).

4.25.4 Cumulative Impacts of Intersite Transportation

The cumulative impacts from transportation of plutonium residues and scrub alloy from Rocky Flats to the Savannah River Site and Los Alamos National Laboratory are identified in Appendix E. Since likely transportation routes cross about nine States, cumulative impacts are computed on a national basis. Occupational radiation exposure to transportation workers and exposure to the public (from Section 4.24) would each increase by about 0.01 percent from the estimated cumulative exposure between 1943 and 2035 and would represent an estimated 0.1 percent of the cumulative exposure over the 10-year processing period. An additional traffic fatality is not expected (Section 4.16), and the incremental increase in traffic fatalities would be less than 0.0001 percent per year.

4.26 Relationship Between Short-Term Uses of the Environment and Long-Term Productivity

Implementation of any of the options for management of plutonium residues and scrub alloy currently stored at Rocky Flats would result in the short-term use of existing facilities and environmental resources. Facility modifications would be required for implementation of some of the offsite processing options such as mediated electrochemical oxidation at the Savannah River Site. However, none of the options would require the construction of new facilities. If offsite processing were selected for implementation, transportation of materials from Rocky Flats to any of the other candidate sites would occur on existing roadways. Estimates of the duration for the various alternatives range from less than 5 years to more than 20 years. Activities during that time would result in emissions to the atmosphere that would not measurably affect regional or global air quality. Although implementation of some of the processing options could impact the scheduled shut-down of Rocky Flats, short-term uses of the environment would have no appreciable beneficial or adverse effects on long-term productivity of the environment on, or in the vicinity of, any of the sites assessed in this EIS.

4.27 Irreversible and Irretrievable Commitment of Resources

All processing activities in this EIS would be conducted at existing facilities. Modifications to existing facilities would consist of improvements required to meet current environmental standards or the installation of new processing equipment. Materials required for the processing options, utilities, and fuel required for transportation options comprise the irretrievable resources required to implement the various options. Section 4.19 discusses these resources in detail. None of the alternatives require resources that would noticeably affect local or national supplies or that would noticeably affect the quality of the local or global environment.

4.28 Industrial Safety

The plutonium residues and scrub alloy will be processed at Rocky Flats and additional processes may be performed at the Savannah River Site F-Canyon and F-B Line, the Savannah River Site H-Canyon and H-B Line, and the Los Alamos National Laboratory. Estimates of potential industry safety impacts to workers processing the residues and scrub alloy at these facilities were made using the average DOE occupational injury/illness and fatality rates shown in **Table 4-89** (DOE 1997h). The potential industry safety impacts to the workers are presented in **Table 4-90**.

Table 4–89 Average Occupational Injury/Illness and Fatality Rates (per worker-year)

Category	All Labor Categories (Process Operations)	
	Total Injury/Illness	Fatalities
DOE and Contractors	0.032	0.000032
Private Industry	0.084	0.000097

Table 4–90 Industrial Safety Impacts from Processing Plutonium Residues and Scrub Alloy

Process Location	Number of Injuries/Illnesses	Number of Fatalities
Rocky Flats	12.5 to 77.0	0.013 to 0.077
Savannah River Site F-Canyon/F-B Line	0 to 14.1	0 to 0.014
Savannah River Site H-Canyon/H-B Line	0 to 32.8	0 to 0.033
Los Alamos National Laboratory	0 to 6.2	0 to 0.0062

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Chapter 5

Applicable Laws, Regulations, and Other Requirements

5. APPLICABLE LAWS, REGULATIONS, AND OTHER REQUIREMENTS

Chapter 5 presents the laws, regulations, and other requirements that apply to the proposed action and alternatives. Federal, State, and departmental statutes, regulations, and orders are identified in Section 5.1. Regulations for hazardous and radioactive material packaging, transportation, and certification are discussed in Section 5.2. Emergency Management response laws and other requirements are addressed in Section 5.3.

5.1 LAWS AND OTHER REQUIREMENTS

This section describes laws, regulations, and Executive Orders that apply to the proposed action and alternatives. During the course of its activities, the Department of Energy (DOE) implements its responsibility for the protection of public health, safety, and the environment through compliance with laws, statutes, regulations, orders, and other requirements.

5.1.1 Federal Environmental Statutes and Regulations

Figure 5–1 illustrates the Federal regulations that are applicable. These statutes are summarized below.

- **National Environmental Policy Act (NEPA) of 1969 (42 U.S.C. 4321 et seq.)**—This Act establishes a national policy to protect and preserve the environment. It requires consideration of environmental impacts during the planning and decision-making stages of Federal projects. It also requires Federal agencies to prepare a detailed statement on the environmental effects of proposed Federal actions that may significantly affect the quality of the human environment.

  Applicable implementing regulations for the NEPA include the Council on Environmental Quality Implementing Regulations (40 CFR 1500 et seq.) and DOE Implementing Regulations (10 CFR 1021).

- **Atomic Energy Act of 1954 (42 U.S.C. 2011 et seq.)**—This Act provides the underlying legal authority (originally vested in the Atomic Energy Commission, and now transferred to DOE) for government ownership and operation of nuclear facilities. As part of that authority, it authorizes the DOE to establish standards to protect health or minimize dangers to life or property with respect to activities under its jurisdiction. Under this authority, DOE has established a comprehensive system of safety standards and requirements.

  In addition, the Act provides the underlying authority for Nuclear Regulatory Commission regulations, and (through Reorganization Plan Number 3 of 1970) for Environmental Protection Agency (EPA) regulations to protect the general environment.

- **Pollution Prevention Act of 1990 (42 U.S.C. 13101 et seq.)**—This Act establishes a national policy for waste management and pollution control. Source reduction is given first preference, followed by environmentally safe recycling, with disposal or releases to the environment as a last resort. In response to the policies established by this act, the DOE committed to participation in the Superfund Amendments and Reauthorization Act, Section 313, EPA 33/50 Pollution Prevention Program. The goal for facilities involved in compliance with Section 313 is to achieve a 33 percent reduction (from a 1993 baseline) in the release of 17 priority chemicals by 1997.

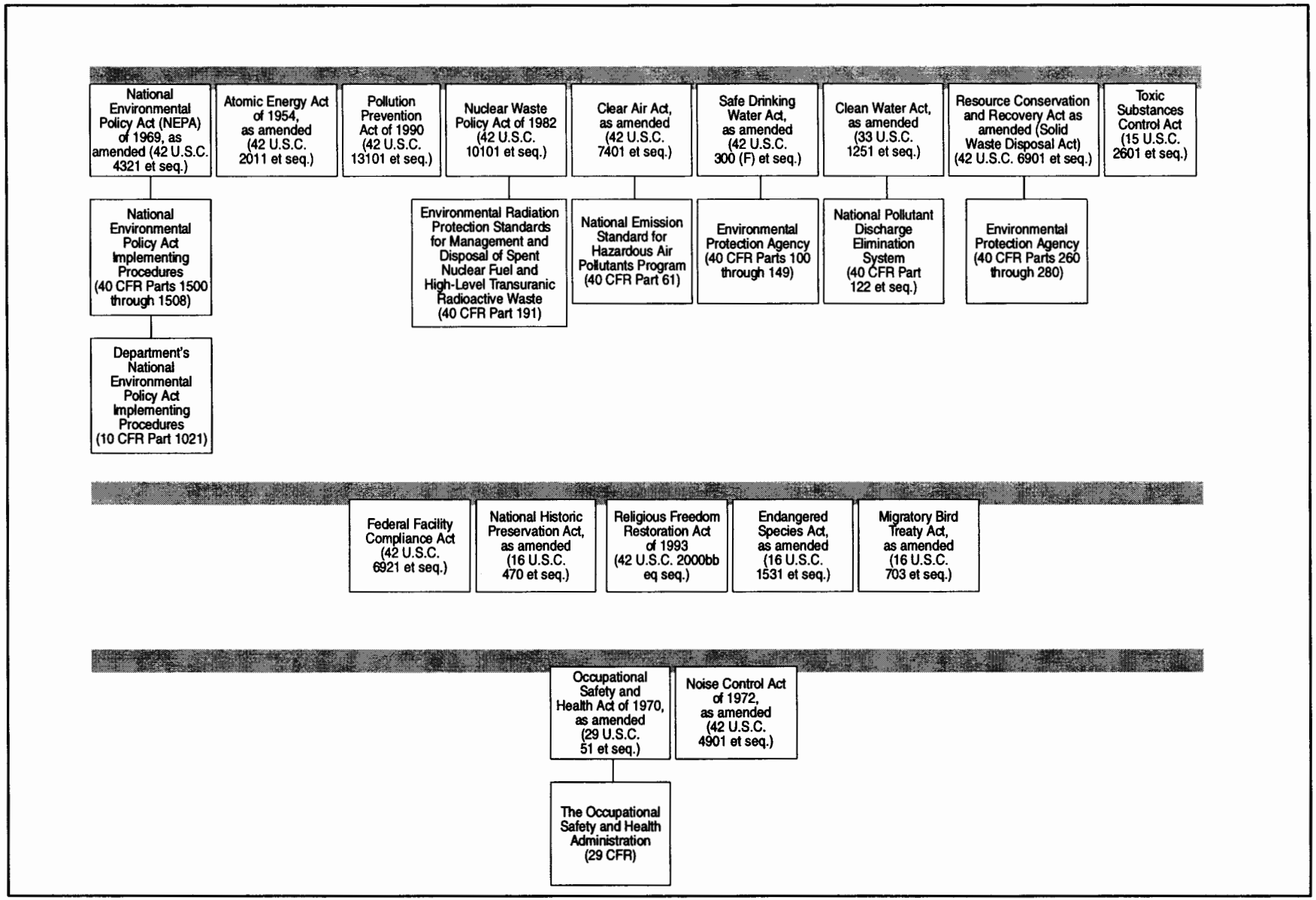


Figure 5–1 Federal Environmental Statutes and Regulations

On August 3, 1993, the President issued Executive Order 12856 requiring the DOE to achieve a 50 percent reduction in total releases of all toxic chemicals by December 31, 1999.

- **Nuclear Waste Policy Act of 1982 (42 U.S.C. 10101 et seq.)**—This Act provides for research, development, and demonstration activities regarding disposal of high-level radioactive waste and spent nuclear fuel not resulting from defense activities. As originally enacted it called for the Secretary of Energy to recommend candidate repository sites; but in 1987 it was amended to require DOE to proceed with characterization of the Yucca Mountain Site only (42 U.S.C. 10133, 10172). The Act also established the Office of Civilian Radioactive Waste Management (OCRWM, 42 U.S.C. 10224), the Office of Nuclear Waste Negotiator (42 U.S.C. 10242), and the Nuclear Waste Fund (42 U.S.C. 10222); and it provides (along with the Atomic Energy Act) authority for the EPA standards for protection of the general environment from the management and disposal of spent nuclear fuel, high-level, and transuranic radioactive wastes (40 CFR 191).

- **Low Level Radioactive Waste Policy Act (42 U.S.C. 2021 et seq.)**—This Act (originally enacted in 1980, and subsequently amended) amended the Atomic Energy Act to specify that the Federal Government is responsible for disposal of low-level waste generated by its activities, and the States are responsible for disposal of other low-level waste. It provides for and encourages interstate compacts to carry out the State responsibilities.

- **Hazardous Material Transportation Act of 1975 (49 U.S.C. 5105 et seq.)**—This Act requires the Department of Transportation to prescribe uniform national regulations for transportation of hazardous materials (including radioactive materials). Most State and local regulations regarding such transportation that are not substantively the same as the Department of Transportation regulations are preempted (i.e., rendered void) (49 U.S.C. 5125). This, in effect, allows State and local governments only to enforce the Federal regulations—not to change or enlarge on them.

  This program is administered by the Research and Special Programs Administration of the Department of Transportation, which coordinates its regulations with those of the Nuclear Regulatory Commission (under the Atomic Energy Act) and with EPA (under the Resource Conservation and Recovery Act), when covering the same activities.

- **Clean Air Act (42 U.S.C. 7401 et seq.)**—This Act is intended to "protect and enhance the quality of the Nation's air resources so as to promote the public health and welfare and the productive capacity of its population." Section 118 of the Clean Air Act (42 U.S.C. 7418) requires that each Federal agency with jurisdiction over any property or facility that might result in the discharge of air pollutants, comply with "all Federal, State, interstate, and local requirements" with regard to the control and abatement of air pollution.

  The Act requires the EPA to establish National Ambient Air Quality Standards as necessary to protect public health, with an adequate margin of safety, from any known or anticipated adverse effects of a regulated pollutant (42 U.S.C. 7409); requires establishment of national standards of performance for new or modified stationary sources of atmospheric pollutants (42 U.S.C. 7411); requires specific emission increases to be evaluated so as to prevent a significant deterioration in air quality (42 U.S.C. 7470); and requires specific standards for releases of hazardous air pollutants (including radionuclides) (42 U.S.C. 7412). These standards are implemented through State implementation plans developed by each State with EPA approval. On July 18, 1997, the EPA issued its final rules establishing new ambient air standards for ozone and particulate matter. The new standards are described in Chapter 3 of this Environmental Impact Statement (EIS). These new rules became effective on September 16, 1997.

Air emissions are regulated by the EPA in 40 CFR Parts 50 through 99. Radionuclide emissions are regulated under the National Emission Standards for Hazardous Air Pollutants Program (40 CFR Part 61).

- **Safe Drinking Water Act of 1974 (42 U.S.C. 300 (F) et seq.)**—The primary objective of this Act is to protect the quality of the public drinking water systems and sources of drinking water. Implementing regulations, administered by the EPA unless delegated to the States, establish standards applicable to public water systems. These regulations include maximum contaminant levels (including those for radioactivity) in public water systems, which are defined as water systems that have at least 15 service connections or regularly serve at least 25 residents. Safe Drinking Water Act requirements have been published by the EPA in 40 CFR Parts 141 through 149.

  For radioactive material, the regulations specify that the average annual concentration of manmade radionuclides in drinking water as delivered to the user by such a system shall not produce a dose equivalent to the total body or an internal organ greater than four mrem/yr beta activity (40 CFR 141.16 (a)). Other programs established by the Safe Drinking Water Act include the Sole Source Aquifer Program, the Wellhead Protection Program, and the Underground Injection Control Program.

- **Clean Water Act of 1972 (33 U.S.C. 1251 et seq.)**—This Act, which amended the Federal Water Pollution Control Act, was enacted to "restore and maintain the chemical, physical and biological integrity of the Nation's water." The Act prohibits the "discharge of toxic pollutants in toxic amounts" to navigable waters of the United States. Section 313 of the Clean Water Act requires all branches of the Federal Government engaged in any activity that might result in a discharge or runoff of pollutants to surface waters to comply with Federal, State, interstate, and local requirements.

  The Clean Water Act provides for water quality standards for the Nation's waterways, guidelines and limitations for effluent discharges from point-source discharges, and the National Pollutant Discharge Elimination System permit program. The National Pollutant Discharge Elimination System program is administered by the Water Management Division of the EPA pursuant to regulations in 40 CFR Part 122 et seq.

  Sections 401 through 405 of the Water Quality Act of 1987 added Section 402(p) to the Clean Water Act, requiring that the EPA establish regulations for permits for storm water discharges associated with industrial activity. Stormwater provisions of the National Pollutant Discharge Elimination System program are set forth at 40 CFR 122.26.

- **Solid Waste Disposal Act, as amended by the Resource Conservation and Recovery Act (42 U.S.C. 6901 et seq.)**—The transportation, treatment, storage, or disposal of hazardous and nonhazardous waste is regulated under the Solid Waste Disposal Act of 1965, as amended by the Resource Conservation and Recovery Act in 1976 and the Hazardous and Solid Waste Amendments of 1984. Under Resource Conservation and Recovery Act, EPA defines and identifies hazardous wastes, establishes standards for its transportation, treatment, storage, and disposal, and requires permits for persons engaged in hazardous waste activities. Section 3006 of the Act (42 U.S.C. 6926) allows States to establish and administer those permit programs with EPA approval. The EPA regulations implementing the Resource Conservation and Recovery Act are found in 40 CFR Parts 260 through 283.

  Regulations imposed on a generator or a treatment, storage, and/or disposal facility vary according to the type and quantity of material or waste generated, treated, stored, and/or disposed of. The method of treatment, storage, and/or disposal also impacts the extent and complexity of the requirements.

- **Federal Facility Compliance Act of 1992 (42 U.S.C. 6961 et seq.)**—This Act made all Resource Conservation and Recovery Act provisions, including fines and penalties for violations, applicable to

Federal facilities by waiving sovereign immunity for such violations. However, Section 102© of the Act delayed that waiver (and therefore the liability for Resource Conservation and Recovery Act penalties) for three years for storage of mixed waste at Federal facilities, and continued that delay indefinitely for mixed waste storage at DOE facilities so long as DOE submits a plan for that storage for State or EPA approval and complies with a Consent Order incorporating the approved plan.

- **National Historic Preservation Act of 1996, as amended (16 U.S.C. 470 et seq.)**—This Act provides that sites with significant national historic value be placed on the *National Register of Historic Places* maintained by the Secretary of the Interior. No permits or certifications are required under the Act. However, if a particular Federal activity may impact a historic property resource, consultation with the Advisory Council on Historic Preservation is required by 16 U.S.C. 470 f. Such consultation usually generates a Memorandum of Agreement, including stipulations that must be followed to minimize adverse impacts. Coordination with the State Historic Preservation Officer is also undertaken to ensure that potentially significant sites are properly identified and appropriate mitigative actions are implemented.

- **Endangered Species Act (16 U.S.C. 1531 et seq.)**—This Act, enacted in 1973, is intended to prevent the further decline of endangered and threatened species and to restore these species and their habitats. Section 7 of the Act requires Federal agencies having reason to believe that a prospective action may affect an endangered or threatened species or its habitat to consult with the Department of the Interior to ensure that the action does not jeopardize the species or destroy its habitat. If, despite reasonable and prudent measures to avoid or minimize such impacts, the species or its habitat would be jeopardized by the action, a review process is specified to determine whether the action may proceed.

- **Occupational Safety and Health Act of 1970 (29 U.S.C. 651 et seq.)**—This Act establishes standards for safe and healthful working conditions in places of employment throughout the United States. The Act is administered and enforced by the Occupational Safety and Health Administration, a U.S. Department of Labor agency. Although the Occupational Safety and Health Administration and the EPA both have a mandate to reduce exposures to toxic substances, the Occupational Safety and Health Administration's jurisdiction is limited to safety and health conditions that exist in the workplace environment.

  Under the Act, it is the duty of each employer to furnish employees a place of employment free of recognized hazards likely to cause death or serious physical harm. Employees have a duty to comply with the occupational safety and health standards and all rules, regulations, and orders issued under the Act. The Occupational Safety and Health Administration regulations (29 CFR) establish specific standards telling employers what must be done to achieve a safe and healthful working environment. Government agencies, including DOE, are not technically subject to the Occupational Safety and Health Administration regulations; but are required (by 29 U.S.C. 668) to establish their own occupational safety and health programs for their places of employment which are consistent with the Occupational Safety and Health Administration standards. DOE does so through DOE Orders, standards that contractors must meet as applicable to their work at Government-owned, contractor-operated facilities (DOE Order 5480.1B, 5483.1A). DOE keeps and makes available the various records of minor illnesses, injuries, and work-related deaths as required by the Occupational Safety and Health Administration regulations.

- **Toxic Substances Control Act of 1976 (15 USC 2601 et seq.)**—The Toxic Substances Control Act provides the U.S. EPA with the authority to require testing of chemical substances entering the environment and to regulate them as necessary. The law complements and expands existing toxic substance laws, such as §112 of the Clean Air Act and §307 of the Clean Water Act. The Toxic Substances Control Act also regulates the treatment, storage, and disposal of polychlorinated biphenyls, chlorofluorocarbons, asbestos, dioxins, certain metal-working fluids, and hexavalent chromium. Asbestos regulations under the Toxic Substances Control Act were ultimately overturned. However, regulations pertaining to asbestos removal, storage, and disposal are promulgated through the National Emission

Standard for Hazardous Air Pollutants Program (40 CFR 61, Subpart M). For chlorofluorocarbons, Title VI of the Clean Air Act Amendments of 1990 requires a reduction of chlorofluorocarbons beginning in 1991, and prohibits production after the year 2000.

5.1.2 Executive Orders

Figure 5–2 illustrates the applicable Executive Orders. These orders are summarized as follows:

- **Executive Order 11514 (Protection and Enhancement of Environmental Quality)**—Executive Order 11514 requires Federal agencies to continually monitor and control their activities to protect and enhance the quality of the environment and to develop procedures to ensure the fullest practicable provision of timely public information and understanding of the Federal plans and programs with environmental impact into obtain the views of interested parties. DOE issued regulations (10 CFR Part 1021) and DOE Order 5440.1E for compliance with this Executive Order.

- **Executive Order 11593 (National Historic Preservation) (May 13, 1971)**— Executive Order 11593 directs Federal agencies to locate, inventory, and nominate properties under their jurisdiction or control to the *National Register of Historic Places* if those properties qualify. This process requires DOE to provide the Advisory Council on Historic Preservation the opportunity to comment on the possible impacts of the proposed activity on any potential eligible or listed resources.

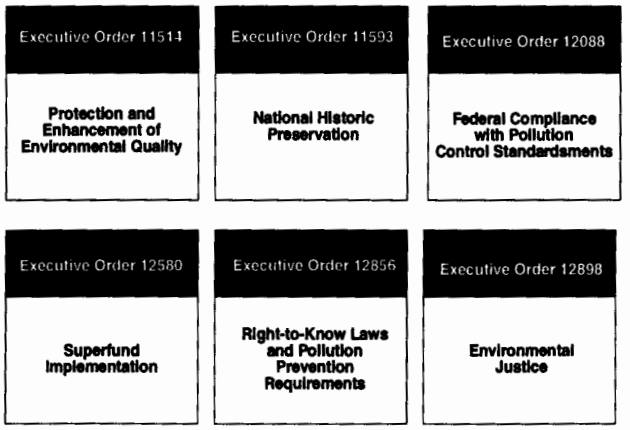


Figure 5–2 Executive Orders

- **Executive Order 12088 (Federal Compliance with Pollution Control Standards) (October 13, 1978), as amended by Executive Order 12580 (January 23, 1987) Federal Compliance with Pollution Control Standards**—Executive Order 12088 directs Federal agencies to comply with applicable administrative and procedural pollution control standards established by, but not limited to, the Clean Air Act, the Noise Control Act, the Clean Water Act, the Safe Drinking Water Act, the Toxic Substances Control Act (15 USC §2061 et seq.), and the Resource Conservation and Recovery Act.

- **Executive Order 12580 (Superfund Implementation)**—Executive Order 12580 delegates to the heads of executive departments and agencies the responsibility for undertaking remedial actions for releases, or threatened releases that are not on the National Priority List and removal actions other than emergencies

where the release is from any facility under the jurisdiction or control of executive departments and agencies.

- **Executive Order 12856 (Right-to-Know Laws and Pollution Prevention Requirements)**—Executive Order 12856 requires all Federal agencies to reduce the toxic chemicals entering any waste stream. This Order also requires Federal agencies to report toxic chemicals entering waste streams; improve emergency planning, response, and accident notification; and encourage clean technologies and testing of innovative prevention technologies.

- **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 populations and low-income populations.

5.1.3 DOE Regulations and Orders

Through the authority of the Atomic Energy Act, DOE is responsible for establishing a comprehensive health, safety, and environmental program for its facilities. DOE Orders are issued in support of health, safety, and environmental programs. The major DOE Orders, notices, and standards pertaining to the proposed action and alternatives are listed in **Table 5–1**.

Table 5–1 Relevant DOE Orders, Notices, and Standards (as of February 4, 1997)

DOE Order/ Notice/Standard	*Subject*
Orders	
Leadership/Management Planning	
O 151.1	Comprehensive Emergency Management System (9-25-95; Chg. 2, 8-21-96)
Information and Analysis	
O 231.1	Environment, Safety, and Health Reporting (9-30-95; Chg. 2, 11-07-96)
O 232.1	Occurrence Reporting and Processing of Operations Information (9-25-95; Chg. 2, 8-12-96)
Work Processes	
O 420.1	Facility Safety (10-3-95; Chg. 2, 10-24-96)
O 425.1	Startup and Restart of Nuclear Facilities (09-29-95); Chg. 1, 10-26-95
O 440.1	Worker Protection Management for DOE Federal and Contractor Employees (9-30-95; Chg. 1, 10-21-96)
O 451.1A	National Environmental Policy Act Compliance Program
O 460.1A	Packaging and Transportation Safety (10-2-96)
O 460.2	Departmental Materials Transportation and Packaging Management (9-27-95; Chg. 1, 10-26-95)
O 470.1	Safeguards and Security Program (9-28-95; Chg. 1, 6-21-96)
Management Systems and Standards	
1300.2A	DOE Technical Standards Program (5-19-92)
1360.2B	Unclassified Computer Security Program (5-18-92)
Personnel Relations and Services	
3790.1B	Federal Employee Occupation Safety and Health Program (1-7-93) [Canceled except for Chapter 8]
Real Property Management	
4330.4B	Maintenance Management Program (2-10-94)
Project Management	
4700.1	Project Management System (3-6-87; Chg. 1, 6-2-92)
Environmental Quality and Impact	
5400.1	General Environmental Protection Program (11-9-88; Chg. 1, 6-29-90)
5400.5	Radiation Protection of the Public and the Environment (2-8-90; Chg. 2, 1-7-93)

DOE Order/ Notice/Standard [a]	*Subject*
5480.1B	Environmental, Safety and Health Program for DOE Operations (9-23-86; Chg. 4, 3-27-90)
5480.18B	Nuclear Facility Training Accreditation Program (08-31-94)
5480.19	Conduct of Operations Requirements for DOE Facilities (7-9-90; Chg.1, 5-18-92)
5480.20A	Personnel Selection, Qualification, and Training Requirements for DOE Nuclear Facilities (11-15-94)
5480.21	Unreviewed Safety Questions (12-24-91)
5480.22	Technical Safety Requirements (2-25-92; Chg. 2, 1-23-96)
5480.23	Nuclear Safety Analysis Reports (4-10-92; Chg. 1, 3-10-94)
5480.27	Equipment Qualification for Reactor and Nonreactor Nuclear Facilities (1-15-93)
5480.4	Environmental Protection, Safety, and Health Protection Standards (5-15-84; Chg. 4, 1-7-93)
5480.6	Safety of Department of Energy-Owned Nuclear Reactors (9-23-86)
5482.1B	Environment, Safety, and Health Appraisal Program (9-23-86; Chg. 1, 11-18-91)
Emergency Preparedness	
5530.3	Radiological Assistance Program (1-14-92; Chg. 1, 4-10-92)
5530.5	Federal Radiological Monitoring and Assessment Center (7-10-92; Chg. 1, 12-2-92)
Defense Programs	
5610.14	Transportation Safeguards System Program Operations (5-12-93)
5633.3B	Control and Accountability of Nuclear Materials (9-7-1994)
5660.1B	Management of Nuclear Materials (5-26-1994)
Energy Programs and Policies—General	
5700.6C	Quality Assurance (8-21-91; Chg. 1, 5-10-96)
Energy Research and Technology	
5820.2A	Radioactive Waste Management (9-26-88)
Design	
6430.1A	General Design Criteria (4-6-89)
Notices	
N 251.4	Site Safety Representatives (09-29-95)
N 251.4	Safety Analysis and Review System (9-29-95)
N 251.6	Comprehensive Environmental Response, Compensation, and Liability Act Requirements (09-29-95)
N 441.1	Department of Energy Laboratory Accreditation Program for Personnel Dosimetry (09-30-95)
N 441.1	Radiation Protection for Occupational Workers (09-30-95)
Standards	
STD-3013-96	Criteria for Preparing and Packaging Plutonium Metals and Oxides for Long-Term Storage (09-96; supersedes DOE-STD-3013-94)

[a] New DOE numbering system, by functional area; within 2 years, the numbering system for these orders will be converted to the new DOE numbering system (3 digit).

DOE regulations are found in 10 CFR. These regulations address areas such as energy conservation, administrative requirements and procedures, nuclear safety, and classified information. For the purposes of this EIS, relevant regulations and draft regulations include 10 CFR Part 834, Radiation Protection of the Public and the Environment; 10 CFR Part 835, Occupational Radiation Protection; 10 CFR Part 1021, Compliance with NEPA; and 10 CFR Part 1022, Compliance with Floodplains/Wetlands Environmental Review Requirements. DOE has enacted occupational radiation protection standards to protect government and contractor employees. These standards are set forth in 10 CFR Part 835, Occupational Radiation Protection, which establishes radiation protection standards, limits, and program requirements for protecting individuals from ionizing radiation resulting from the activities conducted by DOE and its contractors. Activities may include, but are not limited to, design, construction, or operation of facilities. DOE Orders set forth policy and the programs and internal procedures for implementing those policies.

5.1.4 State Environmental Statutes and Regulations

Figure 5–3 illustrates agreements between the States and DOE relevant to the proposed action and alternatives. These agreements and compliance orders are summarized below.

Residues	Environmental Restoration	Transuranic Waste	Water Quality	Mixed Waste
Mixed Residue Settlement Agreement and Compliance Order on Consent No. 89-10-30-01	Rocky Flats Cleanup Agreement Savannah River Site Federal Facility Compliance Agreement	The Agreement for Consultation and Cooperation for Transuranic Waste	Federal Facility Agreement	Federal Facility Agreement

Figure 5–3 Legal Agreements and Compliance Orders

5.1.4.1 The State of Colorado

Before 1989, management of plutonium residues and scrub alloy at the Rocky Flats Environmental Technology Site (Rocky Flats) was governed by the Atomic Energy Act. However, in 1989 the State of Colorado determined that a portion of the residues were mixed with hazardous waste and therefore subject to the Colorado Hazardous Waste Act (CRS 25-15-101 et seq.). The Colorado Department of Health and Environment has been delegated primary Resource Conservation and Recovery Act authority by the EPA, including permitting requirements. Activities associated with the mixed residues must comply with Colorado's hazardous and mixed waste generator, treatment, storage, disposal, and transportation requirements found in 6 Colorado Code of Regulations Chapter 1007, Article 3, Parts 99, 100, and 260-268. Currently, all of the mixed residues are in compliance with the Colorado Resource Conservation Act regulations. Along with the delegation of authority for Resource Conservation and Recovery, the EPA has delegated Clean Air Act and Clean Water Act authority to the State of Colorado.

The Colorado Air Quality Control Board has authority for air pollutants other than radioactive materials. Colorado submitted a State Implementation Plan that was approved by the EPA, that gives them primary permitting and enforcement authority. The governing regulations are found in the Colorado Air Pollution Prevention and Control Act implementing regulations, 5 Colorado Code of Regulations 1001. Of particular relevance to this EIS are Regulations No. 3 and No. 8. Regulation No. 3 requires Rocky Flats to file Air Pollutant Emission Notices to summarize nonradiological air emissions. Air Pollutant Emission Notices include an estimate of quantity and composition of air emissions generated from source operations. In addition to Air Pollutant Emission Notices, operating and construction air permits are required. Regulation No. 8 implements the Federal National Emission Standards for Hazardous Air Pollutants program for nonradioactive hazardous air pollutants in the State of Colorado. The Colorado Air Quality Control Board sets work standards, emission limitations, and ambient air standards for hazardous air pollutants. Colorado is in the process of gaining EPA approval of a radionuclide National Emission Standards for Hazardous Air Pollutants program. The current EPA requirement limits the radiation dose to the public from airborne radionuclide emissions to 10 mrem/yr effective dose equivalent. Once Colorado obtains approval of its program, this standard could be more stringent for Rocky Flats.

The State of Colorado established the Colorado Water Quality Control Commission to implement the Federal National Pollutant Discharge Elimination System permit program, except for Federal facilities such as Rocky Flats. Consequently, although the Colorado Water Quality Control Commission sets the applicable effluent

limitations for surface water quality that Rocky Flats must comply with, the EPA issues and administers National Pollutant Discharge Elimination System permitting. The State does ratify issuance of Federal permits and has the ability to veto the permit if it does not contain sufficient terms to protect all ambient segment water quality standards.

The Site was issued its original National Pollutant Discharge Elimination System permit in 1974 (#CO-0001333). The permit was reissued by the EPA in 1984, expired in 1989, and was modified and extended administratively by the National Pollutant Discharge Elimination System Federal Facility Compliance Agreement in March 1991. Key modifications included (1) eliminating two inactive discharge points and establishing new monitoring parameters for the other discharge locations, (2) changing one "point of compliance" location from Pond B-3 to the wastewater treatment plant, and (3) adding monitoring requirements for total chromium and whole effluent toxicity at terminal ponds A-4, B-5, and C-2 (the only ponds capable of discharging water offsite).

A revised, draft National Pollutant Discharge Elimination System permit (still in the draft stage as of 1996) was issued to the Site in February 1994. When finalized, this permit is expected to change the Site's discharge points to the wastewater treatment plant, Building 374 product water, and six storm water monitoring stations. Until the new permit is in effect, the terms and conditions of the existing National Pollutant Discharge Elimination System permit remain in effect. The draft National Pollutant Discharge Elimination System permit's monitoring requirements, sampling locations, analytical parameters, and sampling frequency details are not yet finalized.

The final permit is expected to apply numeric standards to wastewater treatment plant discharges. It is also expected to require implementation of "best management practices" for storm water. Storm water quality has a direct influence on Site pond water quality because storm water generally has high sediment loads that can carry contaminants into the ponds. Although the National Pollutant Discharge Elimination System permit has historically regulated discharges *from* the Site's detention ponds rather than *to* the ponds, the draft permit regulates wastewater treatment plant and storm water discharges from the developed portion of the Site *prior* to entering the A-, B-, and C-Series ponds. Storm water discharges would be regulated from six locations within the developed portion of the Site. The draft permit requires that existing best management practices for storm water continue to be implemented until the EPA approves the Site's *Stormwater Pollution Prevention Plan.*

The draft National Pollutant Discharge Elimination System permit is also expected to require that footing drain (e.g., building drain) discharges be monitored. Footing drain systems for buildings and structures in the Industrial Area are potential sources of contaminants for surface water at the Site. Water collected in the footing drains is discharged to storm sewers, sanitary sewers, building sumps, or surface outfalls and may reach Site ponds either through exfiltration of water from the sewers or through direct discharge to surface outfalls. Specific examples of footing drain flows that may affect Site ponds include outfalls for Buildings 317/374, 707, and 774. While the volume of water in the footing drains is not large compared to storm runoff, substantial concentrations of chemical contaminants could occur.

Water quality is tested at various discharge points and is compared against site-specific stream standards set by the Colorado Water Quality Control Commission. This dual compliance responsibility is based on the Site's status as a Federal facility. While the EPA has authorized the State of Colorado to implement the Federal National Pollutant Discharge Elimination System permit program for Colorado waters, the State's authority does not extend to Federal facilities such as the Site. Therefore, the EPA retains authority for issuing National Pollutant Discharge Elimination System permits for the Site. The State's authority derives primarily from the stipulation in the Clean Water Act that each State must certify that National Pollutant Discharge Elimination System permit conditions are consistent with its own water quality standards.

The respective roles and responsibilities of the EPA and the State of Colorado in regulating the quality of water onsite and offsite are clarified in the National Pollutant Discharge Elimination System Federal Facility Compliance Agreement (Section 6.5.11).

In March 1990, the Colorado Water Quality Control Commission adopted site-specific water quality standards in lieu of statewide standards for Woman Creek, Walnut Creek, Standley Lake, and Great Western Reservoir. The Commission determined that the site-specific standards were appropriate to establish extra protection for Great Western Reservoir and Standley Lake. As a result, specific stream standards for Woman Creek and Walnut Creek were adopted for organic and inorganic chemicals, metals, radionuclides, and certain physical and biological parameters. "Segment 4" standards adopted for tributaries downstream of the Site's detention ponds were more stringent than "Segment 5" standards adopted for tributaries upstream of these ponds.

In January and April 1995, the Commission issued additional revisions to the standards for Walnut Creek and Woman Creek drainages (e.g., resegmenting portions of Walnut Creek and eliminating the unionized ammonia standards for those segments). The EPA has not yet issued the National Pollutant Discharge Elimination System permit reflecting the Commission's water quality standards; however, the Site is abiding by them. Water is discharged from the Site only with the concurrence of the Colorado Department of Public Health and Environment.

The Colorado Water Quality Control Commission has established radionuclide standards for gross alpha, gross beta, plutonium, americium, tritium, and uranium that were not health-based but based, on existing ambient quality. DOE consistently claimed that the standards were too stringent and inconsistent with the statewide standard. As part of the Rocky Flats Cleanup Agreement (see Agreements), DOE, the EPA, and the Colorado Department of Health and Environment agreed to multiple action levels that will be proposed for approval to the Colorado Water Quality Control Commission, including a health-based standard for radionuclides.

The Colorado Water Quality Control Commission made the following rulings at its December 1996 rulemaking on water quality regulations affecting Rocky Flats: (1) repealed the site-specific radionuclide standard of 0.05 pCi/L and adopted a statewide standard of 0.15 pCi/L and (2) granted Rocky Flats a temporary modification of the nitrate standard to 100 mg/L (an increase from the existing 10 mg/L).

- **Agreements**—On November 3, 1989, DOE, the Colorado Department of Public Health and Environment, and the EPA signed the Mixed Residue Settlement Agreement and Compliance Order on Consent No. 89-10-30-01 to address the issue of alleged violations of the Resource Conservation and Recovery Act pertaining to proper waste management of mixed residues. The Sierra Club civil lawsuit was decided on August 13, 1991, whereby DOE was directed to either obtain a Resource Conservation and Recovery Act permit within two years for the existing inventory of mixed residues or suspend all Site operations generating mixed waste. As of February 7, 1995, the mixed residues are fully permitted and in compliance with the Colorado hazardous waste regulations. Although several subsequent judicial and administrative orders occurred, currently only one governs the residues. Consent No. 93-04-23-01 requires the preparation of the Mixed Residue Reduction Report and that DOE process the backlog of mixed residues into shippable or disposable form as expeditiously as possible.

  The Rocky Flats Cleanup Agreement is the legal document that identifies the relationship between DOE, the EPA, and the Colorado Department of Public Health and Environment during cleanup of the Site. The goal of the Agreement is to create a coordinated approach, using one set of consistent environmental requirements and a process for reaching specific decisions within targeted time frames. The document provides a legal framework for guiding individual cleanup and waste management decisions for environmental restoration without predetermining those decisions. The Rocky Flats Cleanup Agreement does not govern the management of special nuclear materials or residues, nor does it govern the

management of building deactivation and decontamination as long as DOE has a mission for those facilities.

5.1.4.2 The State of South Carolina

Materials shipped from Rocky Flats to the Savannah River Site for treatment, storage, or disposal are required to comply with State of South Carolina laws and regulations. The hazardous waste component of mixed residues are regulated by the South Carolina Department of Health and Environmental Control Resource Conservation and Recovery Act implementing regulations R.61-79.260 through 270. The South Carolina Department of Health and Environmental Control currently does not have land disposal restriction waste authority; therefore, Federal standards would apply. In addition to hazardous waste requirements, South Carolina air and water standards would apply. The South Carolina Department of Health and Environmental Control has been delegated primary enforcement authority. Under the South Carolina Pollution Control Act, the South Carolina Department of Health and Environmental Control operates a permitting program for both air and water. Air permits include operating and construction permits. Furthermore, for facilities within South Carolina, the EPA has maintained authority over radionuclide emissions. The South Carolina Department of Health and Environmental Control has lead authority for regulating all other Clean Air Act hazardous air pollutants.

- **Agreements**—DOE, the EPA, and the South Carolina Department of Health and Environmental Control signed a Federal Facility Compliance Agreement to coordinate cleanup at the Savannah River Site. In addition, DOE and the EPA signed a Federal Facility Agreement regarding land disposal restriction of mixed waste at Savannah River Site. Among other things, the agreement requires Savannah River Site to provide status reports on construction and operation of various waste management facilities and to obtain permits for the construction and operation of additional facilities to meet DOE's needs for treatment of mixed waste.

5.1.4.3 The State of New Mexico

Management of residues and scrub alloy within the State of New Mexico is governed by the New Mexico Health and Environmental Department, Environmental Improvement Division. The New Mexico Environmental Improvement Division has responsibility for enforcement of compliance with the New Mexico Hazardous Waste Act, the New Mexico Water Quality Act, and the New Mexico Air Quality Control Act.

- **Agreements**—The Agreement for Consultation and Cooperation for Transuranic Waste was signed by the State of New Mexico and DOE on April 18, 1988. The agreement specifies the requirements for the packaging, labeling, and transportation of transuranic waste to the Waste Isolation Pilot Plant (WIPP). WIPP is one of the potential disposal sites for Rocky Flats transuranic and transuranic-mixed wastes.

5.2 REGULATIONS FOR RADIOACTIVE MATERIAL PACKAGING AND TRANSPORTATION

5.2.1 Nuclear Regulatory Commission Packaging Certification

Nuclear Regulatory Commission regulations applicable to the transportation of radioactive materials are found in 10 CFR Part 71, which includes detailed packaging design requirements and package certification testing requirements. Complete documentation of design and safety analysis and results of the required testing are submitted to the Nuclear Regulatory Commission to certify the package for use. Certification tests include: heat, physical drop onto an unyielding surface, water submersion, puncture by dropping package onto a steel bar, and gas tightness.

5.2.2 Hazardous and Radioactive Materials Transportation Regulations

Transportation of hazardous and radioactive materials, substances, and wastes is governed by Department of Transportation, Nuclear Regulatory Commission, and the EPA regulations. These regulations may be found in 49 CFR Parts 171 through 178, 49 CFR Parts 383 through 397, 10 CFR Part 71, and 40 CFR Parts 262 and 265, respectively.

Department of Transportation regulations contain requirements for identifying a material as hazardous or radioactive. These regulations interface with the Nuclear Regulatory Commission or the EPA regulations for identifying material, but the Department of Transportation hazardous material regulations govern the hazard communication (such as marking, hazard labeling, vehicle placarding, and emergency response telephone number) and shipping requirements (such as required entries on shipping papers or the EPA waste manifests).

The EPA regulations pertaining to hazardous waste transportation are found in 40 CFR Parts 262 and 265. These regulations address labeling and record keeping requirements, including the use of the EPA waste manifest, which is the required shipping paper for transporting Resource Conservation and Recovery Act regulated hazardous waste.

Transportation casks are subject to numerous inspections and tests (10 CFR 71.87). These tests are designed to ensure that the cask components are properly assembled and meet applicable safety requirements. Tests and inspections are clearly identified in the Safety Analysis Report for Packaging and/or the Certificate of Compliance for each cask. Casks are loaded and inspected by registered users in compliance with approved quality assurance programs. Operations involving the casks are conducted in compliance with 10 CFR 71.91. Reports of defects or accidental mishandling are submitted to the Nuclear Regulatory Commission.

- **Communications**—Proper communication, provided by labels, markings, placarding, and shipping papers or other documents, assists in ensuring safe preparation and handling of transportation casks. Labels (49 CFR 172.403) applied to the cask document the contents and the amount of radiation emanating from the cask exterior (transport index). The transport index lists the ionizing radiation level (in mrem/hr) at a distance of 1 m (3.3 ft) from the cask surface.

  In addition to the label requirements, markings (49 CFR Subpart D and 173.471) should be placed on the exterior of the cask to show the proper shipping name and the consignor and consignee in case the cask is separated from its original shipping documents (40 CFR 172.203). Transportation casks are required to be permanently marked with the designation "Type B," the owner's (or fabricator's) name and address, the Certificate of Compliance number, and the gross weight (10 CFR 71.83).

  Placards (49 CFR 172.500), which indicate the radioactive nature of the contents, are applied to the transport vehicle or freight container holding the transportation cask. In the United States, spent nuclear fuel is a Highway Route Controlled Quantity that must be placarded according to 49 CFR 172.507. Each freight container must be placarded as required by 49 CFR Part 172 Subpart F of the Hazardous Materials Regulations [49 CFR 176.76(f)]. Placards provide the first responders to a traffic or transportation accident with initial information about the nature of the contents.

  Shipping papers should have entries identifying the following: the name of the shipper, emergency response telephone number, description of the spent nuclear fuel, and the shipper's certificate as described in 49 CFR Part 172 Subpart C.

  In addition, drivers of motor vehicles transporting spent nuclear fuel must have training in accordance with the requirements of 49 CFR 172.700. The training requirements include: familiarization with the regulations, emergency response information, and the spent nuclear fuel communication programs required

by the Occupational Safety and Health Administration. Drivers are also required to have training on the procedures necessary for safe operation of the vehicle.

- **Ground Transport**—Overland shipments (by rail car or by truck) are regulated by a variety of the Department of Transportation and Nuclear Regulatory Commission regulations dealing with packaging, notification, escorts and communication. In addition, there are specific regulations for carriage by truck and carriage by rail.

  A package shipped over land in exclusive-use closed transport vehicles may not exceed the following radiation levels as provided in 49 CFR 173.441(b):

  - 200 mrem/hr on the external surface of the package unless the following conditions are met, in which case the limit is 1,000 mrem/hr:
    - The shipment is made in a closed transport vehicle
    - The package is secured within the vehicle so that its position remains fixed during transportation
    - There are no loading or unloading operations between the beginning and the end of the transportation
  - 200 mrem/hr at any point on the outer surface of the vehicle, including the top and underside of the vehicle; or in the case of a flat-bed style vehicle, at any point on the vertical planes projected from the outer edges of the vehicle, on the upper surface of the load (or enclosure if used), and on the lower external surface of the vehicle
  - 10 mrem/hr at any point 2 m (6.6 ft) from the outer lateral surfaces of the vehicle (excluding the top and underside of the vehicle); or in the case of a flat-bed style vehicle, at any point 2 m (6.6 ft) from the vertical planes projected by the outer edges of the vehicle (excluding the top and underside of the vehicle)
  - 2 mrem/hr in any normally occupied space.

  The shipper of record must comply with the requirements of 10 CFR 71.5 and 73.37. Section 71.5 provides that all overland shipments must be in compliance with Department of Transportation and Nuclear Regulatory Commission regulations, which provide for security of irradiated reactor fuel.

5.3 Emergency Management and Response Laws and Other Requirements

This section discusses laws and other requirements related to emergency management and response. Figures 5–4 through 5–6 in the following subsections illustrate statutes, regulations, and Executive Orders applicable to emergency management and response for the proposed action and alternatives.

5.3.1 Federal Statutes

Figure 5–4 illustrates Federal statutes applicable to emergency planning and response. Summaries of these documents follow the figure.

- **Emergency Planning and Community Right-to-Know Act of 1986 (42 U.S.C. 11001 et seq.) (also known as "SARA Title III")**—This Act requires emergency planning and notice to communities and government agencies of the presence and release of specific chemicals. The EPA implements this Act

under regulations found at 40 CFR Parts 355, 370, and 372. Under Subtitle A of this Act, Federal facilities provide various information (such as inventories of specific chemicals used or stored and releases that occur from these sites) to the State Emergency Response Commission and to the Local Emergency Planning Committee to ensure that emergency plans are sufficient to respond to unplanned releases of hazardous substances. Implementation of the provisions of this Act began voluntarily in 1987, and inventory and annual emissions reporting began in 1988. In addition, DOE requires compliance with Title III as a matter of DOE policy. The requirements for this Act were promulgated by the EPA in 40 CFR Parts 350 through 372.

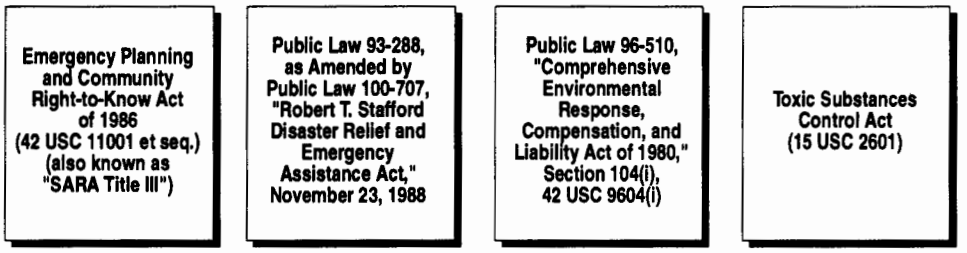


Figure 5–4 Federal Statutes Applicable to Emergency Management and Response

- **Public Law 93-288, as Amended by Public Law 100-707, "Robert T. Stafford Disaster Relief and Emergency Assistance Act," November 23, 1988**—This Act, as amended, provides an orderly and continuing means of assistance by the Federal Government to State and local governments in carrying out their responsibilities to alleviate the suffering and damage resulting from disasters. The President, in response to a State Governor's request, may declare an "emergency" or "major disaster," to provide Federal assistance under the Act. The President, in Executive Order 12148, delegated all functions, except those in Sections 301, 401, and 409, to the Director, Federal Emergency Management Agency. The Act provides for the appointment of a Federal Coordinating Officer who will operate in the designated area with a State Coordinating Officer for the purpose of coordinating State and local disaster assistance efforts with those of the Federal Government.

- **Public Law 96-510, "Comprehensive Environmental Response, Compensation, and Liability Act of 1980," Section 104(I), 42 U.S.C. 9604(I)**—More popularly known as "Superfund," this Act provides the needed general authority for Federal and State governments to respond directly to hazardous substances incidents. The Act requires reporting of spills, including radioactive spills, to the National Response Center.

- **Public Law 98-473, Justice Assistance Act of 1984**—These Department of Justice regulations implement the Emergency Federal Law Enforcement Assistance functions vested in the Attorney General. Those functions were established to assist State and local governments in responding to a law enforcement emergency. The Act defines the term "law enforcement emergency" as an uncommon situation which requires law enforcement, which is or threatens to become of serious or epidemic proportions, and with respect to which State and local resources are inadequate to protect the lives and property of citizens, or to enforce the criminal law.

  Emergencies that are not of an ongoing or chronic nature, such as the Mount Saint Helens volcanic eruption, are eligible for Federal law enforcement assistance. Such assistance is defined as funds,

equipment, training, intelligence information, and personnel. Requests for assistance must be submitted in writing to the Attorney General by the chief executive office of a State. The Plan does not cover the provision of law enforcement assistance. Such assistance will be provided in accordance with the regulations referred to in this paragraph [28 CFR Part 65, implementing the Justice Assistance Act of 1984] or pursuant to any other applicable authority of the Department of Justice.

5.3.2 Executive Orders

Figure 5–5 illustrates Executive Orders applicable to emergency management and response. Summaries of these Executive Orders follow the figure.

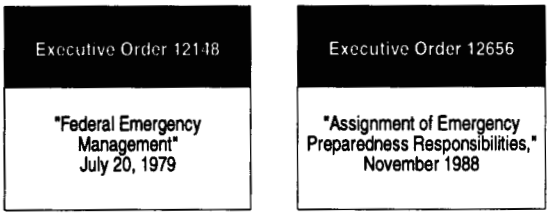


Figure 5–5 Executive Orders Applicable to Emergency Management and Response

- **Executive Order 12148, "Federal Emergency Management," July 20, 1979**—Executive Order 12148 transfers functions and responsibilities associated with Federal emergency management to the Director, Federal Emergency Management Agency. The Order assigns the Director, Federal Emergency Management Agency, the responsibility to establish Federal policies for and to coordinate all civil defense and civil emergency planning, management, mitigation, and assistance functions of Executive Agencies.

- **Executive Order 12656, "Assignment of Emergency Preparedness Responsibilities," November 1988**—Executive Order 12656 assigns emergency preparedness responsibilities to Federal departments and agencies.

5.3.3 Federal Regulations Concerning Emergency Management

Figure 5–6 illustrates Federal regulations applicable to emergency management and response. Summaries of these regulations follow the figure.

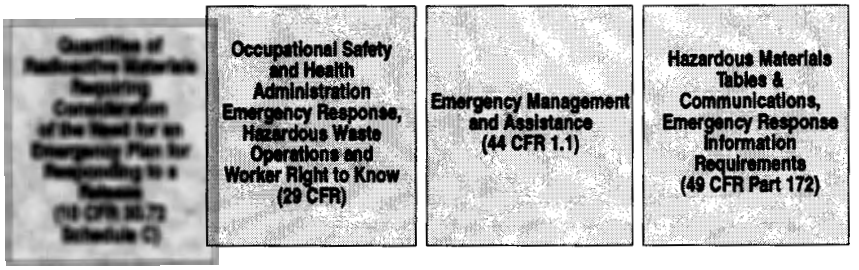


Figure 5–6 Federal Regulations Applicable to Emergency Management and Response

- **Quantities of Radioactive Materials Requiring Consideration of the Need for an Emergency Plan for Responding to a Release (10 CFR 30.72 Schedule C)**—This list is the basis for both the public and private sector to determine if the radiological materials they deal with must have an emergency response plan for unscheduled releases, and is one of the threshold criteria documents for DOE Hazards Assessments required by DOE Order 5500.3A, "Planning and Preparedness for Operational Emergencies." "Federal Radiological Emergency Response Plan," November 1985–Primarily discusses offsite Federal response in support of State and local governments with jurisdiction during a peacetime radiological emergency.

- **Occupational Safety and Health Administration Emergency Response, Hazardous Waste Operations and Worker Right to Know (29 CFR)**—This regulation sets down the Occupational Safety and Health Administration requirements for employee safety in a variety of working environments. The regulation addresses employee emergency and fire prevention plans (Section 1910.38), hazardous waste operations and emergency response (Section 1910.120), and hazards communication (Section 1910.1200) that enables employees to be aware of the dangers they face from hazardous materials at their workplace.

- **Emergency Management and Assistance (44 CFR 1.1)**—This regulation contains the policies and procedures for the Federal Emergency Management Act, National Flood Insurance Program, Federal Crime Insurance Program, Fire Prevention and Control Program, Disaster Assistance Program, and Preparedness Program including radiological planning and preparedness.

- **Hazardous Materials Tables & Communications, Emergency Response Information Requirements (49 CFR Part 172)**—The regulatory requirements for marking, labeling, placarding, and documenting hazardous materials shipments are defined in this regulation. The regulation also specifies the requirements for providing hazardous material information and training.

5.3.4 Emergency Planning

During peacetime radiological emergencies that occur outside of Federal jurisdiction, Federal agencies support State and local governments with jurisdiction for the emergency. The *Federal Radiological Emergency Response Plan* of November 1985 describes the Federal government's concept of operations for this support. The plan outlines policies and planning assumptions that underlie the concept of operations. It also specifies authorities and responsibilities for those Federal agencies that play a significant role during an emergency.

Chapter 6

List of Preparers

6. LIST OF PREPARERS

CHARLES R. HEAD, DEPARTMENT OF ENERGY
EIS RESPONSIBILITIES: **DOE PROJECT MANAGER**

Education: M.S., Control Theory, George Washington University
B.S., Electrical Engineering, Rice University

Experience/ Technical Specialty: Twenty-nine years. Nuclear safety oversight, safeguards and security requirements, Tiger Team assessments, spent fuel storage.

PATRICK J. WELLS, DEPARTMENT OF ENERGY
EIS RESPONSIBILITIES: **ASSISTANT TO THE DOE EIS PROJECT MANAGER**

Education: M.S., Engineering Management, George Washington University
B.S., Civil Engineering, Marquette University

Experience/ Technical Specialty: Thirteen years. Occupational safety and health, oversight system acquisition, reliability, maintainability.

ARNOLD E. GUEVARA, DEPARTMENT OF ENERGY
EIS RESPONSIBILITIES: **PROCESSING TECHNOLOGIES AND ALTERNATIVES**

Education: M.S., Engineering Management, George Washington University
B.S., Chemical Engineering, Tulane University

Experience/ Technical Specialty: Sixteen years. Environmental restoration, project and policy analysis, nuclear materials management.

TRACY MUSTIN, DEPARTMENT OF ENERGY
EIS RESPONSIBILITIES: **PROCESSING TECHNOLOGIES AND ALTERNATIVES**

Education: B.S., Chemical Engineering, North Carolina State University

Experience/ Technical Specialty: Six years. Nuclear material stabilization, environmental assessment, environmental compliance.

ABE ZEITOUN, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
EIS RESPONSIBILITIES: **SAIC PROJECT MANAGER, PURPOSE AND NEED, AND ALTERNATIVES**

Education: Ph.D., Environmental Sciences, Michigan State University
M.S., Fisheries, Michigan State University
B.S., Chemistry & Zoology, University of Alexandria

Experience/ Technical Specialty: Twenty-four years. Environmental regulatory compliance and assessments, social impacts, mitigation of adverse impacts.

D. JANE AARON, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
***EIS RESPONSIBILITIES*: PROCESSING TECHNOLOGIES AND ALTERNATIVES**

Education: M.S., Environmental Policy and Management, University of Denver
B.S., Environmental Design, University of Colorado at Boulder

Experience/ Technical Specialty: Six years. Environmental regulatory compliance and analysis, environmental justice, cultural resource management.

PAULA W. AUSTIN, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
***EIS RESPONSIBILITIES*: PUBLIC SCOPING AND SUMMARY**

Education: B.S., Management and Technology, University of Maryland

Experience/ Technical Specialty: Twenty years. Nuclear and waste management policy analysis, technical writing, and communications.

RAKESH BAHADUR, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
***EIS RESPONSIBILITIES*: ENVIRONMENTAL JUSTICE AND GEOGRAPHIC INFORMATION SYSTEMS (GIS)**

Education: Ph.D., Groundwater Hydrology, Colorado State University
M.S., Groundwater Hydrology, Colorado State University
M.Sc., Geology, Punjab University

Experience/ Technical Specialty: Seventeen years. Hydrology, water pollution and hazardous waste management, site characterization, environmental assessment, risk assessment, modeling, high-resolution simulation.

LOUIS C. BORGHI, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
***EIS RESPONSIBILITIES*: CHEMICAL CONSEQUENCES**

Education: M.S., Ecology, Pennsylvania State University
B.A., Biology, LaSalle University

Experience/ Technical Specialty: Eighteen years. Environmental fate, chemical risk assessment evaluations.

BURRUS M. CARNAHAN, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
***EIS RESPONSIBILITIES*: NONPROLIFERATION CONSEQUENCES**

Education: LL.M., International Law, University of Michigan
J.D., Northwestern University
B.A., Political Science, Drake University

Experience/ Technical Specialty: Nineteen years. Nuclear nonproliferation agreement negotiation and policies.

SYDEL CAVANAUGH, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
***EIS RESPONSIBILITIES*: APPLICABLE REGULATIONS**

Education: B.A., Interdisciplinary Studies – Personnel/Sociology, University of Maryland

Experience/ Technical Specialty: Eleven years. Public participation, technical writing, and communications.

HARRY CHERNOFF, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
EIS RESPONSIBILITIES: **COSTS AND SOCIOECONOMICS**

Education: M.B.A., Marymount University
B.A., Economics, College of William & Mary

Experience/ Technical Specialty: Eighteen years. Energy economics, policy and regulatory analysis, socioeconomics, financial and economic analysis.

ALVA L. COLLINS, JR., SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
EIS RESPONSIBILITIES: **DESCRIPTION OF ALTERNATIVES AND PROCESSING TECHNOLOGIES, SAIC DEPUTY PROJECT MANAGER**

Education: Ph.D., Inorganic Chemistry, Duke University
M.B.A., Public Sector Management, Wharton Graduate School, University of Pennsylvania
M.A., Inorganic Chemistry, Duke University
A.B., Chemistry, Oberlin College

Experience/ Technical Specialty: Twenty years. Strategic and program planning, methodology development, plutonium costing methodologies.

GARY M. DEMOSS, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
EIS RESPONSIBILITIES: **TRANSPORTATION CONSEQUENCES**

Education: M.S., Engineering Administration, Virginia Polytechnic Institute
B.S., Mechanical Engineering, University of Virginia

Experience/ Technical Specialty: Fifteen years. Transportation risk analysis and reliability and safety engineering.

MEL FEATHER, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
EIS RESPONSIBILITIES: **RESIDUES CHARACTERISTICS AND ALTERNATIVES**

Education: M.S., Engineering Physics, University of Virginia
B.S., Nuclear Engineering, University of Virginia

Experience/ Technical Specialty: Fourteen years. Nuclear material production, waste isolation safety, plutonium disposition.

STEVE HOWARD, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
EIS RESPONSIBILITIES: **PROCESSING TECHNOLOGIES AND ALTERNATIVES**

Education: B.S., Civil Engineering, Virginia Polytechnic Institute

Experience/ Technical Specialty: Twenty years. Waste disposal facility project management.

CLARK B. HYDER, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
EIS RESPONSIBILITIES: **TRANSPORTATION AND EMERGENCY PLANNING**

Education: B.S., Emergency Management, North Texas State University
B.A., Economics, North Texas State University

Experience/ Technical Specialty: Eleven years. Emergency management, transportation management, transportation emergency preparedness planning.

RAVI KANDA, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
***EIS RESPONSIBILITIES*: CHEMICAL CONSEQUENCES**

Education: M.S., Environmental Engineering, University of Cincinnati
Bachelor of Technology, Mechanical Engineering, Indian Institute of Technology, Bombay, India

Experience/ Technical Specialty: One year. Air quality modeling.

ROY KARIMI, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
***EIS RESPONSIBILITIES*: RADIOLOGICAL IMPACT ASSESSMENTS AND ACCIDENTS**

Education: Sc.D., Nuclear Engineering, Massachusetts Institute of Technology
N.E., Nuclear Engineering, Massachusetts Institute of Technology
M.S., Nuclear Engineering, Massachusetts Institute of Technology
B.S., Chemical Engineering, Abadan Institute of Technology

Experience/ Technical Specialty: Twenty years. Nuclear powerplant safety, risk and reliability analysis, design analysis, criticality analysis, probabilistic risk assessment.

TODD MILLER, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
***EIS RESPONSIBILITIES*: IMPACT AND ACCIDENT ASSESSMENTS**

Education: M.C.E., Structural Engineering, The Catholic University of America
B.S., Civil Engineering, Worcester Polytechnic Institute

Experience/ Technical Specialty: Six years. Structural analysis, accident analysis, hazardous waste management and assessment, radiological assessments.

JOFU MISHIMA, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
***EIS RESPONSIBILITIES*: RADIOLOGICAL AND ACCIDENT IMPACTS**

Education: B.S., Chemistry, Wayne University

Experience/ Technical Specialty: Forty-two years. Fractional airborne release of radionuclides, plutonium material behavior, plutonium storage safety issues, alternative plutonium shipping forms.

MICHAEL O. MOORE, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
***EIS RESPONSIBILITIES*: AFFECTED ENVIRONMENT AND SUMMARY**

Education: B.A., Economics, University of Maryland

Experience/ Technical Specialty: Thirteen years. Analysis and design of environmental/waste information systems, technical writing and editing.

JOHN NUCKLES, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
***EIS RESPONSIBILITIES*: CHEMICAL CONSEQUENCES**

Education: M.S., Environmental Planning, University of Virginia
B.S., Mechanical Engineering, University of Virginia

Experience/ Technical Specialty: Nine years. Air quality modeling and GIS applications.

WILLIAM B. SAMUELS, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
***EIS RESPONSIBILITIES*: ENVIRONMENTAL JUSTICE AND GEOGRAPHIC INFORMATION SYSTEMS (GIS)**

Education: Ph.D., Biology, Fordham University
M.S., Marine Science, Long Island University
B.S., Biology & Geology, University of Rochester

Experience/ Technical Specialty: Eighteen years. GIS applications and computer simulation and mathematical modeling.

PETE SANFORD, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
***EIS RESPONSIBILITIES*: PROCESSING TECHNOLOGIES AND ALTERNATIVES**

Education: M.S., Engineering/Metallurgical Engineering/Extractive Metallurgy, Colorado School of Mines

Experience/ Technical Specialty: Twenty-one years. Hydrometallurgical extraction and purification operations, design and simulation of electrochemical synthesis, facility deactivation and decontamination.

ELIZABETH C. SARIS, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
***EIS RESPONSIBILITIES*: DESCRIPTION OF ALTERNATIVES AND SUMMARY**

Education: B.A., Political Science, George Washington University

Experience/ Technical Specialty: Nineteen years. Energy and environmental policy analysis, technical writing, and communications.

ROBERT SCHLEGEL, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
***EIS RESPONSIBILITIES*: PROJECT ENGINEER, RADIOLOGICAL IMPACT ASSESSMENTS AND ACCIDENTS**

Education: Degree of Nuclear Engineer, Columbia University
M.S., Nuclear Engineering, Columbia University
B.S., Chemical Engineering, Massachusetts Institute of Technology

Experience/ Technical Specialty: Thirty-four years. Radiological impact assessments, radiological dose/health effects calculations, safety analysis.

PAT SCHWAB, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
***EIS RESPONSIBILITIES*: IMPACT ASSESSMENTS AND ALTERNATIVES**

Education: Ph.D., Nuclear Engineering, University of Wisconsin
M.S., Nuclear Engineering, University of Wisconsin
B.S., Nuclear Engineering, Kansas State University

Experience/ Technical Specialty: Sixteen years. Nuclear engineering, National Environmental Policy Act expertise, nuclear weapon design, nuclear materials production, nuclear weapon proliferation.

JUDITH A. STEWART, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
***EIS RESPONSIBILITIES*: PROCESSING TECHNOLOGIES AND ALTERNATIVES**

Education: B.S., Chemical Engineering, University of Colorado

Experience/ Technical Specialty: Eighteen years. Environmental safety and health compliance, regulatory compliance, chemical engineering.

BARRY D. SULLIVAN, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
***EIS RESPONSIBILITIES*: RADIOLOGICAL IMPACT AND ACCIDENT ASSESSMENTS**

Education:	M.B.A., Hofstra University B.S., Electrical Engineering, Rutgers University
Experience/ Technical Specialty:	Thirty-six years. Radiological impact assessment, safety analysis, facility accident analysis, risk-consequence analysis, design review.

JACK TEMPLETON, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
***EIS RESPONSIBILITIES*: PROCESSING TECHNOLOGIES AND ALTERNATIVES**

Education:	B.S., Chemical Engineering, University of Nevada
Experience/ Technical Specialty:	Thirteen years. Design and assessment of processing systems and equipment, system integration and analysis, technology selection and application.

GILBERT H. WALDMAN, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
***EIS RESPONSIBILITIES*: RADIOLOGICAL IMPACT AND ACCIDENT ASSESSMENTS**

Education:	M.S. Engineering Candidate, Technical Management, Johns Hopkins University B.S., Nuclear Engineering, University of Florida
Experience/ Technical Specialty:	Six years. Radiological impacts analysis, radiological dose modeling, radiological risk assessment.

ALAN K. WILLIAMS, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
***EIS RESPONSIBILITIES*: RESIDUES CHARACTERISTICS AND PROCESSING TECHNOLOGIES**

Education:	B.A., Physical Science, University of Northern Colorado
Experience/ Technical Specialty:	Forty-three years. Chemical processing of plutonium, research and development for processing plutonium, plutonium stabilization.

JOHN W. WILLIAMS, SCIENCE APPLICATIONS INTERNATIONAL CORPORATION
***EIS RESPONSIBILITIES*: AFFECTED ENVIRONMENT, ENVIRONMENTAL JUSTICE, AND APPLICABLE REGULATIONS**

Education:	Ph.D., Physics, New Mexico State University M.S., Physics, New Mexico State University B.S., Mathematics, North Texas State University
Experience/ Technical Specialty:	Twenty-three years. NEPA compliance, electromagnetic models, air quality modeling, ionizing radiation impacts and safety.

Chapter 7

Agencies Consulted

7. AGENCIES CONSULTED

FEDERAL AGENCIES

U.S. Census Bureau, Administrative and Customer Services Branch
U.S. Nuclear Regulatory Commission
U.S. Fish and Wildlife Service

STATE AGENCIES

California Agricultural Statistics Service, Estimation Branch
Colorado Department of Agriculture, Division of Markets
Colorado Department of Public Health and Environment, Emergency Management Program
Colorado State Patrol, Hazardous Material Section
Georgia Department of Natural Resources
Georgia Public Service Commission
Kansas Department of Agriculture
Kansas Department of Health and Environment
Kansas Division of Emergency Management
Kansas Highway Patrol
Kansas State Legislature
Missouri Department of Natural Resources, Environmental Emergency Response
Missouri State Highway Patrol
New Mexico Department of Agriculture, Office of Director/Secretary
South Carolina Budget and Control Board, Office of Research and Statistics, Health and Demographics
South Carolina Department of Health and Environmental Control
State of Colorado Demographic Section
State of Georgia Office of Planning and Budget
Tennessee Department of Environment and Conservation
Tennessee Emergency Management Agency

LOCAL AGENCIES

Aiken Department of Public Safety (South Carolina)
Atlanta Fire Department (Georgia)
City of Denver, Environmental Services (Colorado)
City of Hopkinsville Fire Department (Kentucky)
City of Kansas City, City Planning and Development (Missouri)
City of Kansas City, Environmental Management (Missouri)
City of Russell Fire Department (Kansas)
Colby Fire Department (Kansas)
Commercial Vehicle Enforcement (Tennessee)
Denver City Council (Colorado)
Ellis County Emergency Management (Kansas)
Flagler Fire Department (Colorado)
Hamilton County Sheriff's Department (Tennessee)

LOCAL AGENCIES (CONTINUED)

Jefferson County Sheriff's Department (Illinois)
Johnson County Emergency Management (Kansas)
Kansas City Fire Department (Missouri)
Kansas City Police Department, Commercial Vehicle Enforcement (Missouri)
Montgomery County Emergency Management Agency (Tennessee)
Mt. Vernon City Fire Department (Illinois)
Nashville Fire Department (Tennessee)
Russell County Emergency Management (Kansas)
Shawnee County Emergency Local Preparedness Committee (Kansas)
St. Clair County Sheriff's Department (Illinois)
St. Louis Department of Health and Hospitals (Missouri)
St. Louis Emergency Management Agency (Missouri)
St. Louis Emergency Services (Missouri)
St. Louis Fire Department (Missouri)

OTHER

Hays Fire and Inspection Services (Kansas)
National Agricultural Statistics Service (NASS), Colorado Agricultural Statistics
Southern States Energy Board (Georgia)
University of New Mexico, Bureau of Business and Economic Research, Data Bank
Urban Energy & Transportation Corporation (Washington, DC)
Westinghouse Electric Corporation, Governmental Affairs (New Mexico)
Wyondotte Company Emergency Management (Kansas)

Chapter 8

Glossary

8. GLOSSARY

Abnormal transients—An unusual incident in which operating parameters affecting control of radioactive materials move out of the normal operating range.

Absorbed dose—The energy deposited per unit mass by ionizing radiation. The unit of absorbed dose is the rad.

Actinide—Any of a series of chemically similar, mostly synthetic, radioactive elements with atomic numbers ranging from actinium (89) through lawrencium (103).

Acute exposure—A single exposure to a toxic substance that may result in severe biological harm or death. Acute exposures are usually characterized as lasting no longer than a day.

Air quality standards—The prescribed quantity of pollutants in the air that cannot be exceeded legally during a specified time in a specified area.

Alpha emitter—A radioactive substance that decays by releasing an alpha particle.

Alpha particle—A particle consisting of two protons and two neutrons, given off by the decay of many elements, including uranium, plutonium, and radon. Alpha particles cannot penetrate a sheet of paper. However, alpha emitting isotopes in the body can be very damaging.

Ambient air—The surrounding atmosphere, usually the outside air, as it exists around people, plants, and structures.

Americium—A manmade element. Americium is a metal that is slightly heavier than lead. Americium-241 is produced by the radioactive decay of plutonium-241; in addition to being an alpha-emitter, it is an emitter of gamma rays. Americium-241 has a half-life of 433 years.

Aquifer—A geologic formation that contains sufficient saturated permeable material to conduct groundwater and to yield worthwhile quantities of groundwater to wells and springs.

As low as reasonably achievable (ALARA)—The approach to radiation protection to manage and control exposures (both individual and collective) to the work force and to the general public to as low as is reasonable, taking into account social, technical, economic, practical, and public policy considerations. ALARA is not a dose limit, but a process that has the objective of attaining doses as far below the applicable limits as is reasonably achievable.

Ash residues—This category of residues includes incinerator ash; inorganics; sand, slag, and crucible; graphite fines; and firebrick. These residues are grouped together because of the similar methods in which the residues will be treated and/or repackaged.

Atomic Energy Act (AEA)—A law originally enacted in 1946 and amended in 1954 that placed nuclear production and control of nuclear materials within a civilian agency, originally the Atomic Energy Commission. The Atomic Energy Commission was replaced by the U.S. Nuclear Regulatory Commission and the U.S. Department of Energy.

Atomic number—The number of positively charged protons in the nucleus of an atom or the number of electrons on an electrically neutral atom.

Background radiation—Radiation from: (1) naturally occurring radioactive materials including radon, (2) cosmic sources, (3) global fallout as it exists in the environment (e.g., from the testing of nuclear explosive devices), and (4) consumer products containing nominal amounts of radioactive material or producing nominal amounts of radiation.

Beta emitter—A radioactive substance that decays by releasing a beta particle.

Beta particle—A particle emitted in the radioactive decay of many radionuclides. A beta particle is identical to an electron. It has a short range in air and a small ability to penetrate other materials.

Blend down—A process in which an appropriate material is added to a plutonium-bearing material to reduce the concentration of plutonium in the material. The quantity of plutonium in the material remains the same while the total quantity of material increases.

Bounded—Producing the greatest consequences of any assessment of impacts associated with normal or abnormal operations.

Button—Plutonium metal in a hemispherical shape, weighing approximately 1.8 kilograms (4 pounds).

Calcination—A process in which a material is heated to a high temperature to drive off volatile matter (to remove organic material) or to effect changes (as oxidation or pulverization or to convert it to nodular form). Calciners and nodulizing kilns are considered to be similar units. The temperature is kept below the fusion point.

Canister—A stainless-steel container in which nuclear material is sealed.

Canyon—A heavily shielded building at the Savannah River Site used in the chemical processing of radioactive materials to recover special isotopes. Operation and maintenance are performed by remote control.

Capable fault—A fault that has exhibited one or more of the following characteristics: (1) movement at or near the ground surface at least once within the past 35,000 years or movement of a recurring nature within the past 500,000 years; (2) macro-seismicity instrumentally determined with records of sufficient precision to demonstrate a direct relationship with the fault; (3) a structural relationship to a capable fault according to characteristics (1) or (2) above, such that movement on one could be reasonably expected to be accompanied by movement on the other.

Cask—A heavily shielded massive container for holding nuclear materials during shipment.

Cementation—A process in which cement and water are added to a plutonium-bearing material to create a concrete or grout material form.

Ceramification—A process in which an inorganic oxide is heated at high temperatures to the point at which oxide particles begin to fuse together. This forms a ceramic material.

Characterization—The determination of waste or residue composition and properties, whether by review of process knowledge, nondestructive examination or assay, or sampling and analysis, generally done to determine appropriate storage, treatment, handling, transportation, and disposal requirements.

Collective dose—The sum of the total effective dose equivalents of all individuals in a specified population. Collective dose is expressed in units of person-rem.

Committed effective dose equivalent—The sum of the committed dose equivalents to various tissues in the body, each multiplied by the appropriate weighting factor. Committed effective dose equivalent is expressed in units of rem, and will be accumulated during the 50 years following an intake of radioactive material into an individual's body. Used in cases when a person has an intake of radioactive material to denote that the dose is calculated for a period of 50 years following the intake. (See effective dose equivalent.)

Community (environmental justice definition)—A group of people or a site within a spatial scope exposed to risks that potentially threaten health, ecology, or land values, or exposed to industry that stimulates unwanted noise, smell, industrial traffic, particulate matter, or other nonaesthetic impacts.

Contact-handled waste—Packaged waste whose external surface dose rate does not exceed 200 mrem per hour.

Contamination—The deposition of undesirable radioactive material on the surfaces of structures, areas, objects, or personnel.

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

Criticality—The conditions in which a system is capable of sustaining a nuclear chain reaction.

Cultural resources—Archaeological sites, architectural features, traditional use areas, and Native American sacred sites.

Cumulative impacts—The impacts on the environment that result from the incremental impacts of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

Curie—The basic unit used to describe the intensity of radioactivity in a sample of material. The curie is equal to 37 billion disintegrations per second, which is approximately the rate of decay of 1 gram of the isotope radium-226. A curie is also a quantity of any radionuclide that decays at a rate of 37 billion disintegrations per second.

Decay (radioactive)—Spontaneous disintegration of the nucleus of an unstable atom, resulting in the emission of particles and energy.

Decommissioning—Retirement of a facility, including any necessary decontamination and/or dismantlement.

Decontamination—Removal of unwanted radioactive or hazardous contamination by a chemical or mechanical process.

Depleted uranium—Uranium that, through the process of enrichment, has been stripped of most of the uranium-235 it once contained, so that it has more uranium-238 than natural uranium. It is used as shielding, in some parts of nuclear weapons, and as a raw material for plutonium production.

Digestion—A process that results in the destruction of an organic matrix by heating with an oxidizing acid such as nitric acid.

Discounted dollars—The process of converting a dollar or a stream of dollars at some future date or dates to a single present value (the Net Present Value). The factor used to convert the stream is the discount rate, often called the weighted cost of capital.

Dissolution—A process in which a material is dissolved. In this EIS, it refers to dissolving salts away from plutonium oxide. The material is first heated in air to convert any plutonium metal to plutonium oxide. Then the salt is dissolved away with water leaving plutonium oxide.

DOE Orders—Requirements internal to the U.S. Department of Energy that establish DOE policy and procedures, including those for compliance with applicable laws.

Dose (or radiation dose)—A generic term that means absorbed dose, effective dose equivalent, committed effective dose equivalent, or total effective dose equivalent as defined elsewhere in this glossary.

Dose rate—The radiation dose delivered per unit time (e.g., rem per year).

Ecology—The relationship of living things to each other and to the environment or the study of such relationships.

Ecosystem—A complex of the community of living things and the environment forming a functioning whole in nature.

Effective dose equivalent—The summation of the products of the dose equivalent received by specified tissues of the body and the appropriate weighting factors. It includes the dose from radiation sources internal and/or external to the body. The effective dose equivalent is expressed in units of rem.

Effluent—A gas or liquid discharged into the environment.

Endangered species—Animals, birds, fish, plants, or other living organisms threatened with extinction by manmade or natural changes in their environment. Requirements for declaring a species endangered are contained in the Endangered Species Act, as amended (16 U.S.C. 1531 et seq.), and in similar State laws.

Enriched uranium—Uranium that has greater amounts of the isotope uranium-235 than occur naturally. Naturally occurring uranium is nominally 0.720 percent uranium-235.

Environmental Impact Statement (EIS)—A document required of Federal agencies by NEPA for major Federal actions or legislation with potential for significantly affecting the environment. A tool for decisonmaking, it describes the potential impacts of the proposed and alternative actions.

Environmental monitoring—The process of sampling and analysis of environmental media in and around a facility for the purpose of (1) determining compliance with performance objectives and (2) detection of environment contamination to facilitate timely remedial action.

Epidemiology—The science concerned with the study of the causes, frequency, and distribution of disease, injury, and other health-related events in the human population.

Escalation—A real increase in the price of a good or service, over and above the increase attributable to inflation.

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.

Fissile material—Any material fissionable by thermal (slow) neutrons; the two primary fissile isotopes are uranium-235 and plutonium-239.

Fission—The splitting or breaking of a nucleus into at least two other nuclei and the release of a relatively large amount of energy. Two or three neutrons are usually released during this type of transformation.

Fission products—The nuclei produced by fission of heavy elements, and their radioactive decay products.

Fissionable material—Commonly used as a synonym for fissile material, the meaning of this term has been extended to include material that can be fissioned by fast neutrons, such as uranium-238.

Frit—Finely ground glass used as feedstock input for vitrification.

Ful Flo filter—A filter used to remove particulates that are 1 to 5 microns and larger, from liquid streams. The filter is packed with activated charcoal/graphite or fiberglass.

Gamma ray—Very penetrating electromagnetic radiation of nuclear origin. Except for origin and energy level, identical to x-rays. Electromagnetic radiation frequently accompanying alpha and beta emissions as radioactive materials decay.

Geologic repository—A place to dispose of radioactive waste deep beneath the earth's surface.

Glovebox—Large enclosure that separates workers from equipment used to process hazardous material while allowing the workers to be in physical contact with the equipment; normally constructed of stainless steel with large acrylic/lead glass windows. Workers have access to equipment through the use of heavy-duty, lead-impregnated rubber gloves, the cuffs of which are sealed in portholes in the glovebox windows.

Gray—A unit of absorbed dose (see Rad).

Ground shine—The radiation dose received from radioactive material deposited on the ground's surface.

Half-life—The time in which one-half of the atoms of a particular radioactive substance disintegrate to another nuclear form. Half-lives vary from millionths of a second to billions of years.

Hazard index (HI)—A summation of the hazard quotient for all chemicals to be used at a given time at a site to yield cumulative levels for a site. An HI value of 1.0 or less means that no adverse human health effects (non-cancer) are expected to occur.

Hazard quotient (HQ)—The value used as an assessment of non-cancer associated toxic effects of chemicals (e.g., kidney or liver dysfunction). It is independent of a cancer risk, which is calculated only for those chemicals identified as carcinogens.

Hazardous material—A substance or material in a quantity and form that may pose an unreasonable risk to health and safety or property when transported in commerce.

Hazardous substance—Any substance subject to the reporting and possible response provisions of the Clean Water Act, and the Comprehensive Environmental Response, Compensation, and Liability Act.

Hazardous waste—Under the Resource Conservation and Recovery Act, a solid waste, or combination of solid wastes, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may (a) cause or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness or (b) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, disposed of, or otherwise managed. Source, special nuclear material, and by-product material, as defined by the Atomic Energy Act, are specifically excluded from the definition of solid waste.

High-efficiency particulate air (HEPA) filter—A filter with an efficiency of at least 99.95 percent used to remove particles from air exhaust streams prior to releasing to the atmosphere.

High-level waste—The highly radioactive waste material that results from the reprocessing of spent nuclear fuel, including liquid waste produced directly from reprocessing and any solid waste derived from the liquid that contains a combination of transuranic and fission product nuclides in quantities that require permanent isolation. High-level waste may include the highly radioactive material that the NRC, consistent with existing law, determines by rule requires permanent isolation.

Immobilization—A process that converts plutonium-bearing material to a stable form for disposal.

Inflation—A change in the nominal price level of all goods or services, unrelated to the real escalation of a particular good or service.

Inorganic residues—This category includes all inorganic residues resulting from direct production operations.

Isotopes—Different forms of the same chemical element that differ only by the number of neutrons in their nucleus. Most elements have more than one naturally occurring isotope. Many isotopes that do not exist in nature have been produced in reactors and particle accelerators.

Latent cancer fatalities (LCF)—Deaths occurring at later years from radiation-induced cancers.

Levelization—Conversion of a stream of values that vary at a uniform rate over time to a constant value over the same period of time.

Low enriched uranium (LEU)—Uranium enriched until it consists of up to 20 percent uranium-235. Used as nuclear reactor fuel.

Low-income community—Low income populations in an affected area should be identified with the annual statistical poverty thresholds from the *Bureau of the Census Current Population Reports, Series P-60 on Income and Poverty.*

Low-level waste —Any radioactive waste that is not spent fuel, high-level, or transuranic waste, and does not contain hazardous waste constituents.

Management Approach—Refer to strategic management approach.

Maximally exposed individual (MEI)—A hypothetical individual receiving the maximum exposure.

Maximum contaminant level (MCL)—The maximum permissible levels of a contaminant in water that is delivered to the free flowing outlet of the ultimate user of a public water system, except in the case of turbidity where the maximum permissible level is measured at the point of entry to the distribution system. Contaminants added to the water under the circumstances controlled by the user, except those resulting from corrosion of piping and plumbing caused by water quality, are excluded from this definition.

Mediated electrochemical oxidation (MEO)—A treatment process in which silver ions are used as catalysts to dissolve plutonium oxide and to destroy organic materials.

Micron—One-millionth of a meter.

Millirad (mrad)—One-thousandth of a rad.

Millirem (mrem)—One-thousandth of a rem.

Mitigate—To take practicable means to avoid or minimize the potentially harmful effects of an action (e.g., environmental harm from a selected alternative).

Mixed Oxide (MOX)—A physical blend of uranium oxide and plutonium oxide which can be used as fuel in a nuclear reactor.

Mixed waste—Waste that contains both "hazardous waste" and "radioactive waste" (as defined in this glossary).

Muffle furnaces—Small (approximately 1 cubic foot) oven-like electrically-heated units, lined with refractory material, which can be used to heat material placed onto trays inserted into the unit.

National Environmental Policy Act (NEPA)—A Federal law, enacted in 1970, that requires the Federal Government to consider the environmental impacts of, and alternatives to, major proposed actions in its decisionmaking processes. Commonly referred to by its acronym, NEPA.

Natural phenomena accidents—Accidents that are initiated by phenomena such as earthquakes, tornadoes, floods, etc.

Net present value—The value of a series of future income and expense streams brought forward to the present at the discount rate.

Neutron—An uncharged elementary particle with a mass slightly greater than that of the proton. Neutrons are found in the nucleus of every atom heavier than hydrogen-1.

Nonproliferation—Efforts to prevent or slow the spread of nuclear weapons and the materials and technologies used to produce them.

Normal operation—All normal conditions and those abnormal conditions that frequency estimation techniques indicate occur with a frequency greater than 0.1 events per year.

Nuclear weapon—Any weapon in which the explosion results from the energy released by reactions involving atomic nuclei.

Nuclide—A species of atom characterized by the constitution of its nucleus and hence by the number of protons, the number of neutrons, and the energy content.

Package—For radioactive materials, the packaging together with its radioactive contents as presented for transport (the packaging plus the radioactive contents is the package).

Packaging—For radioactive materials, it may consist of one or more receptacles, absorbent materials, spacing structures, thermal insulation, radiation shielding, and devices for cooling or absorbing mechanical shock to ensure compliance with U.S. Department of Transportation regulations.

Plume immersion—Occurs when an individual is enveloped by a cloud of radioactive gaseous effluent and receives an external radiation dose.

Plutonium—A manmade fissile element. Pure plutonium is a silvery metal that is heavier (for a given volume) than lead. Material rich in the plutonium-239 isotope is preferred for manufacturing nuclear weapons. Plutonium-239 has a half-life of 24,000 years.

Plutonium residues—Material containing plutonium that was generated during the separation and purification of plutonium or during the manufacture of plutonium-bearing components for nuclear weapons.

Population dose—See collective dose.

Probable maximum flood—The largest flood for which there is any reasonable expectancy in a specific area. The probable maximum flood is normally several times larger than the largest flood of record.

Process—Any method or technique designed to change the physical or chemical character of the residue or scrub alloy to render them less hazardous, safer to transport, store or dispose of, and/or less attractive for theft.

Processing Option—A specific technology (e.g., vitrification, water leach, Purex) that can be used to process a particular category of plutonium residues or scrub alloy (e.g., ash, salt, scrub alloy).

PUREX—An acronym for Plutonium-Uranium Extraction, the name of the chemical process usually used to remove plutonium and uranium from spent nuclear fuel, irradiated targets, and other nuclear materials. As used in this EIS, the PUREX process is used to separate out plutonium from residues or scrub alloy.

Pyro-oxidation—A process in which sodium carbonate is heated with a plutonium-bearing salt matrix to a high temperature to convert any reactive metals in the matrix to nonreactive oxides.

Pyrophoric—Pyrophoric liquids are any liquids that ignite spontaneously in dry or moist air at or below 54.4 degrees Centigrade (130 degrees Fahrenheit). A pyrophoric solid is any solid material, other than one classed as an explosive, which under normal conditions is liable to cause fires through friction, retained heat from manufacturing or processing, or which can be ignited readily and when ignited burns so vigorously and persistently as to create a serious transportation, handling, or disposal hazard. Included are spontaneously combustible and water-reactive materials.

Rad—A unit of absorbed dose. It corresponds to an energy absorption of 100 ergs per gram in any medium (1 rad = 0.01 gray).

Radiation (ionizing)—Energy transferred through space or other media in the form of particles or waves. In this document, we refer to ionizing radiation that is capable of breaking up atoms or molecules. The splitting, or decay, of unstable atoms emits ionizing radiation.

Radioactive waste—Waste that is managed for its radioactive content; solid, liquid, or gaseous material that contains radionuclides regulated under the Atomic Energy Act of 1954, as amended and of negligible economic value considering costs of recovery.

Radioactivity—The spontaneous emission of radiation from the nucleus of an atom. Radionuclides lose particles and energy through this process of radioactive decay.

Radioisotopes—Radioactive nuclides of the same element (same number of protons in their nuclei) that differ in the number of neutrons.

Radionuclide—A radioactive element characterized according to its atomic mass and atomic number that can be manmade or naturally occurring.

Raschig (glass) rings—These residues originated from Process Vent Scrubber Systems and in plutonium solutions processing production tanks. The rings are small, hollow, borosilicate glass cylinders that are used to absorb neutrons and thus prevent criticality in the aforementioned production tanks. These rings are coated with insoluble plutonium compounds.

Record of Decision (ROD)—A document prepared in accordance with the requirements of 40 CFR 1505.2 and 10 CFR 1021.315 that provides a concise public record of DOE's decision on a proposed action for which an EIS was prepared. A ROD identifies the alternatives considered in reaching the decision, the environmentally preferable alternative, factors balanced by DOE in making the decision, whether all practicable means to avoid or minimize environmental harm have been adopted, and, if not, why they were not.

Region of influence—Region in which the principal direct and indirect socioeconomic effects of actions are likely to occur and are expected to be of consequence for local jurisdictions.

Regulated substances—A general term used to refer to materials other than radionuclides that may be regulated by other applicable Federal, State, (or possibly local) requirements.

rem (Roentgen Equivalent Man)—A unit of radiation dose. Dose in rem is numerically equal to the absorbed dose in rad multiplied by a quality factor, distribution factor and any other necessary modifying factors (1 rem = 0.01 sievert).

Repackage—A process in which some residue materials may be removed from their current packaging containers and placed in new containers for improved safe secure storage or to meet packaging requirements for shipment.

Resource Conservation and Recovery Act (RCRA) as Amended—The statute or law that establishes, among other things, a system for managing hazardous waste from its generation until its ultimate disposal.

Risk—Expression of an impact that considers both the probability of that impact occurring and the consequences of the impact if it does occur.

Risk assessment (chemical or radiological)—The qualitative and/or quantitative evaluation performed in an effort to define the risk posed to human health and/or the environment by the presence or potential presence and/or use of specific chemical or radiological pollutants.

Safe Secure Trailer (SST)—A specially designed semitrailer, pulled by a specially designed tractor, that is used for the safe, secure transportation of cargo containing nuclear weapons or special nuclear material.

Safeguards termination limit (STL)—Materials containing concentrations (by weight percent) of plutonium, above which actions are required to safeguard them e.g., secure storage facilities.

Salt distillation—A process that separates transuranic materials from a salt matrix by distilling the salt away from any metal oxides present in the salt.

Salt scrub—A process used to recover plutonium from salt residues. The salt is heated with a mixture of aluminum and magnesium. The magnesium reacts with plutonium chloride in the salt to form plutonium metal, which forms an alloy with the aluminum called scrub alloy.

Saltstone—Low-radioactivity fraction of high-level waste formed into a concrete block at the Savannah River Site.

Scoping—Process involving the solicitation of comments from interested persons, groups, and agencies at public meetings, public workshops, in writing, electronically, or via fax, to assist DOE in defining the proposed action, identifying alternatives, and developing preliminary issues to be addressed in an EIS.

Scrub alloy—A magnesium/aluminum/americium/plutonium metal mixture that was created as an interim step in plutonium recovery.

Seismicity—The tendency for the occurrence of earthquakes.

Severe accident—An accident with a frequency rate of less than 10^{-6} per year that would have more severe consequences than a design-basis accident, in terms of damage to the facility, offsite consequences, or both.

Shredding—A process in which materials are cut into small pieces, which have a combined surface area larger than the original materials.

Sievert—A unit of radiation dose (1 sievert = 100 rem).

Slope factor—An upper-bound estimate of the probability of a response per unit intake of a chemical over a lifetime. The slope factor is used to estimate an upper-level bound probability of an individual developing cancer as a result of a lifetime of exposure to a particular level of a potential carcinogen.

Sonic wash—A process that uses sound waves to agitate an aqueous slurry of contaminated materials. It helps to remove plutonium compounds more efficiently from the surface of the contaminated materials.

Source term—The estimated quantities of radionuclides or chemical pollutants released to the environment.

Special nuclear material (SNM)—Plutonium, uranium enriched in the isotope 233 or in the isotope 235, and any other material that the Nuclear Regulatory Commission, pursuant to the provisions of the Atomic Energy Act of 1954, Section 51, determines to be special nuclear material.

Spent fuel standard—A term, coined by the National Academy of Sciences and modified by DOE, meaning that alternatives for the disposition of surplus weapons-usable plutonium should seek to make this plutonium roughly as inaccessible and unattractive for weapons use as the much larger and growing stock of plutonium in civilian spent nuclear fuel.

Strategic Management Approach—The compilation of a complete set of processing options (one option for each residue category and for scrub alloy) which allows a specific management criterion to be met (e.g., least overall processing cost, processing with maximum plutonium separation). For completeness and to allow comparisons among management approaches, the eight management approaches evaluated in this EIS include No Action and the preferred management approach.

Total effective dose equivalent—The sum of the effective dose equivalent from external exposures and the committed effective dose equivalent from internal exposures.

Transuranic—Any element whose atomic number is higher than that of uranium (that is, atomic number 92). All transuranic elements are produced artificially and are radioactive.

Transuranic waste—Waste contaminated with alpha-emitting radionuclides with half-lives greater than 20 years and concentrations greater than 100 nanocuries/gram at time of assay.

Type B packaging—Packaging for radioactive material that meets the standards for Type A packaging and, in addition, meets the standards for the hypothetical accident conditions of transport as prescribed in 49 Code of Federal Regulations Part 173.398(c).

Type B shipping cask—An NRC-certified cask with a protective covering that contains and shields radioactive materials, dissipates heat, prevents damage to the contents, and prevents criticality during normal shipment and accident conditions. It is used for transport of highly radioactive materials, and is tested under severe, hypothetical accident conditions that demonstrate resistance to impact, puncture, fire, and submersion in water.

Undiscounted dollars—Expressing income and expenditures in the year they occur, not at some common point in time.

Uranium—The basic material for nuclear technology. It is a slightly radioactive naturally occurring heavy metal that is more dense than lead. Uranium is 40 times more common than silver.

Vitrification—For the purpose of this EIS, vitrification means a process that uses glass to encapsulate or agglomerate the plutonium contained in residues or scrub alloy in order to immobilize it.

Vulnerabilities—Conditions or weaknesses that may lead to radiation exposure to the public, unnecessary or increased exposure to the workers, or release of radioactive materials to the environment.

Waste Acceptance Criteria (WAC)—The requirements specifying the characteristics of waste and waste packaging acceptable to a disposal facility and the documents and processes the generator needs to certify that waste meets applicable requirements.

Waste classification—Wastes are classified according to DOE Order 5820.2A, "Radioactive Waste Management," and include high-level waste, transuranic waste, and low-level waste.

Waste Isolation Pilot Plant (WIPP)—A facility in southeastern New Mexico being developed as the disposal site for transuranic and transuranic mixed waste, not yet in operation.

Waste management—The planning, coordination, and direction of those functions related to generation, handling, treatment, storage, transportation, and disposal of waste, as well as associated surveillance and maintenance activities.

Waste minimization—An action that avoids or reduces the generation of waste by source or toxicity reduction, improves energy usage, or recycles.

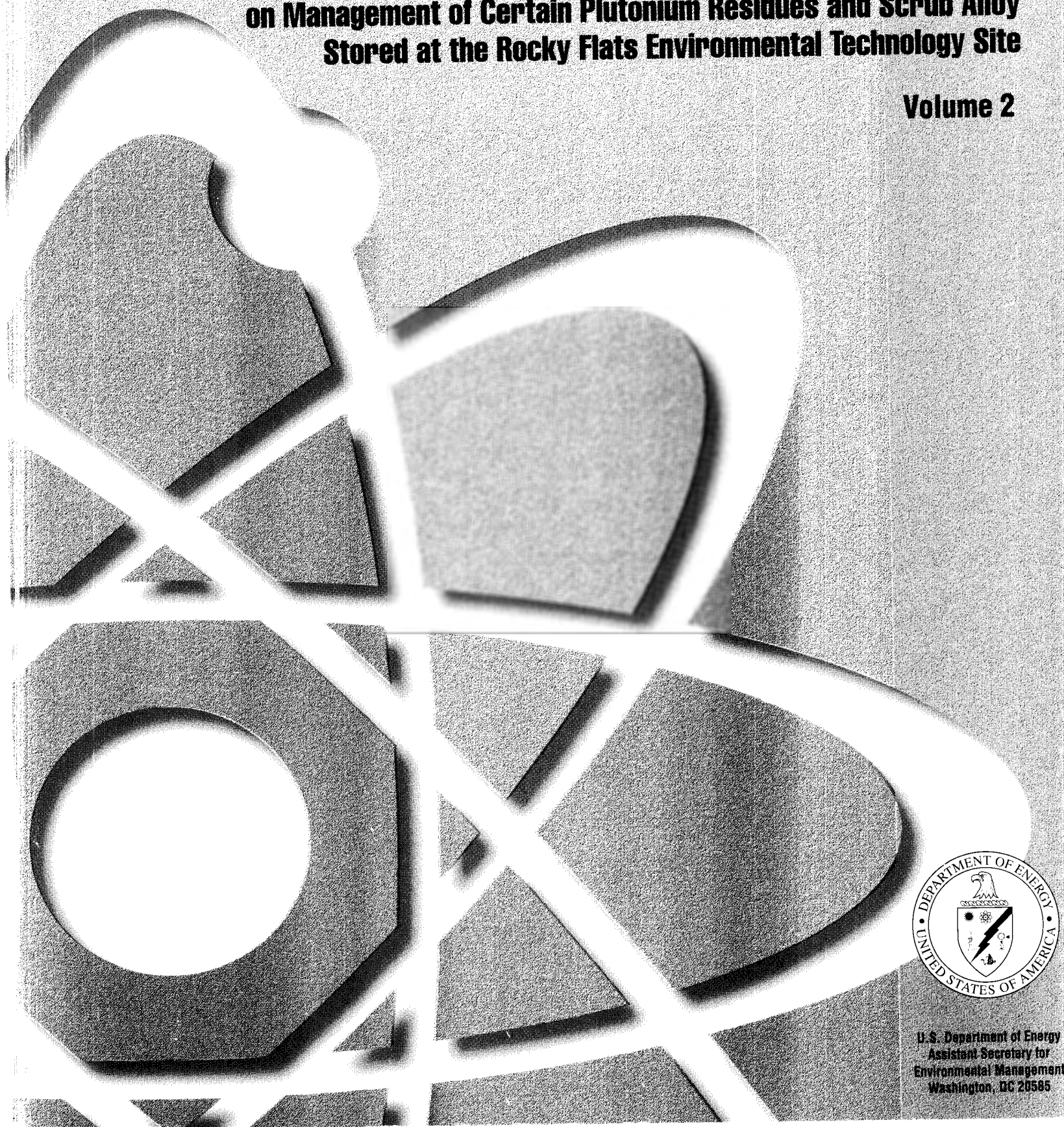
Waste classification—Wastes are classified according to DOE Order 5820.2A, Radioactive Waste Management, and include high-level waste, transuranic waste, and low-level waste.

DOE/EIS - 0277D
November 1997

Draft Environmental Impact Statement

on Management of Certain Plutonium Residues and Scrub Alloy Stored at the Rocky Flats Environmental Technology Site

Volume 2



U.S. Department of Energy
Assistant Secretary for
Environmental Management
Washington, DC 20585

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Volume 2

U.S. Department of Energy
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January 7, 1998

Charles R. Head
NEPA Document Manager
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1000 Independence Avenue, S.W.
Washington, D.C. 20585-0001

Dear Mr. Head:

RE: DRAFT ENVIRONMENTAL IMPACT STATEMENT ON MANAGEMENT OF CERTAIN PLUTONIUM RESIDUES AND SCRUB ALLOY STORED AT THE ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE; U.S. DEPARTMENT OF ENERGY; NOVEMBER 1997

The following provides New Mexico Environment Department (NMED) comments concerning the above-referenced Draft Environmental Impact Statement (DEIS).

1. The "proposed action" is a combination of Alternatives 2 and 3, making it unlikely that all of the possible waste processing will be conducted at the Los Alamos National Laboratory (LANL). However, if any processing is done at LANL, waste containing plutonium will be transported in New Mexico. Waste transport standards should be at least as protective as those for other transuranic waste. Since most of LANL's waste processing capability has been committed to other programs, additional impacts at TA-55 (the Plutonium Facility) and TA-50 (the Liquid Waste Treatment Facility), should be considered. Also, since low-level radioactive waste could be generated, availability of storage at the Low Level Waste Disposal Facility at TA-54 should be considered.

2. Currently LANL has no authority to receive mixed waste (residues) not generated at LANL from off-site. This issue, if applicable, would have to be addressed with a Resource Recovery Conservation Act (RCRA) Permit Modification Application and should be indicated in the DEIS.

3. The Environmental Protection Agency (EPA) is in the process of authorizing only certain types of transuranic waste for acceptance at WIPP which does not currently include treated residues as mentioned in the DEIS. The document should describe in detail the steps for authorization by EPA (and DOE's interaction in the process) of the residue waste prior to acceptance at WIPP. Integral to this procedure is the "ownership" of the residues, once they have been transferred to LANL from Rocky Flats Environmental Technology Site (RFETS). Will the waste be sent to WIPP under the LANL or the RFETS certification authority as granted by EPA? Those issues should be addressed in the DEIS to assure the public that the residues, upon treatment at LANL, would be sent to WIPP rather than stored due to lack of proper authorization and planning.

4. The first line on Page D-75 refers to Table D-23; the table, however, has no information concerning fission gas and iodine released addressed in this bullet. As a result, we recommend the insertion in the DEIS of a correct reference or a complete table.

5. Vol. 2,. Page D-44, Table D-45. Although the source terms for the analyses of each process are listed, it was difficult to determine how these transuranic activities were calculated. The document should delineate how the source terms were determined to allow for an evaluation of the methodology.

6. Vol. 1, page 3-55, Section 3.3.3. A wind rose from 1991 is included in this section with text in the paragraph to describe it. The year 1991, however, was not used in the radiological air quality analysis, instead the years 1993-1996 (vol. 2 p. D-30) were used. Why is the wind rose from 1991 used in Vol. 1 but not used in the analysis? Was 1991 chosen for a specific reason? If so, the document should indicate why. The same situation occurs for Rocky Flats, where a wind rose from 1990 is depicted in Vol. 1, p.3-10 but data from 1994-1996 were used for the radiological impact analysis (Vol. 2, page D-10).

We appreciate the opportunity to comment on this document. Please let us know if you have any questions.

Sincerely,

Gedi Cibas, Ph.D.
Environmental Impact Review Coordinator

NMED File No. 1131ER

COVER SHEET

Responsible Agency: United States Department of Energy (DOE)

Title: Draft Environmental Impact Statement on Management of Certain Plutonium Residues and Scrub Alloy Stored at the Rocky Flats Environmental Technology Site

Contact: For further information, or to submit comments concerning this Draft Environmental Impact Statement (EIS), contact:

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Abstract: DOE proposes to process certain plutonium-bearing materials being stored at the Rocky Flats Environmental Technology Site (Rocky Flats) located near Golden, Colorado. These materials are plutonium residues and scrub alloy remaining from nuclear weapons manufacturing operations formerly conducted by DOE at this site. In their present forms, these materials cannot be disposed of or otherwise dispositioned because they contain plutonium in concentrations exceeding DOE safeguards termination requirements. Defense Nuclear Facilities Safety Board Recommendation 94-1 addressed health and safety concerns with the management of plutonium residues and scrub alloy at Rocky Flats. The proposed processing will address the concerns raised by the Board and also will prepare the plutonium residues and scrub alloy for disposal or other disposition.

DOE has identified and assessed three technical alternatives for processing these plutonium-bearing materials: (1) *No Action*, (2) *Processing without Plutonium Separation*, and (3) *Processing with Plutonium Separation*. Under the No Action Alternative, DOE would stabilize the materials for safe storage at Rocky Flats for the indefinite future or for disposal if safeguards termination limit variances can be applied. Under the Processing without Plutonium Separation Alternative, DOE would conduct more extensive operations at Rocky Flats to process the materials for disposal. Under the Processing with Plutonium Separation Alternative, DOE would remove most of the plutonium from the plutonium-bearing materials in preparation for disposal or other disposition. Rocky Flats, the Savannah River Site, and Los Alamos National Laboratory are the reasonable sites for processing with plutonium separation. Any plutonium resulting from separation processes would be placed in safe and secure storage pending disposition in accordance with decisions to be reached after completion of the Surplus Plutonium Disposition Environmental Impact Statement. The remaining material would be prepared for disposal.

Public Comment: Comments on this Draft EIS may be submitted through the end of the 45-day comment period, which will commence with the issuance of a Notice of Availability from the U.S. Environmental Protection Agency. Comments received after the end of the comment period will be considered to the extent practicable. Comments may be submitted in writing to DOE at the address indicated above. Oral or written comments may also be submitted at public meetings to be held during the comment period on dates and locations to be announced in the *Federal Register* and via other public media shortly after issuance of the Draft EIS. All comments will be considered in the preparation of the Final EIS.

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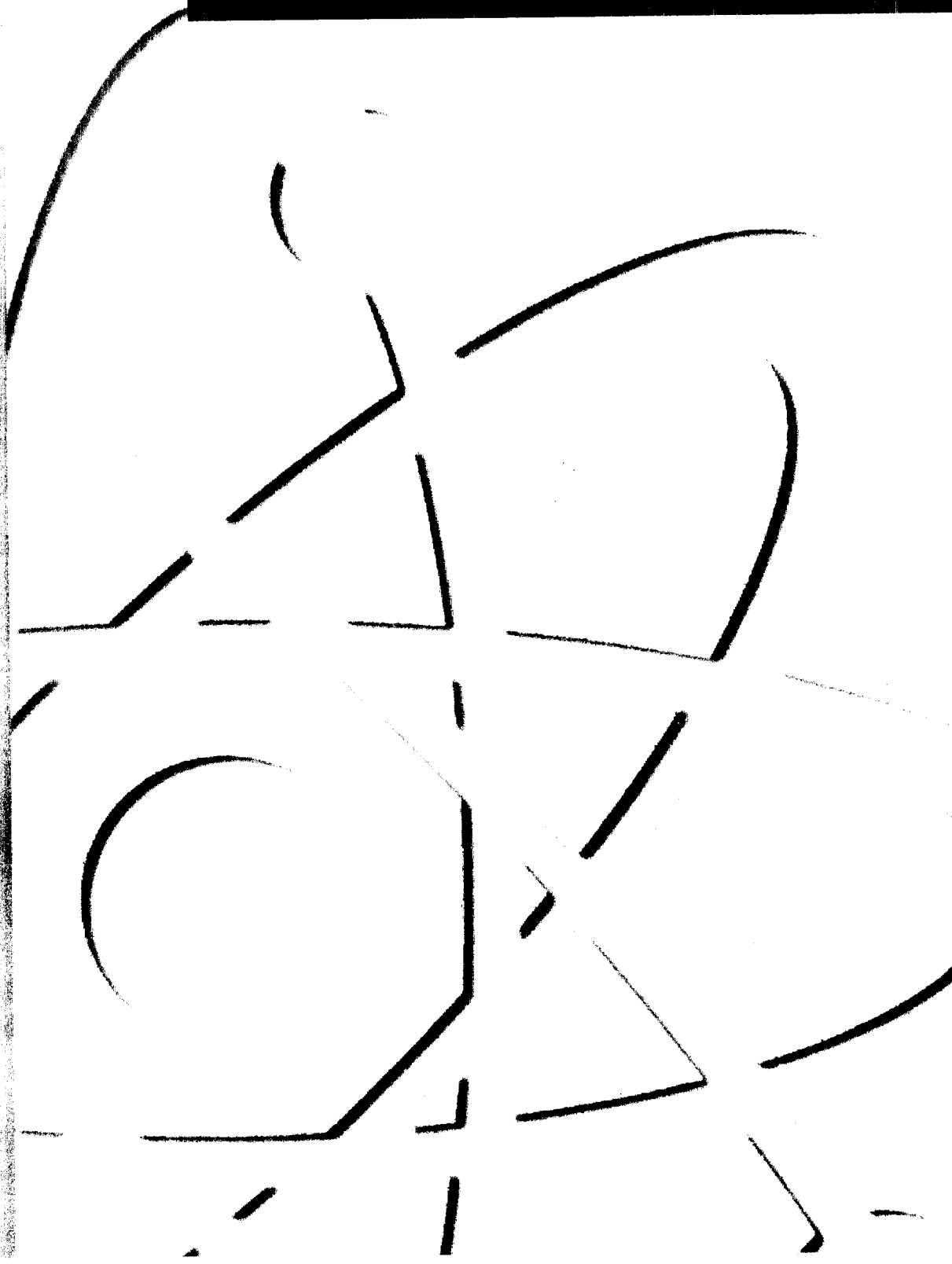

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Acronyms and Abbreviations

ACRONYMS AND ABBREVIATIONS

Acronyms and Abbreviations

Board	Defense Nuclear Facilities Safety Board
CFR	Code of Federal Regulations
DOE	U.S. Department of Energy
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
IDC	Item Description Code
NEPA	National Environmental Policy Act
NRC	Nuclear Regulatory Commission
Rocky Flats	Rocky Flats Environmental Technology Site
WIPP	Waste Isolation Pilot Plant

Chemicals and Units of Measure

ac	acre
Al/NO_3	aluminum nitrate
BTU	British thermal unit
Ci	curie
cm	centimeter
Co	carbon monoxide
ft	foot
g	gram
gal	gallon
ha	hectare
HAN	hydroxylamine nitrate
hr	hour
in	inch
kg	kilogram
km	kilometer
km/sec	kilometers per second
KOH	potassium hydroxide
kW	kilowatt
L	liter
lb	pound
m	meter
m/s	meters per second
M	molar
mg	milligram
mi	mile
mi/sec	miles per second
min	minute
mm	millimeter
mph	miles per hour
mrem	millirem
MWe	megawatts electric
MWh	megawatt hours
n	neutron
nCi	nanocuries
oz	ounce
Pb	lead
ppm	parts per million
rad	radiation absorbed dose
yd	yard
yr	year
°C	degrees Celsius
°F	degrees Fahrenheit

Appendix A

Supplementary Information

Notice of Intent

Frequency: One time.
Affected Public: Individuals or households; Not-for-profit institutions.
Reporting Burden and Recordkeeping:
Responses: 1,600
Burden Hours: 520
Abstract: This submission contains four versions of an instrument to be used in data collection for the summative evaluation of the Eisenhower National Clearinghouse (ENC) dissemination model. Subjects for two of the surveys will be selected through stratified random sampling of U.S. schools to obtain representative samples of principals and teachers, the largest target audience for ENC information and resources. The other two surveys will target known users of ENC services, these individuals being sub-classified as single- and multiple-instance users. The instruments will be distributed by mail in a single data collection effort. All responses are voluntary. Information yielded will form one part of the National Evaluation, and will be included in the Evaluation Report to the U.S. Department of Education.

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BILLING CODE 4000-01-P

DEPARTMENT OF ENERGY

Notice of Intent to Prepare an Environmental Impact Statement on Management of Certain Plutonium Residues and Scrub Alloy Stored at the Rocky Flats Environmental Technology Site

AGENCY: Department of Energy.
ACTION: Notice of intent.

SUMMARY: The Department of Energy (DOE) announces its intent to prepare an Environmental Impact Statement (EIS) pursuant to the National Environmental Policy Act (NEPA), in accordance with the Council on Environmental Quality (CEQ) Regulations for Implementing the Procedural Provisions of NEPA and the DOE NEPA implementing regulations. This EIS will evaluate the potential environmental impacts associated with reasonable management alternatives for certain plutonium residues and all scrub alloy currently being stored at the Rocky Flats Environmental Technology Site in Golden, Colorado. The residues and scrub alloy are materials that were generated during the separation and purification of plutonium, or during the manufacture of plutonium-bearing components for nuclear weapons. Due to the risk they present, DOE previously decided to stabilize and repackage the plutonium residues at the Rocky Flats Site for safe interim storage as discussed in the Solid Residue Treatment, Repackaging, and Storage Environmental Assessment/Finding of No Significant Impact. The activities analyzed in this EIS would be in addition to certain activities described in the Solid Residue Environmental Assessment by subjecting a portion of those residues to further treatment to prepare them for disposal or other disposition. This EIS will also analyze management activities for scrub alloy. This notice describes the proposed scope of the EIS and requests that members of the public submit comments regarding the scope of the EIS. Comments may be submitted in writing at the public scoping period and orally during public scoping meetings as described below.

DATES: The public scoping period begins with the publication of this notice and will continue until December 19, 1996. Written comments postmarked by that date will be considered in preparation of the EIS. Comments postmarked after that date will be considered to the extent practicable.

Public Scoping meetings will be held at the locations and times specified below. This information will also be announced in local public notices before the planned meetings.

Meeting: Rocky Flats Environmental Technology Site.
Date: Tuesday, December 3, 1996.
Time: 6:30 PM to 9:30 PM.
Location: Rocky Flats Environmental Technology Site, Building 060 (Outside the West Gate), State Highway 93, Golden, Colorado 80402.
Contact for the Golden Meeting: Mr. Mike Konczal, Telephone: (303) 966-5993.

Meeting: Savannah River Site.
Date: Thursday, December 12, 1996.
Time: 6:30 PM to 9:30 PM.
Location: North Augusta Community Center, 101 Brookside Drive, North Augusta, South Carolina 29841, (803) 441-4290.
Contact for the North Augusta Meeting: Mr. Andrew R. Grainger, Telephone: 1-800-242-8269.

ADDRESSES: Written comments on the scope of the Rocky Flats Plutonium Residues and Scrub Alloy EIS, including issues to be addressed, questions about the plutonium residues, and/or requests for copies of the draft EIS should be sent to the following address: Mr. Charles R. Head, Office of Nuclear Material and Facility Stabilization (EM-60), United States Department of Energy, 1000 Independence Avenue, S.W., Washington, D.C. 20585, Telephone: 202-586-9441, Facsimile: 202-586-5256.

Members of the public who request a copy of the draft EIS should specify whether they would like a copy of the entire draft EIS (which will consist of multiple bound volumes), or if they would prefer a copy of the Summary of the draft EIS (which will be a brief single volume).

FOR FURTHER INFORMATION CONTACT: For further information on the Rocky Flats Plutonium Residues and Scrub Alloy EIS, please contact Mr. Charles R. Head at the address specified above under the heading **ADDRESSES**.

For general information on the DOE NEPA review process, please contact: Ms. Carol Borgstrom, Director, Office of NEPA Policy and Assistance (EH-42), U.S. Department of Energy, 1000 Independence Avenue, S.W., Washington, D.C. 20585, Telephone: 202-586-4600 or leave a message at 800-472-2756.

Addresses of reading rooms where additional Rocky Flats Plutonium Residues and Scrub Alloy EIS information is available are listed below in the section entitled "Public Scoping Process".

SUPPLEMENTARY INFORMATION: DOE announces its intent to prepare an Environmental Impact Statement pursuant to the National Environmental Policy Act (NEPA) (42 U.S.C. § 4321, *et seq.*), in accordance with the Council on Environmental Quality Regulations for Implementing the Procedural Provisions of NEPA (40 CFR Parts 1500-1508) and the DOE NEPA implementing regulations (10 CFR Part 1021) to evaluate reasonable alternatives for management of certain plutonium residues and all of the scrub alloy at the Rocky Flats Site in Golden, Colorado. Plutonium residues and scrub alloy are materials that were generated while processing plutonium during the manufacture of components for nuclear weapons. The management alternatives to be analyzed include treatment of these materials to enable them to be disposed of as waste or, for some surplus weapons-usable material, otherwise dispositioned.

Purpose and Need

Stabilization activities to mitigate the risks associated with the current storage condition of plutonium residues (e.g., deteriorating and overpressurized storage containers, and ignitability concerns) are in progress at the Rocky Flats Site based on the decisions resulting from the Solid Residue Treatment, Repackaging, and Storage

Environmental Assessment/Finding of No Significant Impact, issued in April 1996 (DOE/EA-1120, the "Solid Residue Environmental Assessment'). The Solid Residue Environmental Assessment addressed the potential environmental impacts associated with stabilizing the entire 106,600 kg inventory of Rocky Flats Site plutonium residues to allow its safe interim storage until the final disposition of the residues could be decided upon and implemented. However, due to the need for expeditious action to resolve problems with storage of the plutonium residues at Rocky Flats, the Solid Residues Environmental Assessment did not address disposal or other disposition of the residues after these materials were stabilized. Decisions regarding treatment of these materials for purposes other than stabilization, i.e., disposal or other disposition,[1] will require the evaluation of several treatment technologies and thus were considered to require a lengthier and more complex evaluation process than could be completed in time to meet the more immediate need to make and implement stabilization decisions.

DOE has determined that, even after stabilization, approximately 42,300 kg of the total of about 106,600 kg of plutonium residues currently in storage at Rocky Flats would remain in forms that, although not directly weapons usable, would contain sufficiently high concentrations of plutonium so as to not meet the safeguards termination requirements for disposal.[2] Because of the plutonium concentration and the relative ease with which plutonium could be recovered from the residues, such residues could be attractive to terrorist organizations as a source of plutonium (about 2,600 kg could be separated from the Rocky Flats residues and scrub alloy) for use in nuclear weapons or other terrorist devices. Diluting these materials could reduce the plutonium concentrations sufficiently to meet disposal requirements but, for many samples of the residues, probably would yield an extremely large waste volume that would be very costly to transport and dispose of. Therefore, in addition to dilution, alternatives need to be considered, such as treatments that would either bind the plutonium in a matrix from which it would be difficult to extract, or treatments that would separate the plutonium from the remaining constituents of the residues and scrub alloy. Any separated plutonium would not be used for nuclear weapons purposes, but would be safely stored in secure facilities with other similar materials, pending disposition (see footnote 1). Whenever feasible, DOE would offer such storage facilities to be placed under International Atomic Energy Agency (IAEA) safeguards. For the other 64,300 kg of plutonium-bearing residues currently in storage at the Rocky Flats Site, the activities discussed in the Solid Residue Environmental Assessment will meet the transuranic waste disposal and safeguards termination requirements and will not be addressed in this EIS.

This EIS will evaluate reasonable management alternatives for the approximately 42,300 kg of plutonium residues discussed above, including treatment of the material to a form and concentration that is suitable for disposal or other disposition. Evaluation of these alternatives at this time will facilitate planning for disposal or other disposition, and allow any additional treatment to be integrated with the on-going stabilization process so that handling the material can be minimized (i.e., by avoiding potential double handling). Minimizing such handling would reduce the worker risk associated with achieving a material form suitable for disposal or other disposition.

In addition to the residues discussed above, approximately 700 kg of scrub alloy (predominately a magnesium/aluminum/americium/plutonium metal mixture) currently in storage at the Rocky Flats Site, containing about 200 kg of plutonium, also needs treatment before being suitable for disposal or other disposition. Due to similarities in the issues related to the management of the scrub alloy and the plutonium residues, management alternatives for the scrub alloy will also be analyzed in this EIS.

The entire inventory of plutonium residues currently stored at Rocky Flats is included in the Draft Waste Management Programmatic Environmental Impact Statement (WMPEIS) under the assumption that it may be managed as transuranic waste. The WMPEIS analyzes storage and treatment configurations (i.e., centralized, regionalized and decentralized treatment and storage) for transuranic wastes, including the Rocky Flats plutonium residues. The analysis of alternatives in this EIS will take into account the analyses of alternatives in the WMPEIS and the decisions made in any Records of Decisions that may result from those analyses.

Background

Plutonium residues and scrub alloy were generated by processes used to recover and purify plutonium and manufacture components for nuclear weapons. Approximately 125,000 kilograms (kg) of residues (containing about 5,800 kg of plutonium) and approximately 700 kg of scrub alloy (containing about 200 kg of plutonium) are currently stored at various DOE sites. Of these totals, approximately 106,600 kg of the residues (containing about 3,000 kg of plutonium), and nearly all of the scrub alloy are stored in various types of containers in six former plutonium production facilities at the Rocky Flats Site. The remaining approximately 18,400 kg of plutonium residues are stored at the Savannah River Site in South Carolina, the Hanford Site in Washington, Los Alamos National Laboratory in New Mexico, and Lawrence Livermore National Laboratory in California. About 6 kg of scrub alloy are stored at the Savannah River Site. Stabilization activities for the approximately 18,400 kg of plutonium residues and 6 kg of scrub alloy not located at the Rocky

[1] After treatment, the Rocky Flats residues and scrub alloy could be disposed of as transuranic wastes or, depending on the treatment, could be transformed or chemically altered so as to concentrate the plutonium for other disposition (see below). "Transuranic" refers to elements, such as plutonium, that have an atomic number greater than that of uranium. The disposal of transuranic waste at the Waste Isolation Pilot Plant (WIPP) is being analyzed in the Draft Waste Isolation Pilot Plant Disposal Phase Supplemental Environmental Impact Statement. DOE is developing WIPP, near Carlsbad, New Mexico, as a potential disposal facility for transuranic wastes. DOE is evaluating the disposition of weapons-usable plutonium, which would be relevant if the residue or scrub alloy materials were treated to separate the plutonium from other constituents. Such potential uses include using the plutonium in mixed oxide fuel for power reactors, immobilization, and disposal in a deep borehole.

As a result of the potential for disposal of these materials at WIPP, "disposal requirements" for the residues and scrub alloy refers to the Planning Basis Waste Acceptance Criteria for WIPP (or alternative treatment level, depending on decision in the Record of Decision for the WIPP SEIS II), and any other requirements that must be met to allow disposal, such as safeguards termination requirements. Requirements for other disposition will be developed as part of detailed NEPA analyses that will be tiered from the Storage and Disposition of Weapons-Usable Fissile Materials Programmatic Environmental Impact Statement (draft issued by DOE in February 1996; also see item 6 under "Related NEPA Documentation" in this Notice).

[2] Materials that could be used to fuel nuclear weapons (e.g., Uranium-235 or Plutonium-239) are required to be placed under a system of controls and protections to ensure that they are not misused or lost. This system of controls and protections is referred to as "safeguards." In general, wastes that contain large enough concentrations of nuclear weapons-usable materials cannot be disposed of unless actions (such as reducing the concentration of nuclear weapons usable materials, or immobilizing such materials so that they would be exceptionally difficult to recover) are taken that make it no longer necessary to "safeguard" them. The requirements that define the state into which such wastes must be converted in order for them no longer to require "safeguards" are referred to as "safeguards termination requirements".

Flats Site are analyzed in NEPA reviews that have already been completed or are currently underway. These reviews are listed and summarized in the section of this notice titled "Related NEPA Documentation." The final approximately 5 kg of plutonium residues are located at several DOE sites, each having an inventory of less than 1 kg. Treatment options for these plutonium residues have been identified or are in the process of being defined by the managements of the installations at which these residues are stored.

The plutonium residues at the Rocky Flats Site that require treatment beyond stabilization prior to disposal or other disposition consist of four categories: ash, salts, wet residues, and direct repackage residues. The residues are grouped into these categories due to chemical similarities or similarities in the manner in which they could be managed. All these residue categories and scrub alloy will be discussed in this EIS and are briefly described below. The approximate quantities in each category requiring treatment beyond stabilization to prepare them to meet the requirements for disposal or other disposition are noted.[3]

1. Ash Residues. The ash residue category consists of approximately 28,000 kg of material containing approximately 1,100 kg of plutonium in three basic groups. Examples from each group are: (a) Incinerator ash, firebrick heels and fines, and soot; (b) pulverized sand, slag and crucible; and (c) graphite fines. Approximately 71 percent of the ash residue inventory (~19,900 kg) would require treatment beyond stabilization for disposal in WIPP or other disposition.

2. Salt Residues. The salt residue category consists of about 16,000 kg of material containing approximately 1,000 kg of plutonium and can be further sub-divided into three groups: electrorefining salts, molten salt extraction salts, and direct oxide reduction salts. These salts consist primarily of sodium chloride, potassium chloride and magnesium chloride. Approximately 93 percent of the salt residue inventory (~14,900 kg) would require treatment beyond stabilization for disposal in WIPP or other disposition.

3. Wet Residues. The wet residues consist of approximately 17,000 kg of material containing approximately 600 kg of plutonium and are made up of a disparate assembly of materials, such as wet (aqueous and organic contaminated) combustibles, plutonium fluorides, high efficiency particulate air filter media, sludges and Raschig (glass) rings. Approximately 26 percent of the wet residue inventory (~4,400 kg) would require treatment beyond stabilization for disposal in WIPP or other disposition.

4. Direct Repackage Residues. The direct repackage residue category consists of about 39,000 kg of material, containing about 300 kg of plutonium, and comprises those plutonium residues that are considered to be stable and do not require stabilization for storage. These residues consist of materials such as paper, rags, cloth, plastic, personal protective equipment, and gaskets. Approximately 8 percent of the direct repackage residue (~3,100 kg) would require treatment for disposal in WIPP.

5. Scrub Alloy. Scrub alloy is predominately a magnesium/aluminum/americium/plutonium metal mixture that was created as an interim step in plutonium recovery. The entire Rocky Flats scrub alloy inventory of approximately 700 kg, containing approximately 200 kg of plutonium, will require treatment to put it in a form that would meet the requirements for disposal in WIPP or other disposition.

Preliminary Alternatives

Discussed below are the preliminary alternatives identified for management of certain Rocky Flats Site plutonium residues (approximately 42,300 kg) and scrub alloy (approximately 700 kg), including transportation to reasonable treatment sites and treatment to prepare them for disposal or other disposition. DOE welcomes comments on these or other reasonable alternatives and on the identification of a preferred alternative.

Alternative 1—No Action: The No Action alternative consists of ongoing residue storage activities, and activities addressed in the Solid Residue Treatment, Repackaging, and Storage Environmental Assessment/Finding of No Significant Impact, plus the on-site storage of the scrub alloy inventory in its current form. Under the No Action alternative, stabilization, repackaging, and monitoring of the entire plutonium residue inventory for safe interim storage would continue. Interim storage would be in containers and under conditions appropriate for a period of approximately 20 years, with approximately 64,300 kg of the residues prepared for waste disposal. The other 42,300 kg of plutonium residues and the scrub alloy would remain in a form that is not suitable for disposal as waste, or other disposition.

Alternative 2—On-Site Treatment: This alternative would involve treatment at the Rocky Flats Site, as discussed below:

a. Treatment Without Plutonium Separation—This alternative includes treating the plutonium residues or scrub alloy to prepare the material for disposal as waste without removal of the plutonium. This treatment alternative would use techniques such as immobilization, (e.g., ceramification or vitrification), or dilution by blending with other matrix materials (e.g., blending the salt residues with depleted uranium oxide or additional salt). The resulting waste form would meet the planning basis waste acceptance criteria for disposal in WIPP. The material would no longer be attractive as a potential source of plutonium since it would be in a physical and chemical form from which it would be difficult to recover the plutonium, or the resulting material would have too low a concentration of plutonium. However, the dilution approach would result in substantially greater amounts of transuranic waste.

b. Treatment With Plutonium Separation—Plutonium separation would consist of removing the plutonium from the residue or scrub alloy. Plutonium separation would generate two distinct forms of material; a treated waste form and a plutonium metal or oxide. The treated waste would meet the planning basis waste acceptance criteria for disposal in WIPP. The plutonium metal or oxide would be in a form that would be suitable for disposition in accordance with the decisions resulting from the Storage and Disposition of Weapons-Usable Fissile Materials Programmatic EIS. The Rocky Flats Plutonium Residues and Scrub Alloy EIS will include analysis of any actions needed to manage separated plutonium until the decisions resulting from the Storage and Disposition of Weapons-Usable Fissile Materials Programmatic EIS are implemented. Under this treatment alternative, there would be no need to dilute the plutonium-bearing materials to allow them to meet transuranic waste disposal requirements, although other types of waste would be produced that are more easily disposed of.[4] The recovered

[3] As noted previously in this Notice, a total of approximately 106,600 kg of plutonium residues is currently in storage at Rocky Flats. Of this total, approximately 6,600 kg is in a residue category designated "Classified Shapes" that does not require treatment beyond that analyzed in the Solid Residue Environmental Assessment. This leaves approximately 100,000 kg of residues in the four listed categories, 42,300 kg of which will need additional treatment beyond that analyzed in the Solid Residue Environmental Assessment. The scrub alloy is not a plutonium residue, and thus is not included in the 100,000 kg residue total.

[4] Both low-level radioactive and hazardous wastes could be generated as a result of such treatment. Any hazardous wastes would be sent to a licensed

plutonium could not be used for nuclear explosive purposes under the DOE Secretarial policy established in December 1994.[5]

Alternative 3—Off-Site Treatment: Under this alternative, the plutonium residues or scrub alloy would be treated off-site using various treatment technologies, with or without plutonium separation, as discussed under Alternative 2 above. The plutonium residues might require pre-treatment at Rocky Flats to modify the material composition and physical packaging so that the material would be in a condition suitable for transportation. Potential locations for off-site treatment include: the Savannah River Site, the Los Alamos National Laboratory (LANL), and the Lawrence Livermore National Laboratory (LLNL). The Savannah River Site has the capability to treat most residues and all scrub alloy efficiently. LANL and LLNL each have facilities that could treat only part of the salt residues (about 13,400 kg), but at much slower rates than treatment at the Savannah River Site. The cost of treatment at LANL and LLNL is expected to be slightly higher than the cost of treatment at the Savannah River Site. None of these facilities, including the Rocky Flats Site, currently is capable of treating all of the ash residues. Further, treatment at LANL and LLNL may be difficult to accommodate in light of the other missions of those sites. Taking account of all these circumstances, the Savannah River Site appears to be a more likely offsite location for treating the Rocky Flats plutonium residues and scrub alloy than LANL or LLNL. Nevertheless, DOE cannot rule out the possibility that further analysis or changing circumstances might provide reasons to treat some of these materials at LANL or LLNL.

Any plutonium that might be separated under the "Treatment With Plutonium Separation" option would be placed in storage pending implementation of decisions made after completion of the Storage and Disposition of Weapons-Usable Fissile Materials Programmatic EIS. As specified for Alternative 2.b above, the Rocky Flats Plutonium Residues and Scrub Alloy EIS will include analysis of any actions needed to manage separated plutonium until the decisions made after completion of the Storage and Disposition of Weapons-Usable Fissile Materials Programmatic EIS are implemented.

Public Scoping Process

To ensure that the full range of issues related to the Rocky Flats Plutonium Residues and Scrub Alloy EIS is addressed, comments on the proposed scope of the EIS are invited from all interested parties during the scoping period. Written comments should be directed to Mr. Charles R. Head at the address indicated above under the heading **ADDRESSES**. Agencies, organizations, and the general public are also invited to present oral comments at the public scoping meetings to be held at the times and dates listed in the **DATES** section above.

Written and oral comments will be given equal consideration. Individuals desiring to speak at a public scoping meeting (or meetings) should pre-register by telephoning or writing the contact person(s) designated for the meeting as specified above in the **DATES** section of this Notice. Pre-registration should occur at least four days before the designated meeting. Persons who register at the meeting will be called on to speak as time permits, after the pre-registered speakers.

To ensure that everyone has an adequate opportunity to speak, each speaker at a scoping meeting will be allotted five minutes. Depending on the number of persons who request an opportunity to speak, more time may be allowed for speakers representing several parties or organizations. Persons wishing to speak on behalf of organizations should identify the organization in their request. Written comments also will be accepted at the meetings, and speakers at scoping meetings are encouraged to provide written versions of their oral comments for the record.

DOE will record and prepare transcripts of the oral comments received during the public scoping meetings. Interested persons will be able to review the transcripts, written comments, reference material, related NEPA documents, and background information during normal business hours at the following locations:

U.S. Department of Energy, Freedom of Information Room, Room 1E-190, Forrestal Building, 1000 Independence Avenue, S.W., Washington, D.C. 20585, Telephone: 202-586-6020

U.S. Department of Energy, Public Reading Room, Gregg Graniteville Library, 171 University Parkway, Aiken, South Carolina 29801, Telephone: 803-641-3465

County Library, 2002 Bull Street, Savannah, Georgia 31299-430, Telephone: 912-234-5127

County Library, 404 King Street, Charleston, South Carolina 29403, Telephone: 803-723-1645

Rocky Flats Citizens Advisory Board, Public Reading Room, 9035 Wadsworth Avenue, Suite 2250, Westminster, Colorado 80021, Telephone: 303-420-7855

Standley Lake Public Reading Room, 8485 Kipling Street, Arvada, Colorado 80005, Telephone: 303-456-0806

U.S. Department of Energy, Golden Field Office, Public Reading Room, 14869 Denver West Parkway, Golden, Colorado 80401, Telephone: 303-275-4742

U.S. EPA Superfund Records Center, 999 18th Street, 5th Floor, Denver, Colorado 80202-2405, Telephone: 303-312-6473

Colorado Department of Public Health and Environment, Information Center, 4300 Cherry Creek Drive South, Denver, Colorado 80222, Telephone: 303-692-2037

Rocky Flats Public Reading Room, Front Range Community College Library, 3645 West 112th Avenue, Westminster, Colorado 80030, Telephone: 303-469-4435

Albuquerque Operations Office, National Atomic Museum, 20358 Wyoming Blvd. S.E., Kirtland Air Force Base, P.O. Box 5400, Albuquerque, New Mexico 87185-5400, Telephone: 505-845-4378

Los Alamos Community Reading Room, 1450 Central, Suite 101, Los Alamos, New Mexico 87544, Telephone: 505-665-2127

Lawrence Livermore National Laboratory, East Gate Visitors Center, Greenville Road, Livermore, California 94550, Telephone: 510-424-4026

Oakland Operations Office, U.S. Department of Energy, Public Reading Room, EIC, 8th Floor, 1301 Clay Street, Oakland, California 94612-5208, Telephone: 510-637-1762

DOE plans to issue the draft EIS in the Spring of 1997. DOE will announce availability of the draft in the Federal Register and other media, and will provide the public, organizations, and agencies with an opportunity to submit comments. These comments will be considered and addressed in the final EIS, scheduled for issuance in the Fall of 1997.

Preliminary Issues: DOE has preliminarily identified the

commercial treatment, storage and disposal facility. Any low-level radioactive wastes would be disposed of along with other low-level radioactive wastes generated at the Rocky Flats Site.

[5] Such plutonium would be stabilized, packaged for storage (under DOE safe storage criteria suitable for 50 years) and would be stored at Rocky Flats pending implementation of storage and disposition decisions. While in storage, the plutonium metal/oxide would remain safe and in a secured facility.

environmental issues listed below for analysis in the Rocky Flats Plutonium Residues and Scrub Alloy EIS. This list is presented to facilitate discussion concerning the scope of the EIS and is not intended to exclude consideration of other pertinent issues that may be suggested during the scoping period or to predetermine the scope of the EIS. DOE invites comments on these and any other issues relevant to the analysis in the EIS. The environmental issues identified by DOE are as follows:

1. Public and Occupational Safety and Health: The potential radiological and non-radiological impacts of the management alternatives for the plutonium residues and scrub alloy, including projected effects on workers and the public from routine operations and potential accidents at the Rocky Flats Site, Savannah River Site, Los Alamos National Laboratory, and Lawrence Livermore National Laboratory, and along transportation routes from the Rocky Flats Site to the other sites.

2. Environmental Media: Potential impacts on soil, water, and the air.

3. Sensitive Environmental Resources: Potential impacts on plants, animals, and habitat, including impacts to flood plains, wetlands, and threatened and endangered species and their habitat.

4. Resource Consumption: Potential impacts from consumption of natural resources and energy, including water, natural gas, and electricity.

5. Socioeconomic: Potential impacts on local communities, including labor force employment and support services.

6. Environmental Justice: Potential for disproportionately high and adverse impacts of DOE activities on minority and low-income populations.

7. Cultural Resources: Potential impacts on cultural resources, such as historic, archaeological, scientific, or culturally important sites.

8. Regulatory Compliance: The impacts of the alternatives on compliance of the Rocky Flats Site, Savannah River Site, Los Alamos National Laboratory, and Lawrence Livermore National Laboratory with applicable Federal and state laws and regulations.

9. Cumulative Impacts: The impacts of these alternatives in conjunction with other past, present and reasonably foreseeable future actions regardless of agency (Federal or non-federal) or persons undertaking such other actions.

10. Potential Irreversible and Irretrievable Commitment of Resources: The potential irreversible and irretrievable commitment of resources that would be involved in each alternative.

11. Non-Proliferation and International Plutonium-processing Policy: The potential impacts to international policy regarding the non-proliferation of nuclear weapons and processing of plutonium that would be involved with the alternatives involving separation of plutonium.

Related NEPA Documentation: Documents that have been or are being prepared that may relate to the scope of the Rocky Flats Plutonium Residues and Scrub Alloy EIS include the following:

12. *Solid Residue Treatment, Repackaging, and Storage Environmental Assessment* (DOE/EA-1120) and Finding of No Significant Impact, issued April 1996. This Environmental Assessment addressed the stabilization of the plutonium residue inventory currently at the Rocky Flats Site. The actions being implemented based on the Environmental Assessment are included in the No Action alternative of the Rocky Flats Plutonium Residues and Scrub Alloy Environmental Impact Statement.

13. *Rocky Flats Site-wide Environmental Impact Statement Notice of Intent* (59 FR 40011, August 5, 1994). This Notice announced DOE's intention to prepare a site-wide EIS for the Rocky Flats Environmental Technology Site. In a Federal Register Notice dated July 17, 1996, DOE deferred completion of the Site-wide EIS pending the completion of a new cleanup agreement (since completed) with the Environmental Protection Agency and the State of Colorado and decisions that may result from issuance of the WM PEIS (see item 5, below).

14. *Interim Storage of Plutonium at the Rocky Flats Environmental Technology Site Environmental Impact Statement Notice of Intent* (61 FR 37247, July 17, 1996). This Notice announced DOE's intention to prepare an environmental impact statement to evaluate the alternatives for providing safe interim storage of approximately 10 metric tons of plutonium at the Rocky Flats Environmental Technology Site pending implementation of decisions based on the Storage of Disposition of Weapons—Usable Fissile Materials Programmatic EIS. Any plutonium that would be separated through the treatment at Rocky Flats of residu: ınd scrub alloy would be stored in accordance with decisions that may result from the analysis in the Interim Storage of Plutonium at the Rocky Flats Environmental Technology Site EIS, pending implementation of decisions based on the Storage and Disposition of Weapons—Usable Fissile Materials Programmatic EIS.

15. *Draft Waste Isolation Pilot Plant Disposal Phase Supplemental Environmental Impact Statement* (DOE/EIS-0026-S2). This is the second supplemental EIS for WIPP, a DOE research and development project that is proposed for the disposal of transuranic wastes. The Department's proposed action is to dispose of transuranic waste at the facility. The Notice of Intent for the second supplemental EIS was issued on August 23, 1995 (60 FR 43779). The Rocky Flats plutonium residues (including transportation to WIPP) are considered in the scope of the supplemental EIS. The draft supplemental EIS is scheduled to be issued in late 1996 and the final supplemental EIS and Record of Decision are scheduled to be issued in the Summer of 1997. The Rocky Flats Plutonium Residues and Scrub Alloy EIS will be prepared in coordination with the WIPP supplemental EIS.

16. *Draft Waste Management Programmatic Environmental Impact Statement* (WMPEIS) (DOE/EIS-0200-D, August 1995). The WMPEIS considers alternative approaches for consolidating the management of the Department of Energy's low-level, low-level mixed, hazardous, transuranic, and high-level waste. Records of Decision based on the WMPEIS are scheduled to be issued starting in 1997 and will be made by waste type. The Rocky Flats Phutonium Residues and Scrub Alloy EIS will be prepared in coordination with the WMPEIS and applicable records of decision that may be issued before completion of this EIS.

17. *Draft Storage and Disposition of Weapons—Usable Fissile Materials Programmatic Environmental Impact Statement* (DOE/EIS-0229-D, February 1996). This Programmatic EIS analyzes the potential environmental impacts associated with approaches to storage and disposition of the Department's weapons-usable fissile materials, including plutonium. Under the No Action alternative, Rocky Flats plutonium metals and oxides, including any plutonium metals or oxides generated as part of plutonium residue treatment, would remain at Rocky Flats. Under all other alternatives, stabilized weapons-usable Rocky Flats material would be transferred to another DOE site. The treatment alternatives discussed in this Notice of Intent that involve separation of plutonium would generate weapons-usable plutonium metals and oxides that would be stored and dispositioned according to decisions made based on the Storage and Disposition of Weapons—Usable Fissile Materials Programmatic EIS. The final Storage and Disposition of

Weapons—Usable Fissile Material Programmatic EIS is scheduled to be issued in late 1996.

18. *Final Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory* (DOE/EIS–0157, August 1992, the "LLNL Site-wide EIS"). This document analyzes the potential environmental impacts of a proposed action to continue operation of Lawrence Livermore National Laboratory and Sandia National Laboratories, Livermore. The LLNL site-wide EIS also analyzes the potential environmental impacts associated with a no-action alternative involving continuing operations at FY 1992 funding levels without further growth, an alternative to modify operations to reduce adverse environmental impacts of operations or facilities, and a shutdown and decommissioning alternative. The Record of Decision for the LLNL Site-wide EIS (58 FR 6268, January 27, 1993) announced that DOE had decided to continue the operation of LLNL and Sandia National Laboratories, Livermore, including near-term (within 5 to 10 years) proposed projects. This action included current operations plus programmatic enhancements and facility modifications required to support the research and development missions established for the Laboratories by Congress and the President. The alternatives to be analyzed in the Rocky Flats Plutonium Residues and Scrub Alloy EIS that would involve treatment of a portion of the Rocky Flats plutonium residues at LLNL will represent activities beyond those considered in the LLNL Site-wide EIS.

19. *Los Alamos National Laboratory Site-wide EIS Notice of Intent* (60 FR 92:25697–8, May 12, 1995). This notice announced DOE's intention to prepare a Site-wide EIS to address operations and planned activities at the Los Alamos National Laboratory foreseen in the next 5 to 10 years. DOE anticipates that this EIS will provide an analysis of all activities at LANL and all DOE land management activities related to operations at LANL. The draft LANL Site-wide EIS is scheduled to be issued in mid-1997. The alternatives to be analyzed in the Rocky Flats Plutonium Residues and Scrub Alloy EIS that would involve treatment of a portion of the Rocky Flats plutonium residues at LANL will be prepared in coordination with the analyses being performed for the LANL Site-wide EIS.

20. *Plutonium Finishing Plant Stabilization Environmental Impact Statement* (DOE/EIS–0244, May 1996). This EIS addressed the potential environmental impacts associated with alternative technological processes at the Hanford Site for stabilizing plutonium-bearing materials, including plutonium residues. In the Record of Decision for this EIS (61 FR 36352, July 10, 1996), DOE decided that the plutonium residues having a low plutonium content (less than 50 weight percent) and meeting criteria established by DOE will be immobilized at the Plutonium Finishing Plant through a cementation process and stored pending disposal. This EIS provided the NEPA analyses required for management of the plutonium residues currently stored at the Hanford Site.

21. *Interim Management of Nuclear Materials at the Savannah River Site Environmental Impact Statement* (DOE/EIS–0220, the IMNM EIS). The IMNM EIS addressed the potential environmental impacts associated with alternatives that the Department could implement to stabilize a variety of nuclear materials that are at the Savannah River Site for improved safety or to convert them to another form to support the Department's programs. This analysis also included an evaluation of the alternatives for the treatment of approximately 1,000 kg of plutonium residues and approximately 6 kg of scrub alloy (discussed in IMNM EIS Section 2.3.3, "Plutonium and Uranium Stored in Vaults"), some of which originated at Rocky Flats Site and is currently in storage at the Savannah River Site. Three Records of Decision have been issued for the IMNM EIS (60 FR 65300, December 19, 1995; 61 FR 6633, February 21, 1996; and 61 FR 48474, September 13, 1996), each covering different materials. The decision regarding the plutonium residues and scrub alloy, specified in the first Record of Decision, was to process these materials through the canyon facilities to a form that meets the DOE storage criteria (DOE-STD-3013–94) and to store the plutonium at the Savannah River site.

Issued in Washington, D.C. on this 15th day of November, 1996.

Peter N. Brush,

Acting Assistant Secretary, Environment, Safety and Health.

[FR Doc. 96–29650 Filed 11–15–96; 12:52 pm]

BILLING CODE 6450–01–P

Availability of the Stockpile Stewardship and Management Final Programmatic Environmental Impact Statement

AGENCY: Department of Energy.

ACTION: Notice of availability.

SUMMARY: The Department of Energy (DOE) announces the availability of the Stockpile Stewardship and Management Final Programmatic Environmental Impact Statement (PEIS), DOE/EIS–0236. The Stockpile Stewardship and Management PEIS analyzes the consequences to the environment associated with alternative ways of maintaining the safety and reliability of the nuclear weapons stockpile in the absence of underground nuclear testing.

DATES: The Environmental Protection Agency published its Notice of Availability regarding this Final PEIS on November 15, 1996. DOE intends to issue a Record of Decision on the Stockpile Stewardship and Management PEIS no sooner than 30 days from the publication date of the Environmental Protection Agency Notice of Availability in the Federal Register.

ADDRESSES AND FURTHER INFORMATION: A copy of the entire Final PEIS (five volumes) or its Summary may be obtained upon request by calling 1–800–776–2765, or writing to: Reconfiguration Group, Office of Technical, and Environmental Support, DP–45, U.S. Department of Energy, 1000 Independence Avenue, S.W., Washington, D.C. 20585.

Requests for copies of the Final PEIS can also be made electronically via computer as follows: Federal Information Exchange Bulletin Board, InterNet Address: http://web.fie.com/fedix/doeoor.html, Modem Toll-Free: 1–800–783–3349, DC Metro Modem: 301–258–0953.

For general information on the DOE NEPA process, please contact: Carol M. Borgstrom, Director, Office of NEPA Policy and Assistance, EH–42, U.S. Department of Energy, 1000 Independence Avenue, S.W., Washington DC 20585, (202) 586–4600 or (800) 472–2756.

SUPPLEMENTARY INFORMATION: In response to the end of the Cold War and changes in the world political regimes, the United States is no longer producing new design nuclear weapons and is no longer conducting underground nuclear testing. Instead, the emphasis of the United States' nuclear weapons program is on reducing the size of the Nation's nuclear stockpile by dismantling existing nuclear weapons. The DOE has been directed by the President and Congress to maintain the safety and reliability of the reduced nuclear weapons stockpile in the absence of underground nuclear testing. In order to fulfill that responsibility, DOE has developed the Stockpile Stewardship

Factsheet

MANAGEMENT OF PLUTONIUM RESIDUES AND SCRUB ALLOY

DOE Initiates Environmental Impact Statement

NEPA requires an Environmental Impact Statement for proposed major Federal actions that could have significant impacts on the environment. An Environmental Impact Statement looks at both the short-term and long-term effects of the proposed actions and considers possible mitigation measures.

The Department of Energy is conducting the scoping process for an Environmental Impact Statement (EIS), in accordance with the National Environmental Policy Act, to evaluate alternatives for managing a portion of the plutonium residues and scrub alloy currently stored at the Rocky Flats Environmental Technology Site (RFETS). Alternatives to be evaluated include:

- **No action (continued stabilization for interim storage at RFETS), with residues and scrub alloy left in a form not suitable for disposition;**
- **Further on-site treatment (at RFETS) to prepare for disposal at the Waste Isolation Pilot Plant (WIPP) or other disposition; and**
- **Further off-site treatment to prepare for disposal at WIPP or other disposition.**

Background

From 1952 through the cessation of plutonium manufacturing and processing in 1989, the United States Department of Energy's (DOE) Rocky Flats Plant (now the Rocky Flats Environmental Technology Site or RFETS) produced nuclear weapons components as part of the Nation's defense program. Some of those components were made of plutonium. As a result of the processes used to recover and purify plutonium and manufacture the weapons components, a variety of materials became contaminated with plutonium. These materials include:

- **Plutonium residues**, *primarily in the forms of salts, ash, sludge, and contamination on rags, glass, and metal pieces. Some of the residues also contain hazardous constituents regulated under the Resource Conservation and Recovery Act (RCRA); and*
- **Scrub alloy**, *primarily a magnesium/aluminum/americium/plutonium metal mixture created as an interim step in plutonium recovery.*

In the past, when plutonium manufacturing and processing activities were still being conducted, plutonium was recovered from some of the residues, and the interim step of plutonium recovery resulted in plutonium-bearing scrub alloy. Now that manufacturing and processing activities have ceased, the residues and scrub alloy are stored pending their ultimate disposition. About 85 percent of DOE's plutonium residues and scrub alloy are stored at RFETS, with the bulk of the remainder stored at the Savannah River Site, Hanford Site, Lawrence Livermore National Laboratory, and Los Alamos National Laboratory. This EIS deals only with a portion (about 40 percent) of the residues and scrub alloy stored at RFETS (the remainder is covered under other NEPA reviews).

Residues from processing

Packaged residues

Drums in storage

How Are Plutonium Residues and Scrub Alloy Currently Managed?

The plutonium residues and scrub alloy are currently stored in 55-gallon drums, 10 gallon drums, and other small containers at six former plutonium processing facilities at RFETS. Inside the drums, the materials are in a variety of packaging configurations, such as plastic bags, 1- to 4-liter plastic bottles, 1- to 2-liter stainless steel cans, and 1- to 2-liter tin cans.

Because DOE originally intended to process these residues for plutonium recovery, the current packaging configurations for these residues were not designed for long-term storage. To mitigate risks associated with the current storage situation, stabilization and repackaging activities are currently underway at RFETS to enable safer interim storage of the residues and scrub alloy until final disposition methods are decided upon and implemented. The current stabilization and repackaging activities are addressed in the *Solid Residue Treatment, Repackaging, and Storage Environmental Assessment/Finding of No Significant Impact,* DOE/EA-1120, April 1996.

Why Is Further Treatment Needed?

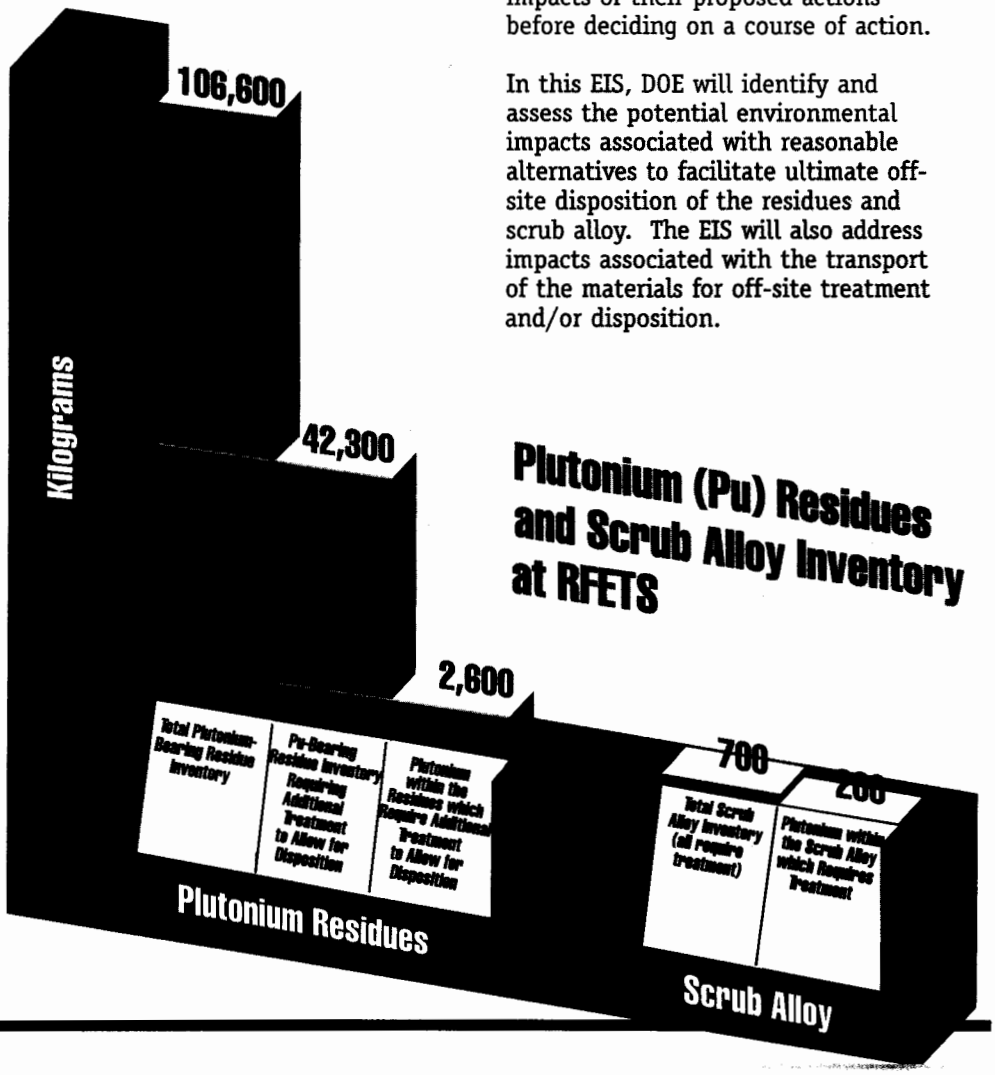
About 40 percent (42,300 kg) of the total 106,600 kg residue inventory cannot be disposed of at WIPP without further treatment, even after stabilization and/or repackaging, because the plutonium concentration of the residues could be attractive to terrorists, or other similar organizations, as a source of plutonium (about 2,600 kg) for use in nuclear weapons or other terrorist devices.

Alternative treatments will be evaluated for the approximately 42,300 kg of plutonium residues and the entire inventory of about 700 kg of scrub alloy (containing about 200 kg of plutonium) to achieve a form and concentration that is suitable for ultimate disposition.

Diluting these materials would reduce the plutonium concentrations sufficiently to meet disposal requirements. However, dilution would increase the waste volume, making it very costly to transport and dispose of the residue material.

Alternatives other than dilution need to be considered, such as treatment that would either bind the plutonium in a matrix from which it would be difficult to extract, or treatment that would separate the recoverable plutonium from the remaining constituents of the residues and scrub alloy.

The most likely location off-site for treatment of residues or the scrub alloy, if any treatment is done off-site, would be the Savannah River Site (SRS) because it has processing facilities and is stabilizing its plutonium inventory.



Plutonium (Pu) Residues and Scrub Alloy Inventory at RFETS

DOE will also evaluate treatment of residues at the Los Alamos National Laboratory (LANL) and the Lawrence Livermore National Laboratory (LLNL), although the limited capabilities and capacity of the facilities at these sites make their use less likely as long as SRS facilities are available.

Why Is an EIS Being Prepared?

The National Environmental Policy Act of 1969 (NEPA) requires the preparation of an EIS for major Federal actions that may affect the quality of the environment. NEPA requires Federal agencies to consider a range of alternatives and their potential consequences on the environment. Under NEPA, the term "environment" encompasses the natural and physical environment as well as the relationship of people with that environment. The goal of Congress in enacting NEPA was to ensure that Federal agencies consider the potential environmental impacts of their proposed actions before deciding on a course of action.

In this EIS, DOE will identify and assess the potential environmental impacts associated with reasonable alternatives to facilitate ultimate off-site disposition of the residues and scrub alloy. The EIS will also address impacts associated with the transport of the materials for off-site treatment and/or disposition.

Alternatives to be Analyzed in the EIS

DOE has initially identified the following three alternatives for further analyses in the EIS. Public comments are being sought on the reasonableness of these alternatives or if other alternatives should be considered.

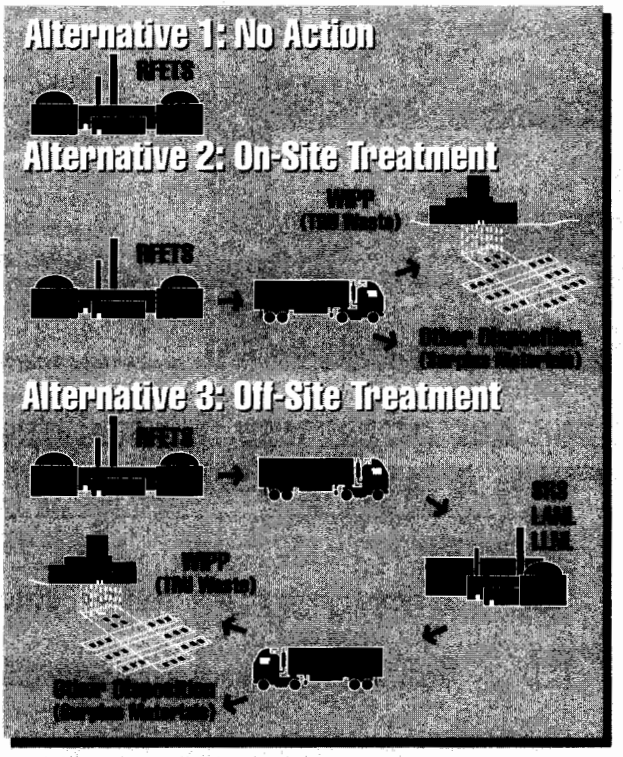
1. **No Action:** *Under the No Action alternative, existing stabilization, repackaging, and monitoring of the entire plutonium residues inventory (approximately 106,600 kg) for safe interim storage at RFETS would continue. Interim storage would be in containers and under conditions appropriate for a period of approximately 20 years. Because of nuclear weapons non-proliferation concerns, approximately 42,300 kg would remain in a form that is not suitable for disposal. Scrub alloy would remain at RFETS for storage.*

2. **On-Site Treatment:** *The On-Site Treatment alternative would encompass two options which would result in a material form that is suitable for final disposition from RFETS.*

   - *Treatment without plutonium separation, using techniques such as immobilization (e.g., cementation, ceramification, or vitrification) or blending with other matrix materials (e.g., blending the salt residues with depleted uranium oxide or additional salt).*

   - *Treatment with plutonium separation, in which the plutonium from the residues or scrub alloy would be removed, generating two distinct forms of material for disposal (a treated waste form and a plutonium metal or oxide). The treated waste would meet the waste acceptance criteria for WIPP. The recovered plutonium would be stabilized and packaged for long-term storage (up to 50 years) pending final disposition.*

3. **Off-Site Treatment:** *Under the Off-Site Treatment alternative, the plutonium residues and scrub alloy would be treated off-site; however, they may require pre-treatment to a condition suitable for transportation and off-site treatment. The most likely location for off-site treatment would be the Savannah River Site (SRS), although the limited capabilities of the Los Alamos National Laboratory (LANL) and the Lawrence Livermore National Laboratory (LLNL) will also be evaluated. This alternative would also consider the use of different treatment technologies, and treatment with or without plutonium separation, as discussed under the on-site treatment alternative.*



Issues to be Addressed in the EIS

The EIS will address the f[illegible]ng issues. DOE seeks public commen[illegible]efining the scope of these issues.

- **Public and Occupationa[illegible]nd Health: Potential radiol[illegible] non-radiological impacts of the [illegible]um residue and scrub alloy treat[illegible] storage, and disposal alternatives, including projected effects on workers and the public under routine operations and potential accident conditions.**

- **Environmental Media: Potential impacts on soil, water, and the air.**

- **Sensitive Environmental Resources: Potential impacts on plants, animals, and habitat, including impacts on flood plains, wetlands, and threatened and endangered species and their habitat.**

- **Resource Consumption: Potential impacts from consumption of natural resources and energy, including water, natural gas, [illegible]ctricity.**

- **[illegible]conomic: Potential impacts on [illegible]ommunities, including labor force [illegible]oyment and support services.**

- **[illegible]onmental Justice: Potential for dis[illegible]ortionately high and adverse impacts of DOE activities on minority and low-income populations.**

- **Cultural Resources: Potential impacts on cultural resources, such as historic, archeological, scientific, or culturally important sites.**

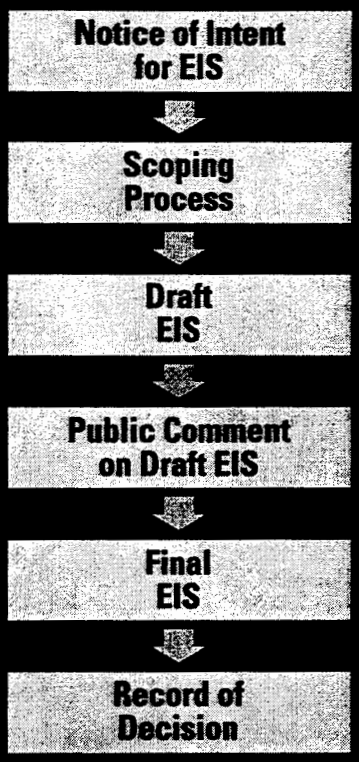
- **Regulatory Compliance: Impacts of the alternatives on compliance of RFETS, SRS, LANL, and LLNL with applicable Federal and State laws and regulations.**

- **Cumulative Impacts: Impacts of these alternatives in conjunction with other past, present, and reasonable foreseeable future actions, regardless of agency (Federal or non-Federal) or persons undertaking such other actions.**

- **Potential Irreversible and Irretrievable Commitment of Resources: Potential irre[illegible]versible and irretrievable commitment of [illegible]esources that would be involved in each alternative.**

- **Non-Proliferation and International Plutonium-Processing Policy: Potential impacts on international policy regarding the non-proliferation of nuclear weapons and processing of plutonium.**

NEPA PROCESS



Schedule and Opportunity to Comment on this Environmental Impact Statement

The Notice of Intent (NOI) for this EIS was published in November 1996. The scoping period is 30 days from the issuance of the NOI. During this time, the public may provide comments directly to DOE on the scope of the EIS and help determine the alternatives, issues, and environmental impacts to be analyzed. The Draft EIS is expected to be issued for public comment in Spring 1997. A Federal Register notice will announce the availability of the Draft EIS. Public comments on the Draft EIS will be considered in the preparation of the Final EIS. After the public comment period and resolution of all comments, the Final EIS will be released. After a 30-day waiting period, a Record of Decision (ROD) will be issued.

To submit comments on the scope of the EIS, or for more information, write to:

C. R. Head
U. S. Department of Energy
EM-60
1000 Independence Avenue, SW
Washington, DC 20585

Comments and requests for information may also be sent by E-mail to:
RFPR.EIS@EM.DOE.GOV

IF YOU ARE INTERESTED IN RECEIVING THE DRAFT EIS WHEN IT IS ISSUED, PLEASE FILL OUT THE FORM BELOW.

☐ Summary only (one volume, about 50 pages)

☐ Full Draft EIS (several large volumes, about 1,000 to 3,000 pages)

NAME:

ORGANIZATION:

ADDRESS:

CITY: STATE: ZIP:

Please fax this form to C. R. Head (202) 586-5256 or mail to:

C. R. Head
U. S. Department of Energy
EM-60
1000 Independence Avenue, SW
Washington, DC 20585

Public Reading Rooms

PUBLIC READING ROOMS

A complete copy of the Draft EIS may be reviewed at any of the Public Reading Rooms and Libraries listed below.

Simi Valley Public Library
2629 Tapo Canyon Road
Simi Valley, CA 93063

Lawrence Livermore National Laboratory
East Gate Visitors Center
Greenville Road
Livermore, CA 94550

CSU Northridge/Oviatt Library
18111 Nordhoff Street
Northridge, CA 91330

U.S. Department of Energy
Oakland Operations Office
1301 Clay Street
Room EIC, 8th Floor
Oakland, CA 94612

Platt Brand Public Library
23600 Victory Boulevard
Woodland Hills, CA 91367

U.S. Department of Energy
Golden Field Office
Public Reading Room
14869 Denver West Parkway
Golden, CO 80401

U.S. EPA
Superfund Records Center
999 18th Street, Floor 5
Denver, CO 80202

Rocky Flats Citizens Advisory Board
Public Reading Room
9035 Wadsworth Avenue, Ste. 2250
Westminster, CO 80021

Standley Lake Public Reading Room
8485 Kipling Street
Arvada, CO 80005

Rocky Flats Public Reading Room
Front Range Community College Library
3645 W. 112th Avenue
Westminster, CO 80030

University of Colorado Libraries
Government Publications
Campus Box 184
Boulder, CO 80309

Colorado Department of Public Health
4300 Cherry Creek Drive South
Denver, CO 80222

Colorado State University
Document Department
The Libraries
Fort Collins, CO 80523

Colorado School of Mines
Arthur Lakes Library
1400 Illinois Street
P.O. Box 4029
Golden, CO 80401

Colorado State University
Library Documents Department
Ft. Collins, CO 80523

U.S. Department of Energy
1000 Independence Avenue SW
FOI Room, 1E-190, Forrestal Bldg.
Washington, DC 20585

Pullen Public Library
100 Decatur Street SE
Atlanta, GA 30303

Chatham Effingham Library
2002 Bull Street
Savannah, GA 31499

Reese Library
Augusta College
2500 Walton Way
Augusta, GA 30904

Georgia Institute of Technology
Bobby Dodd Way
Atlanta, GA 30332

Argonne National Laboratory
Technical Library
P.O. Box 2528
Idaho Falls, ID 83403

University of Illinois at Chicago
U.S. DOE Public Documents Room
801 S. Morgan Street, 3rd Floor
Chicago, IL 60607

East St. Louis Public Library
Dr. Ram Chauhan
405 North 9th Street
East St. Louis, IL 62201

Lincoln Library
Reference Department
326 South 7th Street
Springfield, IL 62701

Salina Public Library
Marc Boucher, Reference Librarian
301 West Elm
Salinas, KS 67401

Washburn Law Library
1700 College
Topeka, KS 66621

Paducah Public Library
555 Washington Street
Paducah, KY 42001

U.S. DOE
Environmental Information Center
175 Freedom Boulevard
Kevil, KY 42053

Mid Continent Public Library
Blue Ridge Branch
9253 Blue Ridge Boulevard
Kansas City, MO 64138

St. Louis Public Library
1301 Olive Street
St. Louis, MO 63103

Scenic Regional Library
308 Hawthorn Drive
Union, MO 63084

Los Alamos Community Reading Room
1350 Central Avenue, Suite 101
Los Alamos, NM 87544

U.S. DOE Albuquerque Operations Office
National Atomic Museum
20358 Wyoming Boulevard SE
Kirtland Air Force Base
P.O. Box 5400
Albuquerque, NM 87185

U.S. Department of Energy
FOIA Reading Room
4700 Morris NE
Albuquerque, NM 87111

U.S. Department of Energy
Technical Vocational Institute
Main Campus Library
525 Buena Vista SE
Albuquerque, NM 87106

Los Alamos Community Reading Room
1350 Central Avenue, Suite 101
MS-C314
Los Alamos, NM 87544

New Mexico State Library
325 Don Gasper
Santa Fe, NM 87503

U.S. Department of Energy
Gregg Graniteville Library
171 University Parkway
Aiken, SC 29801

County Library
404 King Street
Charleston, SC 29403

South Carolina State Library
1500 Senate Street
P.O. Box 11469
Columbia, SC 29211

Orangeburg County Free Library
510 Louis Street NE
P.O. Box 1367
Orangeburg, SC 29116

Lawson McGhee Public Library
500 West Church Avenue
Knoxville, TN 37902

Nashville Public Library
225 Polk Avenue
Nashville, TN 37203

DOE Public Reading Room
Oak Ridge Operations Office
55 Jefferson Circle, Room 1123
Oak Ridge, TN 37831

Contractor Disclosure Statement

NEPA DISCLOSURE STATEMENT FOR PREPARATION OF EIS ON MANAGEMENT OF CERTAIN PLUTONIUM RESIDUES AND SCRUB ALLOYS STORED AT ROCKY FLATS

CEQ Regulations at 40 CFR 1506.5(c), which have been adopted by the DOE (10 CFR 1021), require contractors who will prepare an EIS to execute a disclosure specifying that they have no financial or other interest in the outcome of the project. The term "financial interest or other interest in the outcome of the project "for the purposes of this disclosure is defined in the March 23, 1981 guidance "Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations," 46 FR 18026-18038 at Question 17a and b.

"Financial or other interest in the outcome of the project "includes" any financial benefit such as a promise of future construction or design work in the project, as well as indirect benefits the contractor is aware of (e.g., if the project would aid proposals sponsored by the firm's other clients)." 46 FR 18026-18038 at 18031.

In accordance with these requirements, the offeror and any proposed subcontractors hereby certify as follows: (check either (a) or (b) to assure consideration of your proposal).

(a) __✓__ Offeror and any proposed subcontractor have no financial interest in the outcome of the project.

(b) _____ Offeror and any proposed subcontractor have the following financial or other interest in the outcome of the project and hereby agree to divest themselves of such interest prior to award of this contract.

Financial or Other Interests:

1.
2.
3.

Certified by:

Ibrahim Zeitoun
Signature

Ibrahim H. Zeitoun
Name

Project Manager and Vice President

April 17, 1997
Date

Science Applications International Corporation

Appendix B

Plutonium Residues and Scrub Alloy Characteristics

APPENDIX B
PLUTONIUM RESIDUES AND SCRUB ALLOY CHARACTERISTICS

B.1 SUMMARY

The Rocky Flats Environmental Technology Site (Rocky Flats) currently stores 106,600 kilograms (kg) (235,000 pounds [lb]) of residues and 700 kg (1,540 lb) of scrub alloy containing approximately 3,000 and 200 kg (6,600 and 440 lb) of plutonium, respectively. The plutonium residues were analyzed in the *Environmental Assessment, Finding of No Significant Impact, and Response to Comments—Solid Residue Treatment, Repackaging, and Storage* (DOE 1996e), referred to herein as the "Solid Residue Environmental Assessment." Approximately 40 percent of the residues discussed in the Solid Residue Environmental Assessment contain plutonium in concentrations that meet neither the Safeguards Termination Limits established by the U.S. Department of Energy (DOE) Office of Safeguards and Security in 1996 nor the criteria for long-term storage as oxide or metal in accordance with DOE-STD-3013-96, *DOE Standard: Criteria for Preparing and Packaging Plutonium Metals and Oxides for Long-Term Storage* (DOE 1996b). The Safeguards Termination Limits are plutonium concentration limits imposed on special nuclear material that cannot be exceeded if material accountability requirements are to be terminated, as would be required if the residues were to be shipped to the Waste Isolation Pilot Plant (WIPP). As a result, the plutonium residues require further processing to meet criteria for disposal or other disposition.[1] The Rocky Flats scrub alloy is a DOE Defense Programs material and is not considered a waste material. Scrub alloy is included in this Environmental Impact Statement (EIS) to provide National Environmental Policy Act (NEPA) documentation for its stabilization.

This appendix describes all residues and scrub alloy at Rocky Flats, including the total inventory of the residues that would remain above the Safeguards Termination Limits after being processed by the methods described in the Solid Residue Environmental Assessment. Material categories are identified and processing of the materials according to the Rocky Flats baseline plans (DOE 1996c) is discussed. Processes used for the generation of each of the specific materials, identification of the buildings in which the generation occurred, material descriptions, packaging and configurations, and material compositions are also included.

The Rocky Flats materials were grouped into five categories in the *Notice of Intent to Prepare an Environmental Impact Statement on Management of Certain Plutonium Residues and Scrub Alloy Stored at the Rocky Flats Environmental Technology Site* (DOE 1996a) based on similarities in potential processing alternatives. The five categories include four residue categories (ash, salt, wet, and direct repackage) and one scrub alloy category. The four residue categories are divided into subcategories, which are further divided into the Item Description Codes (IDCs) used by Rocky Flats to categorize its residues. IDCs were developed in the late 1970s and early 1980s as a means to determine which nondestructive assay standard to use. There are approximately 100 IDCs in use at Rocky Flats. The total quantity of bulk material and plutonium (in kilograms [pounds)], the quantity of plutonium that would require processing to meet the Safeguards Termination Limits (in kilograms [pounds]), the bulk containing that plutonium (in kilograms [pounds]), and the Safeguards Termination Limit for the material (in weight percent) are itemized by IDC in tables throughout this appendix. The five Rocky Flats material categories from the Notice of Intent are described in the following paragraphs:

- **Ash Residues**—Residues in this category were generated during production, research and development, strip-out, and maintenance operations and contain approximately 27,900 kg (61,500 lb) of total residue

[1] *Some of the plutonium residues have been or are being proposed to be dispositioned through the Safeguards Termination Limit variance (or waiver) process.*

material, including approximately 1,250 kg (2,760 lb) of plutonium. Approximately 72 percent of the total residue material requires additional processing to meet the Safeguards Termination Limits. The subcategories include incinerator ash residues; inorganic residues; sand, slag, and crucible residues; and graphite fines residues.

- **Salt Residues**—Residues in this category were generated in pyrochemical operations and contain approximately 16,000 kg (35,300 lb) of total residue material, including approximately 1,000 kg (2,200 lb) of plutonium. Approximately 93 percent of the total residue material requires additional processing to meet the Safeguards Termination Limits. The subcategories include electrorefining salt residues, molten salt extraction salt residues, and direct oxide reduction salt residues.

- **Wet Residues**—Residues in this category generally resulted from contact with solutions in the normal course of processing, inventory, and cleanout operations and contain approximately 16,500 kg (36,400 lb) of total residue material, including approximately 340 kg (750 lb) of plutonium. Approximately 26 percent of the total residue material requires additional processing to meet the Safeguards Termination Limits. The subcategories include wet combustible residues, plutonium fluoride residues, Raschig ring residues, sludge residues, and greases/oily sludge residues.

- **Direct Repackage Residues**—Residues in this category resulted from processing, plutonium foundry, maintenance, construction, and inventory operations and contain approximately 39,300 kg (86,600 lb) of total residue material, including approximately 340 kg (750 lb) of plutonium. Approximately 7 percent of the total residue material requires additional processing to meet the Safeguards Termination Limits. The subcategories include dry combustible residues, glass residues, miscellaneous residues, and graphite and firebrick residues.

- **Scrub Alloy**—Materials in this category resulted from the salt scrub process of molten salt extraction salts and the anode alloy processing of electrorefining anode heels; they contain approximately 700 kg (1,540 lb) of total material, including approximately 200 kg (440 lb) of plutonium. All of the scrub alloy material (100 percent) requires processing. The scrub alloy material includes magnesium/aluminum alloy that was processed at the Savannah River Site and alloy that contains calcium, which was not processed at the Savannah River Site.

B.2 Rocky Flats Residue Generation

B.2.1 Introduction

See Attachment 1
Attachment 1 contains the figures for this appendix in the form of flow diagrams that show how each residue category and subcategory was produced. The IDCs for each of the subcategories are also provided.

The plutonium residues at Rocky Flats were produced during plutonium recovery and purification, manufacturing operations, or subsequent processing from 1953 to 1990. As a result of the processes used to recover and purify plutonium and to manufacture components, a variety of materials became contaminated with plutonium. If the level of contamination was low, the material was considered either transuranic or low-level waste and was disposed of at offsite burial locations. If the concentration of plutonium in the material exceeded an "economic discard limit,"[2] however, the material was classified as residue rather than waste and was stored for later recovery of the contained plutonium. Although large quantities of residues were processed during the operation of Rocky Flats, other residues, primarily those more difficult to process, accumulated at the site in storage.

[2]*Economic Discard Limit—The threshold for determining whether a material was waste or residue based on the economics of recovery. If the cost of recovery of the plutonium was less than the cost of new plutonium, the material was considered a residue and retained for recovery; otherwise, it was declared a waste to be disposed of.*

The processes at Rocky Flats generated widely varied and complex residues. For example, some pyrochemical salts used in the purification process have residual plutonium and americium dispersed throughout a spent salt matrix. Other residue materials were generated primarily because of incidental contamination—mainly surface-contaminated materials, such as metals, molds and crucibles, paper, plastics, filters (air and liquids), and refractory materials (firebrick) from the incinerators. Another broad category of residues resulted from intermediate recovery treatment steps or ancillary treatment systems; these residues include ash generated from the volume reduction of combustibles (e.g., plastic, paper, and rags) via an incineration process, soot produced from incinerator cleanout activities, and heels and sludges produced by aqueous treatments of various hard-to-dissolve materials (e.g., ash, soot, crucibles). Emissions treatment systems also produced several additional types of sludges, such as off-gas scrubber systems and filters from liquid filtration systems.

In addition to being contaminated with plutonium, some residues may contain co-contaminants that are subject to the Resource Conservation and Recovery Act (EPA 1976) and the Colorado Hazardous Waste Act (CDPHE 1984a) and that are regulated by the U.S. Environmental Protection Agency (EPA) or the State of Colorado. In 1991, a DOE review of backlogged residues was accomplished based on 40 Code of Federal Regulations (CFR) Part 261, Identification and Listing of Hazardous Waste (EPA 1996). This review was delivered to the Colorado Department of Health and the Environment and was accepted as the Mixed Residue Reduction Report (DOE 1992). Since this initial review, there have been periodic reviews of the nature and status of the residue hazardous waste compliance baseline, which have been incorporated in the backlog waste reassessment process (RMRS 1996). The basis of the original determination was re-evaluated and the amount of residues regulated by the Resource Conservation and Recovery Act was reduced from 90 percent to approximately 48 percent by bulk weight.

Some of the Rocky Flats residues have both characteristic and listed EPA hazardous waste numbers (EPA 1976). A description of the characteristics associated with the EPA hazardous waste numbers can be found in §261.22-24 of 6 CCR 1007-3 (CDPHE 1984b).

B.2.2 Programmatic History

The essential goal for DOE remains the safe storage of the mixed residues, residues, and scrub alloy until their ultimate processing and final offsite disposition. In 1992, Rocky Flats initiated the Residue Elimination Project to address the treatment and elimination of its stored residues. Safe storage of these materials has been evaluated by DOE and by the Defense Nuclear Facilities Safety Board (the "Board"). Once the Board makes a recommendation, the Secretary of Energy establishes an approval process and develops an implementation plan. When the plan is approved, the Board publishes the recommendation in the *Federal Register*. Currently, Board Recommendation 94-1 (DNFSB 1994b) and Board Recommendation 94-3 (DNFSB 1994a) relate to the safe storage and management of residues and scrub alloy.

The Residue Elimination Project focused primarily on eliminating the residues by simply repackaging them, with minimal treatment, to meet the *Waste Isolation Pilot Plant Waste Acceptance Criteria* (DOE 1981). On May 26, 1994, the Board approved and issued Recommendation 94-1, which, in general, raised safety-related concerns about continued storage and about the potential management of residues and in-process materials.

In addition to the safe management of these materials, the Board was concerned with the results of the abrupt halt of nuclear weapons production and DOE's efforts to remediate its facilities. The Board concluded that immediate hazards could arise unless certain problems were corrected throughout the DOE complex. These problems related to liquids and solids containing fissile materials and other radioactive substances in spent fuel storage pools, reactor basins, reprocessing canyons, processing lines, and various buildings once used for processing and weapons manufacture. The Board addressed its concerns in Recommendation 94-1 and proposed an accelerated schedule to convert these material to forms more suitable for safe interim storage.

Notwithstanding its acknowledgment of DOE's vulnerability assessment efforts and the NEPA documentation related to these situations, the Board made the following recommendations regarding the Rocky Flats residues and scrub alloy:

- That an integrated plan be formulated to convert plutonium-bearing materials for safe interim storage within 2 to 3 years.

- That the plan should include ways to store all plutonium metals and oxides in conformance with DOE-STD-3013-94, *Criteria for Safe Storage of Plutonium Metals and Oxides* (DOE 1994a), which was superseded by DOE-STD-3013-96, *DOE Standard: Criteria for Preparing and Packaging Plutonium Metals and Oxides for Long-Term Storage* (DOE 1996b).

- That preparations be expedited to repackage plutonium metal in contact with plastic to eliminate the generation of hydrogen gas.

- That preparations be accelerated to process containers of possibly unstable residues from past plutonium operations and change the plutonium into a form suitable for safe interim storage.

To respond to Board Recommendation 94-1, Rocky Flats developed the Site Integrated Stabilization Management Plan (DOE 1996c), which describes the program and schedules to stabilize and package the residues to meet a 50-year storage standard. This plan is the governing document for the management of the Rocky Flats residues and scrub alloy, although Consent No. 93-04-23-01 (State of Colorado 1993) imposes additional requirements on the portion of residues mixed with hazardous constituents. The plan incorporates Board Recommendation 94-1 Implementation Plan milestones, which Rocky Flats routinely updates.

In April 1996, DOE's Rocky Flats Field Office issued the *Environmental Assessment, Finding of No Significant Impact, and Response to Comments—Solid Residue Treatment, Repackaging, and Storage* (DOE 1996e). The information and analyses in the "Environmental Assessment" section evaluate the impacts associated with implementation of the Site Integrated Stabilization Management Plan. The "Finding of No Significant Impact" section determines that this evaluation supports the conclusion that the proposed action would not constitute a major Federal action significantly affecting the quality of the human environment. This determination allows Rocky Flats to begin preparation to process and repackage possibly unstable residues and to store them for interim safe storage until their disposition is decided.

B.2.3 Safeguards Termination Limits, Item Description Codes, and Site Integrated Stabilization Management Plan Groups

See Attachment 1

Attachment 1 contains the figures for this appendix in the form of flow diagrams that show how each residue category and subcategory was produced. The IDCs for each of the subcategories are also provided.

On July 22, 1996, the DOE Office of Safeguards and Security issued guidance (DOE 1996d) concerning plutonium enrichment of special nuclear material that can be categorized as "attractiveness level E" for the purposes of determining levels of safeguards protection. This guidance complements existing requirements given in DOE Order 5633.3B (DOE 1994b). **Table B–1** provides a summary of the Safeguards Termination Limits established by the DOE Office of Safeguards and Security for this special nuclear material. Implementation of this new guidance indicates that approximately 40 percent of the materials to be processed as described in the Site Integrated Stabilization Management Plan would not meet the new guidance requirements.

Table B–2, "Residue IDCs Comparison Between the Solid Residue Environmental Assessment and the Site Integrated Stabilization Management Plan Information," tracks Item Description Codes (IDCs) by the various residue management mechanisms that have been used over the past several years. The table provides a method for cross-correlating individual IDCs using the Solid Residue Environmental Assessment residue categories

and the Site Integrated Stabilization Management Plan (DOE 1996c) group categorizations. Table B–2 also shows selected safety concerns and the current baseline Site Integrated Stabilization Management Plan processing methods being pursued by Rocky Flats for each IDC.

Table B–1 Safeguards Termination Limits Attractiveness Level E Criteria for Special Nuclear Material

Category	Description/Form	Threshold (Weight %)	
		A [a]	B [b]
Readily Recoverable	Special nuclear material solutions and oxides: nitrate, caustic, chloride solutions, contaminated/impure oxides, metal fines and turnings, glovebox sweepings	0.1	N/A
Recoverable	Special nuclear material amenable to dissolution and subsequent separation: pyrochemical salts; chloride melt; hydroxide cake; floor sweepings; alumina; condensates; reduction residues; sand, slag, and crucible; magnesium oxide crucible	0.1	0.2
Difficult to Recover	Special nuclear material in organic matrices or requiring pyrochemical separation disassembly and subsequent multiple recovery operations: high-efficiency particulate air filters, organic solutions, oils and sludges, graphite or carbon scrap; surface contaminated plastics, metal components, combustible rubber	0.2	1.0
Extremely Difficult to Recover	Special nuclear material bound in matrix of solid sintered or agglomerated refractory materials: special nuclear material embedded in glass or plastic, high fired incinerator ash, special resins, salt sludges, raffinates and sulfides	0.5	2.0
Practically Unrecoverable	Special nuclear material microencapsulated in refractory compounds or in solid dilution: vitrified, bituminized, cemented, or polymer-encapsulated materials; special nuclear material alloyed with refractory elements (tungsten, palladium, chromium, stainless steel), ceramic/glass salvage	1.0	5.0

N/A = Not applicable

[a] Threshold A: Maximum special nuclear material concentration upon which Materials, Controls, and Accountability and physical protection can be terminated if conditions in DOE Order 5633.3B, 1, 1, 1 are met.

[b] Threshold B: Maximum special nuclear material concentrations upon which only physical protection measures equivalent to category IV requirements can be applied if conditions in DOE Order 5633.3B 1, 1, 1 are met. The various categories (I through IV) relate to the amount of fissile material contained in various nuclear materials and are discussed in detail in DOE Order 5633.3B.

Table B–2 Residue IDCs Comparison Between the Solid Residue Environmental Assessment and the Site Integrated Stabilization Management Plan Information

Environmental Assessment Category	IDC		Site Integrated Stabilization Management Plan			
	Number	Description	Residue Type	Group # [a]	Safety Concern [b]	Treatment [c]
Ash Residues	310	Graphite Fines	Ash	4	3	3
	333	Calcium	Salt	3	2	2
	368	Magnesium Oxide Crucible	Ash	11	N/A	9
	372 [d]	Grit	Ash	11	N/A	9
	373 [d]	Firebrick Heel	Wet/Misc	11	N/A	9
	378	Firebrick, Fines	Ash	11	N/A	9
	387	Reburned Sand, Slag, and Crucible Sweepings	Ash	4	3	3
	390	Unpulverized Slag	Ash	4	3	3
	391	Unpulverized Sand and Crucible	Ash	4	3	3
	392	Unpulverized Sand, Slag, and Crucible	Ash	4	3	3
	393	Sand, Slag, and Crucible Heel	Ash	4	3	3
	394	Sand from Button Breakout	Ash	4	3	3
	395	Unpulverized Slag and Crucible	Ash	4	3	3
	396	Pulverized Slag	Ash	4	3	3
	398	Pulverized Sand, Slag, and Crucible	Ash	4	3	3
	419	Unpulverized Incinerator Ash	Ash	9	N/A	8
	420	Pulverized Incinerator Ash	Ash	9	N/A	8
	421	Ash Heel	Ash	9	N/A	8
	422	Soot	Ash	9	N/A	8
	423 [d]	Soot Heels	Ash	9	N/A	8
	428	Incinerator Ash for Materials Management	Ash	9	N/A	8
	H61	Oxide from Ducts	Wet/Misc	11	N/A	9

Environmental Assessment Category	IDC		Site Integrated Stabilization Management Plan			
	Number	Description	Residue Type	Group #[a]	Safety Concern[b]	Treatment[c]
Salt Residues	044	Americium and Miscellaneous Oxide	Salt	2	2	2
N/E	363	Electrorefining Salt - 1st Run	Salt	1	2	2
N/E	364	Electrorefining Salt - 2nd Run	Salt	1	2	2
	365	Salt from Bad Direct Oxide Reduction	Salt	3	2	2
	404	Molten Salt Calcium, Zinc, Potassium	Salt	3	2	2
	405	Molten Salt Extraction Salt	Salt	2	2	2
	406	Molten Salt Extraction Salt	Salt	2	2	2
	407	Molten Salt Extraction Salt	Salt	2	2	2
	408	Molten Salt Extraction Salt	Salt	2	2	2
	409	Molten Salt Extraction Salt	Salt	2	2	2
	410	Molten Salt Extraction Salt	Salt	2	2	2
	411	Electrorefining Salt	Salt	1	2	2
	412	Gibson Salt	Salt	3	2	2
	413	Impure Salt/Cleanout	Salt	3	2	2
	414	Direct Oxide Reduction Salt with Calcium	Salt	3	2	2
	415	Plutonium Chloride Mixed Salt	Salt	3	2	2
	416	Zinc/Magnesium Alloy Metal	Salt	3	2	2
	418	Molten Salt Extraction Salt for Los Alamos National Laboratory	Salt	2	2	2
N/E	426	Reburned IDC 413	Salt	3	2	2
	427	Molten Salt Extraction Dicesium Salt	Salt	3	2	2
	429	Scrub Alloy Salt	Salt	1	2	2
	433	Spent Dicesium Salt	Salt	3	2	2
	434	Salt with Free Calcium	Salt	3	2	2
N/E	435	Spent Cerium/Calcium Salt Scrub	Salt	3	2	2
	473	Electrorefining Salt for Los Alamos National Laboratory	Salt	1	2	2
	601	Aluminum/Magnesium Oxide	Salt	11	N/A	9
	654	Electrorefining Salt from Plutonium/Neptunium	Salt	1	2	2
	655	Electrorefining Ceramics from Plutonium/ Neptunium	Ash	11	N/A	9
Wet Residues	089	Grease Oxide	Combustible	7	6	6
	090	Plutonium Fluoride	Wet Misc	8	7	7
	091	Non-Specification Plutonium Fluoride	Wet Misc	8	7	7
	092	Plutonium Fluoride Heel	Wet Misc	8	7	7
	093	Sodium Fluoride Pellets	Wet Misc	8	7	7
	097	Impure Plutonium Fluoride	Wet Misc	8	7	7
	099	Grease Fluoride	Combustible	7	6	6
	290	Filter Sludge	Wet Misc	12	8	10
	291	Lab Fluoride Sludge	Wet Misc	12	8	10
	292	Incinerator Sludge	Wet Misc	12	8	10
	299	Miscellaneous Sludge	Wet Misc	12	8	10
	331	Split Ful Flo, Organic Contaminated	Combustible	6	5	5
	331	Split Ful Flo, Nitrate Contaminated	Combustible	5	4	4
	332	Oily Sludge	Combustible	7	6	6
	335	Drybox Filters/Not Acid Contaminated	Wet Misc	5	4	4
	336	Split Wet Combust, Organic Contaminated	Combustible	6	5	5
	336	Split Wet Combust, Nitrate Contaminated	Combustible	5	4	4
	338	HEPA Filter Media	Combustible	5	4	4
	339[d]	Leaded Gloves	Combustible	5	4	4
	340	Sludge from Size Reduction Vault	Wet Misc	12	8	10
	341	Leaded Gloves/Acid Contaminated	Combustible	5	4	4
	342	Drybox Filters/Acid Contaminated	Combustible	5	4	4
	376	Processed HEPA Filter Media	Combustible	5	4	4
	441	Unleached Raschig Rings	Inorganic	13	N/A	11
	490	HEPA Filters Non-Acid Content	Combustible	5	4	4

Environmental Assessment Category	*IDC*		*Site Integrated Stabilization Management Plan*			
	Number	*Description*	*Residue Type*	*Group #*[a]	*Safety Concern*[b]	*Treatment*[c]
Direct Repackage Residues	197	Tantalum Targets	Inorganic	11	N/A	9
	300	Graphite Mold	Wet Misc	11	N/A	9
	303	Graphite Chunks	Inorganic	11	N/A	9
	312	Graphite Coarse	Inorganic	11	N/A	9
	320	Heavy Metal Non-Special Source	Wet Misc	11	N/A	9
	321 [d]	Lead	Inorganic	11	N/A	9
	330	Dry Combustibles	Combustible	10	N/A	9
	334 [d]	Fire Blanket	Inorganic	11	N/A	9
	337	Plastics	Combustible	10	N/A	9
N/E	360	Aluminum Oxide Ceramic Crucible	Inorganic	11	N/A	9
	374 [d]	Blacktop, Concrete	Ash	11	N/A	9
	370	LECO Crucible	Inorganic	11	N/A	9
	371 [d]	Firebrick	Inorganic	11	N/A	9
	377	Coarse Firebrick	Inorganic	11	N/A	9
	438	Insulation	Inorganic	11	N/A	9
	440	Glass	Inorganic	13	N/A	11
	442	Leached Raschig Rings	Inorganic	13	N/A	11
	479 [d]	Empty Reusable Cans in Drum	N/E	N/E		
	480	Light Metal	Inorganic	11	N/A	9

HEPA = high-efficiency particulate air MISC = miscellaneous N/A = not applicable
N/E = No entry in the Solid Residue Environmental Assessment

[a] ***Site Integrated Stabilization Management Program Group Numbers***

1. Electrorefining and Salt Scrub Salts
2. Molten Salt Extraction Salts
3. Direct Oxide Reduction and Dicesium Hexachloroplutonate Salts
4. Sand, Slag, and Crucible and Graphite Fines
5. Nitrate-Contaminated Combustibles
6. Organic-Contaminated Combustibles
7. Greases and Oily Sludges
8. Fluorides
9. Ash
10. Dry Combustibles
11. Firebrick, Graphite and Inorganics
12. Sludges
13. Glass
14. Classified Inorganics*

[b] ***Site Integrated Stabilization Management Program Safety Concerns***

1. Oxidizer
2. Water Reactive, Shock Sensitive, Pyrophoric
3. Pyrophoric
4. Fuel/Oxidizer
5. Corrosivity
6. Gas Generation
7. Radiation Exposure
8. Free Liquid

[c] ***Site Integrated Stabilization Management Program Treatments****

1. Cementation
2. Molten Oxidation
3. Calcination
4. Wash and Dry
5. Low Temp Thermal Desorption/Water Oxidation
6. Venting
7. Dissolution and Conversion to Oxide
8. Calcination to Meet Interim Safe Storage Criteria
9. Repack to Meet Interim Safe Storage Criteria and Waste Acceptance Criteria
10. Dried or Absorbed
11. Repack to Waste Acceptance Criteria
12. Declassified and Repacked

[d] IDCs that do not contain any material identified for further processing to meet the safeguards limits for low-grade special nuclear materials.
*This table does not include residues that have been categorized as "Classified Shapes or Classified Inorganics." These residues do not require further processing beyond that analyzed in the Solid Residues Environmental Assessment.
**These treatments were the basis for analyses in the Solid Residues Environmental Assessment and are the "no action" processes discussed in this EIS.

Not all the residue IDCs identified in Table B–2 will require further processing to meet the safeguards limits for low-grade special nuclear materials. The rest of this appendix describes those residues that may require further processing.

B.3 DETAILED DISCUSSIONS OF ROCKY FLATS RESIDUES

B.3.1 Introduction

The following sections give technical descriptions of the plutonium-bearing residues stored at Rocky Flats. In the Notice of Intent, the residues and scrub alloy buttons are divided into the five categories. To further characterize the residue material categories that were identified in the Notice of Intent, 10 material categories have been defined and are described in detail in Section 2.7 Management Alternatives—Sections 2.7.2 through 2.7.11—of this EIS, which also includes processing/technology discussions. The 10 residue material categories are as follows:

1. Ash Residues
2. Pyrochemical Salt Residues
3. Plutonium Fluoride Residues
4. Sludge Residues
5. Filter Media Residues
6. Combustible Residues
7. Glass Residues
8. Graphite Residues
9. Inorganic (Metals and Others) Residues
10. Scrub Alloy

Table B–3 shows how these 10 categories correspond to the 5 residue material categories identified in the Notice of Intent. The table includes the Notice of Intent residue material categories, the corresponding EIS material categories, and the material Item Description Codes (IDCs) associated with each.

Table B–3 Correspondence Between Notice of Intent Categories and EIS Categories

Notice of Intent Categories	*EIS Categories*	*IDCs*
Ash Residues	**Ash Residues**	
- Incinerator Ash	- Incinerator Ash	378, 419, 420, 421, 422, 428
- Sand, Slag, and Crucible	- Sand, Slag, and Crucible	333, 387, 390, 391, 392, 393, 394, 395, 396, 398
- Graphite Fines	- Graphite Fines	310
- Inorganic Ash	- Inorganic Ash	368, H61
Salt Residues	**Pyrochemical Salt Residues**	
- Electrorefining Salts	- Electrorefining Salts	411, 473, 654, 655
- Molten Salt Extraction Salts	- Molten Salt Extraction Salts	044, 405, 406, 407, 408, 409, 410, 418, 429, 601
- Direct Oxide Reduction Salts	- Direct Oxide Reduction Salts	365, 404, 412, 413, 414, 415, 416, 427, 433, 434, 435
Wet Residues		
- Plutonium Fluoride	**Plutonium Fluoride Residues**	090, 091, 092, 093, 097
	Sludge Residues	
- Sludge	- Sludge	290, 291, 292, 299, 340
- Greases/Oily Sludge	- Greases/Oily Sludge	089, 099, 332
	Filter Media Residues	331, 335, 338, 342, 376, 490
- Wet Combustibles	**Combustible Residues** (Partial) - Aqueous/Organic-Contaminated Combustibles	336, 341
- Raschig Ring	**Glass Residues (Partial)** - Raschig Ring (Unleached, Leached)	441, 442

Notice of Intent Categories	EIS Categories	IDCs
Direct Repackage - Glass	**Glass Residues (Partial)** - Other Glass	440
- Dry Combustibles	**Combustible Residues** (Partial) - Dry Combustibles	330, 337
- Graphite, Firebrick	**Graphite Residues** - Graphite, Firebrick	300, 303, 312, 377
- Miscellaneous	**Inorganic (Metal and Others) Residues** - Miscellaneous	197, 320, 360, 370, 438, 480
Scrub Alloy	**Scrub Alloy**	025, 600, 602, 603, 604, 620

The sections that follow include estimates of the bulk and plutonium quantity for either the IDCs or the group of IDCs that are above the safeguards termination limits. The figures in Attachment 1, using process flow diagrams, show how the residues were generated.

B.3.2 Ash Residues

The subcategories under ash residues include incinerator ash; inorganics; sand, slag, and crucible; and graphite fines. These residues are grouped together because they are chemically alike or because they will be processed and repackaged in a similar way. According to the Solid Residues Environmental Assessment, these ash residues will be calcined, cemented if necessary, and repackaged to meet interim safe storage criteria. The baseline processing of these residues removes moisture and organics that may generate flammable or corrosive gases posing risks to workers and the public, convert plutonium metals and other metals to an oxide, and immobilize respirable fines to reduce dispersible risks. Approximately 72 percent of this category (approximately 20,100 kg [44,300 lb]) may require additional processing. Further discussions follow on the Item Description Codes within each subcategory that may require additional processing.

B.3.2.1 Incinerator Ash Residues

Incinerator ash residues are materials resulting from the combustion of feed materials during the operation of the residue recovery incinerator in Building 771 and strip-out operations of the incinerator in Building 371, though plutonium materials were never processed in Building 371. The Item Description Codes (IDCs) included in this subcategory are 378, 419, 420, 421, 422, and 428. These IDCs are classified as mixed residues. They are described in the following paragraphs:

> **See Attachment 1**
> Figure B-1 shows the sources and types of incinerator ash residues generated at Rocky Flats; Figures B-11 and B-12 show the generation of IDC 421; and Figure B-12 shows the generation of IDC 378.

- **IDC 378, Firebrick, Pulverized or Fines**—IDC 378 was generated in the residue recovery incinerators in Building 771; the firebrick was used to line the incinerator. The fines were generated from the scarfing of firebrick to remove plutonium. This material consists of firebricks, pulverized firebrick or firebrick fines, and chunks of high-density aluminum ceramic material in various sizes. This IDC contains plutonium and americium oxides, metal oxides, and high-density aluminum substrate material, which are packaged in 55-gallon drums and stainless steel slip lid cans.

- **IDC 419, Unpulverized Incinerator Ash**—This ash category is a nonhomogeneous material containing partially burned feed materials (combustibles) that vary in size from fine particulates that will pass through a 100-mesh screen to relatively large pieces of material. This ash contains measurable quantities of organics and carbon and was generated in the Building 771 residue recovery incinerator system and the

Building 371 incinerator strip-out operations (ash from Building 371 was generated during nonplutonium tests). The ash is stored in 55-gallon drums or stainless steel slip lid cans.

- **IDC 420, Pulverized Incinerator Ash**—This ash category is a nonhomogeneous mixture that was crushed through a ball mill and contains a mixture of coarse, granular, fine, and very fine particulates. The ash, which contains some bits of metal, organics, and carbon, was generated in the Building 771 residue recovery incinerator system and in Building 371 incinerator strip-out operations (no plutonium material was processed in Building 371). The ash is stored in 55-gallon drums, stainless steel slip lid cans, plastic bottles, and other special containers.

Table B–4 presents the analyses of the composition of ash for IDC 419 and IDC 420.

Table B–4 Incinerator Ash Analyses for IDC 419 and IDC 420

Constituent	*Ash*	
	Range (Weight %)	*Average (Weight %)*
Al_2O_3	0.95 to 5.7	3.33
AmO_2	0.02	–
B_2O_3	0.32 to 3.2	1.76
BaO	0.58 to 1.2	0.89
CaO	1.1 to 7.0	4.05
Cr_2O_3	0.44 to 0.88	0.66
CuO	0.63 to 1.3	0.97
Fe_2O_3	1.1 to 10.3	5.70
K_2O	0.24 to 1.2	0.72
MgO	0.83 to 8.3	4.57
MnO_2	0.03 to 0.08	0.06
Na_2O	0.0 to 2.4	1.20
NiO	0.25 to 0.64	0.45
P_2O_5	0.23	–
PbO	0.58 to 0.92	0.75
PuO_2	1.8 to 3.8	2.80
SnO	0.0 to 0.25	0.13
Ta_2O_5	0.0 to 0.73	0.37
TiO_2	1.0 to 1.7	1.35
C	7.5 to 36.0	21.75
SiO_2	14.17 to 74.10	48.49
Weight Loss	–	–
Total	–	100.00

- **IDC 421, Ash Heel**—Incinerator ash heel was generated from processing incinerator ash (IDCs 419 and 420) in Building 771; it is the insoluble residue (ash heel) that remains after ash dissolution in nitric acid. The ash heel is fairly homogeneous and contains fine to very fine particulates. It is stored in 55-gallon drums, stainless slip lid cans, bottles, and other special containers. This material will contain the same constituents as incinerator ash but in different concentrations. **Table B–5** presents the analysis of the composition of this ash heel.

Table B–5 Incinerator Ash Analysis of IDC 421

Constituent	Ash	
	Range (Weight %)	Average (Weight %)
Al_2O_3	1.1 to 7.2	4.15
AmO_2	0.02	–
B_2O_3	0.02 to 3.2	1.61
BaO	0.06 to 0.58	0.32
CaO	1.1 to 5.60	3.35
Cr_2O_3	0.58 to 2.9	1.74
CuO	0.06 to 0.5	0.28
Fe_2O_3	0.72 to 11.7	6.21
K_2O	0.02 to 0.6	0.31
MgO	0.83 to 1.7	1.27
MnO_2	0.03 to 0.16	0.10
Na_2O	0.0 to 1.2	0.60
NiO	0.25 to 0.64	0.45
P_2O_5	0.0 to 2.3	1.15
PbO	0.09 to 0.58	0.34
PuO_2	1.6 to 16.4	9.00
SnO	0.0 to 0.38	0.19
Ta_2O_5	0.61 to 1.2	0.91
TiO_2	1.0 to 5.0	3.00
C	10.4 to 44.8	27.60
SiO_2	0.00 to 81.53	37.42
Weight Loss	–	–
Total	–	100.00

- **IDC 422, Soot**—Incinerator soot is the incomplete combustion product from incinerator operations and is a mixture of fine to very fine fly ash. This material was generated in Building 771 during incineration operations and was collected during filter change operations of the incinerator plenum and during incinerator stripout operations in Building 371, though no plutonium was processed in Building 371. The soot is fairly homogeneous and is stored in 55-gallon drums. The soot composition generally has silica and carbon as the major components and aluminum oxide, calcium oxide, ferric oxide, and sodium oxide as the minor components.

- **IDC 428, Ash Selected for the Materials Management Executive Committee**—This ash is pulverized incinerator ash selected from IDC 420 that was set aside at the request of DOE's Materials Management Executive Committee for shipment and processing at another DOE site. The Committee was active in the 1980s.

Table B–6 shows the total bulk and plutonium concentrations for the incinerator ash residues.

Table B–6 Incinerator Ash Residues That Are Evaluated in this EIS

IDC	Residue	Kg of Total Bulk of IDC	Kg of Pu in Total Bulk	Kg Bulk Requiring Processing	Kg of Pu in Bulk Requiring Processing	STL Pu Weight %	Bulk % > STL	Pu % > STL
378	Firebrick, Pulverized or Fines	284	13.6	26.2	10.8	5.0	9.2	79.4
419	Unpulverized Incinerator Ash	29.2	1.8	29.2	1.8	2.0	100	100
420	Pulverized Incinerator Ash	10,031	696	8,497	679	2.0	84.7	97.6
421	Ash Heel	8,905	270	5,244	211	2.0	58.9	77.9
422	Soot	666	12	242	5.9	2.0	36.4	50.4
428	Ash Selected for MMEC	18.2	1.3	18.2	1.3	2.0	100	100

Pu = Plutonium STL = Safeguards Termination Limit MMEC = Materials Management Executive Committee

The number and types of packages for each IDC are given in **Table B–7**. These packages are either 55-gallon drums or other containers. Other containers are defined as cans, bottles, or other special receptacles.

Table B–7 Number and Types of Packages of Incinerator Ash Residues

IDC	Description	55-Gallon Drums (Total)	Other (Total)	55-Gallon Drums (Above STL)	Other (Above STL)
378	Firebrick, Pulverized or Fines	4	36	0	29
419	Unpulverized Incinerator Ash	3	2	3	2
420	Pulverized Incinerator Ash	783	13	749	10
421	Ash Heel	327	4	256	3
422	Soot	18	0	7	0
428	Ash Selected for MMEC	1	10	1	10

STL = Safeguards Termination Limit MMEC = Materials Management Executive Committee.

B.3.2.2 Graphite Fines Residues

Graphite fines residues were generated in Buildings 371, 707, 771, and 777. Graphite was used as mold material in plutonium foundry operations. The Item Description Code (IDC) is 310 and is described in the following paragraph:

See Attachment 1
Figure B–2 shows the source and type of graphite fines residues.

- **IDC 310, Graphite Scarfings and Fines**—Graphite scarfings and fines residues were generated in Buildings 771, 371, 777, and 707 during plutonium foundry operations and graphite scarfing operations. Graphite molds were mechanically cleaned to remove the mold coating and plutonium embedded on the graphite surface. The resulting fines and small pieces were identified as IDC 310. These residues contain a mixture of granular, fine, and very fine particulates. The matrix is mostly graphite containing small quantities of calcium fluoride and calcium and magnesium metals or oxides with plutonium metals and oxides. IDC 310 was packaged into 55-gallon drums and stainless steel slip lid cans.

Table B–8 shows the total bulk and plutonium concentrations for the graphite fines residues.

Table B–8 Graphite Fines Residues That Are Evaluated in this EIS

IDC	Residue	Kg of Total Bulk of this IDC	Kg of Pu in Total Bulk	Kg Bulk Requiring Processing	Kg of Pu in Bulk Requiring Processing	STL Pu Weight %	Bulk % > STL	Pu % > STL
310	Graphite Scarfings and Fines	946	74.3	899	74.0	1.0	95.0	99.6

Pu = Plutonium STL = Safeguards Termination Limit

The number and types of packages for IDC 310 are given in **Table B–9**.

Table B–9 Number and Types of Packages of Graphite Fines Residues

IDC	Description	55-Gallon Drums (Total)	Other (Total)	55-Gallon Drums (Above STL)	Other (Above STL)
310	Graphite Scarfings and Fines	84	26	81	26

STL = Safeguards Termination Limit

B.3.2.3 Sand, Slag, and Crucible Residues

> **See Attachment 1**
> Figure B-3 shows most of the sources and types of sand, slag, and crucible residues. Figure B-12 shows the generation of IDCs 333, 393, 396, and 398.

Sand, slag, and crucible residues were generated in Building 771 during reduction and button breakout, dissolution system, and preparatory plutonium recovery processes (crushing and grinding). Additionally, small quantities of residues were generated in the research and development gloveboxes in Building 779 and during an attempted start-up of processes in Building 371. The Item Description Codes (IDCs) included in this subcategory are 333, 387, 390, 391, 392, 393, 394, 395, 396, and 398. IDCs in this subcategory are described in the following paragraphs:

- **IDC 333, Calcium Metal**—IDC 333 originated from Building 771 metal reduction operations. The material consists of calcium metal contaminated with plutonium oxide and plutonium fluoride.

- **IDC 387, Reburned Sand, Slag, and Crucible Sweepings**—IDC 387 is material generated from the cleanup of sand, slag, and crucible from the reduction process gloveboxes in Building 771 that was then heated to stabilize the material (oxidize any reactive metals). Additionally, small quantities of IDC 387 were generated in the research and development gloveboxes in Building 779. This material consists of granular, fine, and very fine materials stored in stainless steel slip lid cans.

- **IDC 390, Unpulverized Slag; IDC 391, Unpulverized Sand and Crucible; IDC 392, Unpulverized Sand, Slag, and Crucible; IDC 394, Sand from Button Breakout; IDC 395, Unpulverized Slag and Crucible; IDC 396, Pulverized Slag; IDC 398, Pulverized Sand, Slag, and Crucible**—IDCs 390, 391, 392, 394, 395, 396, and 398 were generated in Building 771 from the reduction and button breakout process and during start-up of Building 371 recovery processes. The unpulverized slag (IDC 390) was generated when the slag was separated from the sand and crucible (IDC 391) following the removal of the plutonium button. The slag is nonhomogeneous and is a mixture of coarse chunks of calcium fluoride; it contains uncoalesced plutonium metal, excess calcium metal, magnesium metal, plutonium fluoride, and magnesium oxide sand. The sand and crucible residue may contain uncoalesced plutonium metal, calcium metal, magnesium metal, calcium fluoride slag, and trace amounts of a pyrotechnic initiator that contains potassium iodide and sodium peroxide. The residue will range in size from chunks of the magnesium oxide crucible to grains of sand. IDC 392 consists of IDCs 390 and 391 that were not separated. IDC 394 consists of magnesium oxide sand (for reuse in the process) that was screened from the sand, slag, and crucible. The slag and crucible generated during the screening of the sand is IDC 395.

  IDC 396 was generated from the crushing and grinding of IDC 390 in the Building 771 jaw crusher and hammer mill in preparation for the dissolution process. The pulverized slag consists of granular to very fine particles, with the same composition as IDC 390. IDC 398 was also generated in the Building 771 jaw crusher and hammer mill from the crushing and grinding of magnesium oxide sand, calcium fluoride slag, and crucibles in preparation for dissolution. The pulverized sand, slag, and crucible consists of coarse to very fine particles and has the same constituents as IDC 392. IDCs 396 and 398 were generated to be eventually processed through the Building 771 dissolution process to recover any plutonium within these IDCs.

- **IDC 393, Sand, Slag, and Crucible Heel**—Sand, slag, and crucible heel was generated in the Building 771 dissolution process from the feed materials identified as IDCs 396 and 398. IDCs 396 and 398 were dissolved in nitric acid and aluminum nitrate, and the solution was filtered to remove any undissolved solids. The undissolved solids (IDC 393) were dried and packaged to await further plutonium recovery. IDC 393 consists of coarse to very fine materials and contains constituents similar to the feed materials, except that the reactive materials have been oxidized.

Table B–10 shows the total bulk and plutonium concentrations for sand, slag, and crucible residues.

Table B–10 Sand, Slag, and Crucible Residue IDCs That Are Evaluated in this EIS

IDC	Residue	Kg of Total Bulk of this IDC	Kg of Pu in Total Bulk	Kg Bulk Requiring Processing	Kg of Pu in Bulk Requiring Processing	STL Pu Weight %	Bulk % > STL	Pu % > STL
333	Calcium Metal	2.70	0.21	2.70	0.21	0.2	100	100
387	Reburned SS&C Sweepings	3.62	1.55	3.62	1.55	0.2	100	100
390	Unpulverized Slag	20.8	2.95	20.6	2.95	0.2	99.0	100
391	Unpulverized Sand and Crucible	758	28.4	746	28.4	0.2	98.5	100
392	Unpulverized SS&C	1,614	55.3	1,608	55.3	0.2	99.6	100
393	SS&C Heel	325	6.7	53.8	4.32	2.0	16.6	64.5
394	Sand from Button Break-out	78.5	8.13	67.1	8.13	0.2	85.5	100
395	Unpulverized Slag and Crucible	29.8	0.564	29.8	0.564	0.2	100	100
396	Pulverized Slag	0.884	0.03	0.884	0.027	0.2	100	100
398	Pulverized SS&C	529	27.4	529	27.4	0.2	100	100

Pu = Plutonium STL = Safeguards Termination Limit SS&C = Sand, Slag, and Crucible

The number and types of packages for each IDC are given in **Table B–11**.

Table B–11 Number and Types of Packages of Sand, Slag, and Crucible Residues

IDC	Description	55-Gallon Drums (Total)	Other (Total)	55-Gallon Drums (Above STL)	Other (Above STL)
333	Calcium Metal	1	1	1	1
387	Reburned SS&C Sweepings	0	4	0	4
390	Unpulverized Slag	4	1	4	0
391	Unpulverized Sand and Crucible	28	150	26	144
392	Unpulverized SS&C	62	44	62	38
393	SS&C Heel	18	0	9	0
394	Sand from Button Break-out	9	10	9	7
395	Unpulverized Slag and Crucible	0	9	0	9
396	Pulverized Slag	0	1	0	1
398	Pulverized SS&C	27	10	27	10

STL = Safeguards Termination Limit SS&C = Sand, Slag, and Crucible

B.3.2.4 Inorganic Ash Residues

Inorganic ash residues result from production operations. At Rocky Flats, these residues were generated in Buildings 371, 707, 776, 771, and 779. The Item Description Codes (IDCs) included in this category are 368 and H61; they are described in the following paragraphs:

See Attachment 1
Figures B–4, B–5, B–6, and B–12 show the sources and types of inorganic ash residues (IDCs 368 and H61) generated at Rocky Flats.

- **IDC 368, Magnesium Oxide Ceramic Crucible**—IDC 368 was generated from electrorefining, reduction, direct oxide reduction, and salt scrub processes in Buildings 371, 771, 776, and 779. Typically, the material consists of the spent magnesium oxide ceramic crucibles that were broken to remove the contents of the crucible. This IDC is nonhomogeneous and consists of irregularly shaped pieces of magnesium

oxide containing salt residue from pyrochemical processing and possibly reactive metals. The particle size ranges from dust (1 to 25 microns [0.000039 to 0.00098 inches]) to large chunks (5.1 to 7.6 centimeters [2 to 3 inches]).

- **IDC H61, Oxide from Ducts**—Oxides from ducts residue were generated from duct remediation and cleanout activities in Buildings 371, 707, 771, and 776 and are a powder-like material that is 1 to 25 microns (0.000039 to 0.00098 inches) in size. This oxide is low in plutonium content. **Table B–12** shows the major components in oxide form.

Table B–12 Oxide from Ducts, IDC H61

Constituent	%
Plutonium	18
Calcium	40
Carbon	21
Chlorine	6
Aluminum	9
Iron	2
Lanthanum	1
Silicon	1
Magnesium	1

Table B–13 shows the total bulk and plutonium concentrations for the inorganic ash residues.

Table B–13 Inorganic Ash Residues That Are Evaluated in this EIS

IDC	Residue	Kg of Total Bulk of this IDC	Kg of Pu in Total Bulk	Kg Bulk Requiring Processing	Kg of Pu in Bulk Requiring Processing	STL Pu Weight %	Bulk % > STL	Pu % > STL
368	Magnesium Oxide Ceramic Crucible	3,330	47.4	2,003	46	0.2	60.2	96.6
H61	Oxide from Ducts	40	4.9	40	4.9	0.2	100	100

Pu = Plutonium STL = Safeguards Termination Limit

The number and types of packages for each IDC are given in **Table B–14**.

Table B–14 Number and Types of Packages of Inorganic Ash Residues

IDC	Description	55-Gallon Drums (Total)	Other (Total)	55-Gallon Drums (Above STL)	Other (Above STL)
368	Magnesium Oxide Ceramic Crucible	59	164	46	162
H61	Oxide from Ducts	0	75	0	75

STL = Safeguards Termination Limit

B.3.3 Salt Residues

The subcategories within the salt residues requiring additional processing are electrorefining salts, molten salt extraction salts, and direct oxide reduction salts. These residues are grouped together based on their chemical similarity. Most of the electrorefining and molten salt extraction salts consist of sodium chloride, potassium chloride, and magnesium chloride; the major differences are the concentrations of plutonium, americium, and magnesium chlorides. All salts in the direct oxide reduction subcategory contain calcium chloride; however, because many processes used calcium chloride (e.g., direct oxide reduction, molten salt extraction, and pyroredox), the salt residues in the direct oxide reduction subcategory contain a variety of salt mixtures with the calcium chloride, including calcium oxide, cesium chloride, zinc chloride, and potassium chloride.

Grouping the salt residues based on the chemical composition is not straightforward. For example, there are two types of molten salt extraction salt residues: residues with a sodium chloride/potassium chloride salt matrix (IDCs 405–410 and 418) and residues with a calcium chloride salt matrix (IDC 427). The IDC 427 residue could have been grouped with IDCs 405–410 and 418 in the molten salt extraction subcategory (high americium) or with the direct oxide reduction subcategory (calcium chloride). The IDC 427 residue was included in the direct oxide reduction subcategory in this EIS because the salt distillation process for the molten salt extraction subcategory is not applicable to calcium chloride salts.

Approximately 93 percent of this inventory (about 14,900 kg [32,800 lb]) would require additional processing to meet the Safeguards Termination Limits. Further discussions on the IDCs within each of the subcategories follow.

B.3.3.1 Electrorefining Salt Residues

The electrorefining salt residues are materials resulting from the electrorefining stationary furnaces in Buildings 776 and 779 and from the tilt pour furnaces in Buildings 371 and 776. The major constituents in electrorefining salt residues are sodium chloride and potassium chloride. The Item Description Codes (IDCs) included in this subcategory are 411, 473, 654, and 655. They are described in the following paragraphs:

See Attachment 1
Figure B-4 shows the sources and types of electrorefining salt residues generated at Rocky Flats.

- **IDC 411, Electrorefining Salt; IDC 473, Electrorefining Salt Packaged for Los Alamos National Laboratory; and IDC 654, Electrorefining Salt from Plutonium/Neptunium**—IDCs 411, 473, and 654 are the salts generated from the "tilt-pour" electrorefining furnaces in Buildings 371 and 776 and the stationary electrorefining furnaces in Buildings 776 and 779 during the purification of nonspecification plutonium metal. A tilt-pour furnace melts material and then tilts to remove the material from the furnace. These electrorefining salts are nonhomogeneous and are a mixture of chunks, granular, and fine particulates; they may contain plutonium chloride, americium chloride, minor amounts of magnesium chloride, and possibly small amounts of free sodium. The electrorefining salts may also contain plutonium oxides. IDC 654 was generated on a limited scale from experimental runs to study neptunium distribution within plutonium. Electrorefining salt may also contain free potassium metal and such reactive metals as calcium, magnesium, plutonium, and neptunium. IDC 473 is the same as IDC 411 that has been repackaged for shipment to Los Alamos National Laboratory. Residue IDCs 411, 473, and 654 may be packaged in 55-gallon drums or other containers.

- **IDC 655, Electrorefining Ceramics from Plutonium/Neptunium**—Electrorefining ceramics from plutonium/neptunium residues were generated in the electrorefining furnaces in Buildings 776 and 779, on a limited basis, when electrorefining processing of plutonium-neptunium alloys was performed. Once the crucible containing the alloy was cooled, the crucible was broken, the contents removed, and the broken crucible was identified as IDC 655. This IDC is composed of broken pieces of crucibles and contains coated magnesium oxide with pyrochemical salts and reactive metals, such as calcium, magnesium, plutonium, and neptunium. IDC 655 residues may be packaged in 55-gallon drums, stainless steel slip lid cans, or produce cans.

Table B–15 shows the total bulk and plutonium concentrations for the electrorefining salt residues.

Table B–15 Electrorefining Salt Residues That Are Evaluated in this EIS

IDC	Residue	Kg of Total Bulk of IDC	Kg of Pu in Total Bulk	Kg Bulk Requiring Processing	Kg of Pu in Bulk Requiring Processing	STL Pu Weight %	Bulk % > STL	Pu % > STL
411	Electrorefining Salt	7,371	470	7,211	470	0.2	97.8	>99.9
473	Electrorefining Salt Packaged for LANL	176	12.9	176	12.9	0.2	100	100
654	Electrorefining Salt from Pu/Np	28.3	4.80	28.3	4.80	0.2	100	100
655	Electrorefining Ceramics from Pu/Np [a]	5.54	0.498	5.54	0.498	0.2	100	100

Pu = Plutonium STL = Safeguards Termination Limit LANL = Los Alamos National Laboratory Pu/Np = Plutonium/neptunium
[a] These residues may be processed with sand, slag, and crucibles.

The number and types of packages for each IDC are given in **Table B–16**.

Table B–16 Number and Types of Packages of Electrorefining Salt Residues

IDC	Description	55-Gallon Drums (Total)	Other (Total)	55-Gallon Drums (Above STL)	Other (Above STL)
411	Electrorefining Salt	167	2,282	166	2,277
473	Electrorefining Salt Packaged for Los Alamos National Laboratory	11	49	11	49
654	Electrorefining Salt from Pu/NP	1	15	1	15
655	Electrorefining Ceramics from Pu/NP	1	2	1	2

STL = Safeguards Termination Limit Pu/Np = Plutonium/neptunium

B.3.3.2 Molten Salt Extraction Salt Residues

See Attachment 1
Figures B–5 and B–12 show the sources and types of molten salt extraction salt residues generated at Rocky Flats.

Molten salt extraction was used to remove americium from plutonium metal. Aged plutonium metal, such as metal returning to Rocky Flats from the nuclear weapons stockpile, slowly builds up in americium content from the radioactive decay of plutonium-241. Americium-241 has some low energy but intense gamma radiation that increases personnel exposure when handling the material. Molten salt extraction salt residues are materials resulting from the molten salt extraction process. Stationary furnaces for molten salt extraction were located in Buildings 776 and 779. The residue Item Description Codes (IDCs) included in this subcategory are IDCs 044, 405, 406, 407, 408, 409, 410, 418, 429, and 601. IDCs in this subcategory are described in the following paragraphs:

- **IDC 044, Americium and Miscellaneous Oxide**—IDC 044 was generated in Building 771 in the americium purification process.

- **IDC 405, Molten Salt, Unknown Percent Unpulverized; IDC 406, Molten Salt, Unknown Percent Pulverized; IDC 407, Molten Salt, 8 Percent Unpulverized; IDC 408, Molten Salt, 8 Percent Pulverized; IDC 409, Molten Salt, 30 Percent Unpulverized; IDC 410, Molten Salt, 30 Percent Pulverized; IDC 418, Molten Salt Packaged for Los Alamos National Laboratory**—Molten salt extraction salts categorized with IDCs 405 through 410 and IDC 418 were generated in Building 776 during the molten salt extraction production recovery processes and in Building 779 from nonproduction operations with varying percentages of magnesium chloride. The molten salt extraction process removed

americium from aged plutonium metal and produced an americium deficient plutonium metal, molten salt extraction salts containing the americium, and other residues such as crucible materials and metal stirrers. Molten salt extraction salts are nonhomogeneous and are in the form of chunks, pulverized and unpulverized, and may contain sodium chloride, potassium chloride, magnesium chloride, plutonium oxides and chlorides, americium chlorides and oxides, and elemental magnesium and plutonium. The descriptions of the IDCs denote the original percentage of magnesium chloride in the reagent salt and whether the salt was pulverized. IDC 418 is the same as IDC 410 and is material that had been repackaged for shipment to the Los Alamos National Laboratory. These materials are packaged in 55-gallon drums and other containers.

- **IDC 429, Scrub Alloy Spent Salt**—IDC 429 residues are salts remaining from the salt scrub process. The major components of IDC 429 include sodium chloride and potassium chloride but also may include magnesium chloride, magnesium oxide, and residual amounts of plutonium and americium compounds (metal, chloride, and oxide). This subcategory of residues is nonhomogeneous and is in the form of chunks and fines.

- **IDC 601, Aluminum-Magnesium Oxide**—IDC 601 was generated during nonproduction activities in the scrub alloy process from molten salt extraction salts in Buildings 776 and 779. The material contains the crucible pieces and aluminum oxide residue remaining in the crucible after the alloy button is removed. The crucibles are contaminated with salts, plutonium, and small amounts of sodium metal.

Table B–17 shows the total bulk and plutonium concentrations for the molten salt extraction residues.

Table B–17 Molten Salt Extraction Residues That Are Evaluated in this EIS

IDC	Residue	Kg of Total Bulk of IDC	Kg of Pu in Total Bulk	Kg Bulk Requiring Processing	Kg of Pu in Bulk Requiring Processing	STL Pu Weight %	Bulk % > STL	Pu % > STL
044	Americium and Miscellaneous Oxide [a]	3.19	0.73	3.19	0.73	0.2	100	100
405	Molten Salt, Unknown % Unpulverized	1,539	32.2	1,451	32.0	0.2	94.3	99.7
406	Molten Salt, Unknown % Pulverized	24.3	5.10	24.3	5.10	0.2	100	100
407	Molten Salt, 8% Unpulverized	463	16.2	463	16.2	0.2	100	100
408	Molten Salt, 8% Pulverized	210	4.8	210	4.8	0.2	100	100
409	Molten Salt, 30% Unpulverized	1,474	237	1,474	237	0.2	100	100
410	Molten Salt, 30% Pulverized	17.6	3.78	17.5	3.78	0.2	99.4	100
418	Molten Salt Packaged for LANL	49.5	10.1	49.5	10.1	0.2	100	100
429	Scrub Alloy Spent Salt	1,748	14.0	1,602	13.8	0.2	91.7	98.7
601	Aluminum Magnesium Oxide [a]	1.18	0.31	1.18	0.31	0.2	100	100

Pu = Plutonium STL = Safeguards Termination Limit LANL = Los Alamos National Laboratory
[a] This residue may be processed with sand, slag, and crucibles.

The number and types of packages for each IDC are given in **Table B–18.**

Table B–18 Number and Types of Packages of Molten Salt Extraction Salt Residues

IDC	Description	55-Gallon Drums (Total)	Other (Total)	55-Gallon Drums (Above STL)	Other (Above STL)
044	Americium and Miscellaneous Oxide	1	3	1	3
405	Molten Salt, Unknown % Unpulverized	29	4	28	4
406	Molten Salt, Unknown % Pulverized	0	24	0	24
407	Molten Salt, 8% Unpulverized	18	5	18	5
408	Molten Salt, 8% Pulverized	6	0	6	0
409	Molten Salt, 30% Unpulverized	272	24	272	24
410	Molten Salt 30% Pulverized	4	2	4	1

IDC	Description	55-Gallon Drums (Total)	Other (Total)	55-Gallon Drums (Above STL)	Other (Above STL)
418	Molten Salt Packaged for Los Alamos National Laboratory	0	32	0	32
429	Scrub Alloy Spent Salt	44	2	40	2
601	Aluminum Magnesium Oxide	0	2	0	2

STL = Safeguards Termination Limit

B.3.3.3 Direct Oxide Reduction Salt Residues

All of the salts in this subcategory contain calcium chloride. The salts were generated from several processes, including direct oxide reduction, molten salt extraction, salt scrub, and pyroredox. The processing was done in stationary furnaces.

See Attachment 1
Figures B-5, B-6, and B-12 show the sources and types of direct oxide reduction and other salt residues generated at Rocky Flats.

Calcium chloride is used as a flux in the direct oxide reduction process to promote coalescence of plutonium metal during the reduction of plutonium oxide by calcium metal to produce high yields of plutonium metal as a product. Calcium oxide, a byproduct of the reduction, also is present in the salt residue.

Dicesium hexachloroplutonate was generated in Building 371 for use as the oxidant in the calcium chloride-based molten salt extraction process to remove americium from aged plutonium metal. During the molten salt extraction process, the dicesium hexachloroplutonate decomposes to cesium chloride and plutonium chloride. Pure dicesium hexachloroplutonate is a Defense Programs material and is not considered as a residue nor is it being considered as part of this EIS.

Some of the calcium chloride salts were scrubbed to remove plutonium and americium, analogous to the salt scrub process for sodium chloride/potassium chloride salts.

The pyroredox process purified impure plutonium metal. In the oxidation step of the pyroredox process, impure plutonium metal was heated with zinc chloride in a calcium chloride/potassium chloride salt flux. The plutonium and more reactive impurities were oxidized into the salt by the zinc chloride; that resulting salt was identified as IDC 415. The plutonium in the IDC 415 salts was reduced with calcium in the next step of the pyroredox process; those residues were identified as IDC 412. The plutonium metal from the reduction step was contaminated with calcium and zinc, which were removed with a vacuum melt process; the vacuum melt residues were identified as IDC 416.

The residue IDCs included in this subcategory are IDCs 365, 404, 412, 413, 414, 415, 416, 427, 433, 434, and 435. IDCs in this subcategory are described in the following paragraphs:

- **IDC 365, Salt from Bad Direct Oxide Reduction Run**—IDC 365 was generated from the stationary furnaces in Building 776 and from nonproduction operations in Building 779. IDC 365 was generated from failed direct oxide reduction runs and consists of mixtures of the calcium chloride, calcium oxide, plutonium oxide, plutonium metal, and calcium metal. A direct oxide reduction run was considered a failure any time the quantity of unreduced plutonium oxide exceeded the acceptable limit. It contains plutonium in the form of chunks and fines, and is nonhomogeneous.

- **IDC 404, Molten Salt, Calcium, Zinc, Potassium**—IDC 404 residue is a salt generated from a nonproduction process performed in Building 776. This process used sodium chloride, potassium chloride, and magnesium chloride as the basic reagent salt mixture and was enhanced with zinc chloride and calcium chloride to improve the extraction process. This IDC is nonhomogeneous and consists of chunks of fused

salts with high concentrations of americium and plutonium chloride, zinc metal, plutonium and americium compounds, and possibly sodium and potassium metal.

- **IDC 412, Gibson Salts**—Gibson salt residues were generated from the plutonium reduction step of the Pyroredox process in Buildings 776 and 779. The Gibson salt residues may contain potassium chloride; plutonium chloride; zinc chloride; and minor amounts of chlorides of chromium, zirconium, titanium, vanadium, niobium, manganese, americium, uranium, and neptunium; and small amounts of aluminum and silicon.

- **IDC 413, Impure Salt from Cell Cleanout**—Residues within IDC 413 were generated by the cell cleanout from molten salt extraction and electrorefining salt processes both in the stationary furnaces in Building 776 and in the tilt-pour furnaces in Building 371; the residues were stored for future processing. Additionally, small amounts of residues were generated in nonproduction operations in Building 779 during cell cleanout. This salt residue is composed of chunks, granular, and fine particulates containing americium chloride, plutonium chloride, sodium chloride, potassium chloride, calcium chloride, small amounts of magnesium chloride, and possibly small amounts of free sodium. It is possible that residues generated in Building 779 and those generated in Building 776 during the early 1980s and after March 1989 may contain calcium chloride. IDC 413 residues may be packaged in 55-gallon drums, stainless steel slip lid cans, plastic bottles, produce cans, or special containers.

- **IDC 414, Direct Oxide Reduction Salt, Unoxidized Calcium**—IDC 414 is a direct oxide reduction salt originating from the direct oxide reduction process in Building 776 and for nonproduction operations in Building 779. This IDC is nonhomogeneous, may contain calcium oxide, calcium metal, calcium chloride and plutonium oxide, and is in the form of chunks and fines.

- **IDC 415, Plutonium Chloride Mixed Salt**—IDC 415 residues were generated from the plutonium oxidation step of the Pyroredox process and may include potassium chloride, calcium chloride, plutonium chloride, americium chloride, zinc chloride, aluminum chloride, lithium chloride, cesium chloride, copper chloride, gallium chloride, tantalum chloride, and tungsten chloride. This salt is a mixture of chunks, granular, and fine particulates. IDC 415 residues are packaged in 55-gallon drums and stainless steel slip lid cans.

- **IDC 416, Zinc-Magnesium Alloy Metal**—IDC 416 was generated during the Building 776 and Building 779 vacuum melt process, used to remove contaminants (calcium, magnesium, and zinc) from plutonium metal produced in the reduction step of the Pyroredox process. It is a zinc/magnesium alloy in a powdery form that contains plutonium.

- **IDC 427, Molten Salt Extraction Spent Dicesium Salt**—IDC 427 is spent salt produced from the molten salt extraction process and consists of calcium chloride, cesium chloride, americium chloride, plutonium chloride, plutonium oxide, and elemental plutonium. The material is in the form of chunks with some material pulverized into fines.

- **IDC 433, Scrub Alloy Spent Dicesium Salt**—IDC 433 residue was generated from scrubbed molten salt extraction spent dicesium salts (IDC 427) using a magnesium/aluminum scrub process. IDC 433 salts are composed of a mixture of calcium chloride and cesium chloride.

- **IDC 434, Free Calcium Containing Spent Salt**—IDC 434 was generated in Building 779 from scrubbed molten salt extraction spent dicesium salts (IDC 427) using a calcium/gallium scrub process. The material is a salt phase byproduct of the calcium-gallium scrub alloy of the molten salt extraction Process Development effort. Some additional IDC 434 was generated in Building 776 as part of the calcium/gallium salt scrub process demonstration in the fall of 1989. IDC 434 is nonhomogeneous and may contain chunks and fine particles. The salt matrix is the same as that of IDC 433.

- **IDC 435, Cerium/Calcium Scrub Alloy Spent Salts**—Cerium/calcium scrub alloy spent salts were generated as a byproduct of a salt scrub development program in Building 779, where a cerium/calcium metal alloy was tested as a substitute for the normal aluminum/magnesium alloy routinely used in the molten salt extraction process. The salts were produced in a standard stationary furnace and ceramic crucibles. The spent molten salt extraction salts were heated to a molten state, stirred with molten alloy, allowed to cool, and separated from the solidified metal alloy button. Initial test results were not favorable, so the process development was stopped. The salt residues are composed of calcium chloride; cesium chloride; cerium chloride; plutonium and americium chlorides, metals, and oxides; and elemental calcium and cerium. The material consists of dry, fused salts in the form of chunks and fines.

Table B–19 shows the total bulk and plutonium concentrations for the direct oxide reduction residues.

Table B–19 Direct Oxide Reduction Salt Residues That Are Evaluated in this EIS

IDC	Residue	Kg of Total Bulk of IDC(s)	Kg of Pu in Total Bulk	Kg Bulk Requiring Processing	Kg of Pu in Bulk Requiring Processing	STL Pu Weight %	Bulk % > STL	Pu % > STL
365, 414	Salt from Bad DOR Run, DOR Salt–Unoxidized Calcium	1,231	64.6	1,231	64.6	0.2	100	100
404	Molten Salt, Calcium, Zinc, Potassium	516	1.9	4.00	1.50	0.2	0.8	79.0
412	Gibson Salt	240	1.2	67.2	0.98	0.2	28.0	81.7
413	Impure Salt from Cell Cleanout	502	68.3	502	68.3	0.2	100	100
415	Plutonium Chloride Mixed Salt	122	6.84	122	6.84	0.2	100	100
416	Zinc-Magnesium Alloy Metal	4.77	0.39	4.77	0.39	0.2	100	100
427	Molten Salt Extraction Spent Dicesium Salt	194	44.9	194	44.9	0.2	100	100
433	Scrub Alloy Spent Dicesium Salt	21.0	0.31	21.0	0.31	0.2	100	100
434	Free Calcium Containing Spent Salt	18.4	2.02	17.8	2.02	0.2	96.7	100
435	Spent Cerium/Calcium Salt Scrub	7.7	0.2	7.7	0.2	0.2	100	100

Pu = Plutonium STL = Safeguards Termination Limit DOR = Direct Oxide Reduction

The number and types of packages for each IDC are given in **Table B–20**.

Table B–20 Number and Types of Packages of Direct Oxide Reduction Salt Residues

IDC	Description	55-Gallon Drums (Total)	Other (Total)	55-Gallon Drums (Above STL)	Other (Above STL)
365	Salt from Bad Direct Oxide Reduction Run	0	16	0	16
404	Molten Salt, Calcium, Zinc, Potassium	4	0	2	0
412	Gibson Salt	3	0	1	0
413	Impure Salt from Cell Cleanout	32	219	32	219
414	Direct Oxide Reduction Salt - Unoxidized Calcium	34	114	33	110
415	Plutonium Chloride Mixed Salt	8	18	8	18
416	Zinc-Magnesium Alloy Metal	0	3	0	3
427	Molten Salt Extraction Spent Dicesium Salt	3	130	3	130
433	Scrub Alloy Spent Dicesium Salt	2	1	2	1
434	Free Calcium Containing Spent Salt	0	10	0	9
435	Spent Cerium/Calcium Salt Scrub	1	0	1	0

STL = Safeguards Termination Limit

B.3.4 Plutonium Fluoride Residues

Plutonium fluoride residues are residue materials generated in fluoride conversion and metal reduction. Some of these residues are high plutonium content; however, the presence of fluoride results in a high neutron emission rate caused by alpha-neutron reactions between plutonium alpha particles and fluorine nucleus. These Item Description Codes (IDCs) were generated in Buildings 371 and 771. The IDCs included are 090, 091, 092, 093, and 097. IDCs in this subcategory are described in the following paragraphs:

See Attachment 1
Figures B-7 and B-12 show the sources and types of plutonium fluoride residues generated at Rocky Flats.

- **IDC 090, Plutonium Tetrafluoride, and IDC 091, Nonspecification Fluoride**—IDC 090 and IDC 091 were generated in Building 771 from the reaction of anhydrous hydrogen fluoride with plutonium oxide to form plutonium tetrafluoride. These residues are in a powder form and are referred to as "pink cake." IDC 090 is feed for conversion to metal; IDC 091 material did not meet the purity specification for further processing into metal. Residue IDCs 090 and 091 are classified as mixed residues.

- **IDC 092, Impure Fluoride Heel, and IDC 097, Impure Fluoride Heel in Small Inner Cans**—Residues within IDCs 092 and 097 were generated in the dissolution process in Building 771 from residues within IDC 091. These residues are the dry heel resulting from this process and were packaged for further dissolution. IDCs 092 and 097 differ only in the type of packaging used. Residue IDCs 092 and 097 are mixed residues.

- **IDC 093, Sodium Fluoride Pellets**—Sodium fluoride pellet residues were generated in a Fluidized Bed Fluorination Process in Building 371 and in a Fluoride Volatility Study in Building 771. Sodium fluoride pellets were used to absorb small quantities of plutonium hexafluoride gas that were not converted to plutonium tetrafluoride.

Table B–21 shows the total bulk and plutonium concentrations for the plutonium fluoride residues.

Table B–21 Plutonium Fluoride Residues That Are Evaluated in this EIS

IDC	*Residue*	*Kg of Total Bulk of this IDC*	*Kg of Pu in Total Bulk*	*Kg Bulk Requiring Processing*	*Kg of Pu in Bulk Requiring Processing*	*STL Pu Weight %*	*Bulk % > STL*	*Pu % > STL*
090	Plutonium Tetrafluoride	2.38	–	2.38	–	0.2	100	100
091	Non-Specification Fluoride	185	–	185	–	0.2	100	100
092	Impure Fluoride Heel	40.5	–	40.5	–	0.2	100	100
093	Sodium Fluoride Pellets	70.6	–	69.5	–	0.2	98.5	99.99
097	Impure Fluoride in Small Inner Cans	18.0	–		–	0.2	100	100
090-093, 097	All Above Residues	316.5	141.5	315.4	141.5	0.2	99.7	~100

Pu = Plutonium STL = Safeguards Termination Limit

The number and types of packages for each IDC are given in **Table B–22**.

Table B–22 Number and Types of Packages of Plutonium Fluoride Residues

IDC	*Description*	*55-Gallon Drums (Total)*	*Other (Total)*	*55-Gallon Drums (Above STL)*	*Other (Above STL)*
090	Plutonium Tetrafluoride	0	5	0	5
091	Non-Specification Fluoride	0	129	0	129
092	Impure Fluoride Heel	0	30	0	30

IDC	Description	55-Gallon Drums (Total)	Other (Total)	55-Gallon Drums (Above STL)	Other (Above STL)
093	Sodium Fluoride Pellets	0	59	0	58
097	Impure Fluoride in Small Inner Cans	0	34	0	34

STL = Safeguards Termination Limit

B.3.5 Sludge Residues

This category includes sludge residues and greases and oily sludge residues. Sludge residues are insoluble plutonium-bearing materials collected on filters from processing equipment. The sludges have been generated in Buildings 559, 371, 771, and 776. Greases and oily sludge residues are materials resulting from routine operations and inventory and cleanout operations. These materials were generated in Buildings 771, 776, and 777. The Item Description Codes (IDCs) in this subcategory are 089, 099, 290, 291, 292, 299, 332, and 340. They are described in the following paragraphs:

See Attachment 1
Figures B-1 and B-8 show the sources and type of sludge residues generated at Rocky Flats. Figure B-7 and Figure B-8 show the sources and types of greases and oily sludge residues generated at Rocky Flats.

- **IDC 089, Grease Oxide (Green Cake)**—Material in IDC 089 originated from inventory and cleanout operations of the calcination process in Building 771. The calcination process converts precipitated plutonium peroxide, an unstable material, to stable plutonium oxide. The plutonium oxide powder is finely divided and, in the calcination process, becomes entrained on calciner wear plates and other rotating surfaces that need to be lubricated.

- **IDC 099, Grease Fluoride**—The material in IDC 099 originated from routine maintenance, inventory, and cleanout operations of the continuous hydrofluorination process in Building 771. This is a high plutonium content residue and is a mixture of plutonium fluoride, plutonium oxide, and grease. The plutonium powder is finely divided and, in the hydrofluorination process, becomes entrained on wear plates and other rotating surfaces that need to be lubricated.

- **IDC 290, Filter Sludge**—Filter sludges in IDC 290 were generated from the calcination processes in Building 771, from laboratory processes in Buildings 559 and 771, and from vacuum pumps and other process equipment in Building 771. The sludge is nonhomogeneous and ranges from a damp mass with the consistency of paste to a partially dried powder containing fines. IDC 290 may contain trace amounts of the following chemicals: alcohols/glycols (e.g., butanol ethanol, isopropanol, and methanol), hydrocarbons (e.g., ethyl benzene, toluene, and xylene), halogenated organics (e.g., 1,1,1 trichloroethane, 1,1,2 trichloro-1,1,2 trifluoroethane, carbon tetrachloride, and methylene chloride), metal compounds (e.g., beryllium, cadmium, and lead), tributyl phosphate, and a flocculating agent (polyelectrolyte).

- **IDC 291, Dried Lab Waste Fluoride Sludge**—IDC 291 is practically the same as IDC 290.

- **IDC 292, Incinerator Sludge**—Incinerator sludge residues identified as IDC 292 were generated from the recovery incinerator in Building 771 and were collected by filtering the scrubber solution. This material is nonhomogeneous, consists primarily of diatomite filter bed, and ranges from a paste-like damp mass to a partially dried mass that may contain fines. IDC 292 may contain trace amounts of alcohols/glycols (e.g., butanol ethanol, isopropanol, and methanol), hydrocarbons (e.g., ethyl benzene, toluene, and xylene), halogenated organics (e.g., 1,1,1 trichloroethane, 1,1,2 trichloro-1,1,2 trifluoroethane, carbon tetrachloride, and methylene chloride), metal compounds (e.g., beryllium, cadmium, and lead), tributyl phosphate, and a flocculating agent (polyelectrolyte).

- **IDC 299, Miscellaneous Sludge**—Filter sludges in IDC 299 are insoluble residues from nitric acid dissolution in Building 771, residues from the analytical laboratories in Building 371, and insoluble residues from miscellaneous operations in other buildings handling plutonium. The residues under this IDC have been characterized as mixed residues.

- **IDC 332, Oily Sludge**—The materials in IDC 332 are residues generated from routine maintenance of production equipment in Buildings 776 and 777. These residues are described as oily sludges resulting from routine equipment maintenance.

- **IDC 340, Sludge from Size Reduction Area**—Residue sludge from the size reduction area was generated in Building 776 in the size reduction vault. The size reduction vault operation recovered plutonium from non-Resource Conservation and Recovery Act–regulated metals and other materials, such as glovebox gloves. This material is nonhomogeneous and ranges from a paste-like damp mass to a partially dried powder that may contain fines.

Table B–23 shows the total bulk and plutonium concentrations for the sludge residues.

Table B–23 Sludge Residues That Are Evaluated in this EIS

IDC	Residue	Kg of Total Bulk of this IDC	Kg of Pu in Total Bulk	Kg Bulk Requiring Processing	Kg of Pu in Bulk Requiring Processing	STL Pu Weight %	Bulk % > STL	Pu % > STL
089	Grease Oxide	1.3	0.3	1.3	0.3	1.0	100	100
099	Grease Fluoride	3.1	0.6	3.1	0.6	1.0	100	100
290	Filter Sludge	348	13.2	348	13.2	0.2	100	100
291	Dried Lab Waste Fluoride Sludge	18.9	0.88	18.9	0.88	0.2	100	100
292	Incinerator Sludge	7.9	0.56	7.9	0.56	0.2	100	100
299	Miscellaneous Sludge	151	7	102	7	0.2	67.9	>99
332	Oily Sludge	2.6	0.05	2.6	0.05	1.0	100	100
340	Sludge from Size Reduction Area	135	4.1	135	4.1	0.2	100	100

Pu = Plutonium STL = Safeguards Termination Limit

The number and types of packages for each IDC are given in **Table B–24**.

Table B–24 Number and Types of Packages of Sludge Residues

IDC	Description	55-Gallon Drums (Total)	Other (Total)	55-Gallon Drums (Above STL)	Other (Above STL)
089	Grease Oxide	0	6	0	6
099	Grease Fluoride	0	7	0	7
290	Filter Sludge	33	0	33	0
291	Dried Lab Waste Fluoride Sludge	2	0	2	0
292	Incinerator Sludge	1	3	1	3
299	Miscellaneous Sludge	9	21	8	18
332	Oily Sludge	1	0	1	0
340	Sludge from Size Reduction Area	9	0	9	0

STL = Safeguards Termination Limit

B.3.6 Filter Media Residues

Filter media residues are categorized as residue materials that have been wetted with liquids (e.g., acid, water, or organic solutions) in the normal course of processing

See Attachment 1
Figures B–1, B–9, and B–10 show the sources and types of filter media generated at Rocky Flats.

plutonium-bearing materials. The sources of these residues are all the plutonium-processing buildings at Rocky Flats. The Item Description Codes (IDCs) included in this category are 331, 335, 338, 342, 376, and 490. They are described in the following paragraphs:

- **IDC 331, Filters, Ful Flo, Not From Incinerator**—Ful Flo filters were used for separating particulates from acid solution streams in plutonium recovery operations. These particulates contain insoluble plutonium imbedded in the filter media (polypropylene). Ful Flo filters also were used for separating particulates from machine coolant in fabrication operations; these particulates include plutonium metal particles. The filter media may be either polypropylene or cotton. IDC 331 was generated in Buildings 371, 707, 771, 776, 777, and 779. The Ful Flo filters were used to filter nitric acid and hydrochloric acid solution, caustic solution, solvent systems, water systems, and oil lubricating systems. The filters may contain small amounts of these liquids and may be contaminated with carbon tetrachloride, chromium, and Freon. This IDC can be a mixed or nonmixed residue.

- **IDC 335, Absolute Drybox Filters, Not Acid Contaminated**—High-efficiency particulate air (HEPA) filters (24'x24'x12') consist of a filter media of glass fibers and corrugated aluminum stiffeners. The filter media is held in place using an adhesive and sealant to a frame of fire retardant exterior grade plywood or wood particle board. Frames also consist of 14 U.S. gauge cadmium-plated or chromized carbon steel. Newer HEPA filters consist of glass and aromatic polyamide fibers and aluminum alloy stiffeners coated with a thermoset vinyl or epoxy. Small HEPA prefilters are used in ventilation systems in plutonium processing areas to filter out particulates from gloveboxes. These filters contain a glass fiber filter media and a wood frame. These prefilters are used at the glovebox for removing dust from the air exiting the glovebox. The sources of IDC 335 were Buildings 371, 374, 559, 707, 771, 774, 776, 779, and 881.

- **IDC 338, Filter Media**—IDC 338 is the filter media portion of the used filters, with the frame and the supporting stiffeners removed. It was generated in Buildings 371, 374, 559, 707, 771, and 776. This material can be wet or dry.

- **IDC 342, Absolute Drybox Filters, Acid Contaminated**—This IDC consists of HEPA filters used in filter plenums for removal of entrained particulates from air handling systems in all plutonium buildings. These filters are changed periodically when they become loaded with particulates or fail for other reasons. Although many of the filters are waste, some contain recoverable quantities of plutonium. These filters usually come from high dust operations where moisture, organics, or other nonacids also may collect; typically, they are contaminated with dilute nitric acid. These materials were generated in Buildings 559, 771, and 779.

- **IDC 376, Processed Filter Media**—This IDC is the same as IDC 338 but has been processed in an attempt to recover the embedded plutonium. IDC 376 is composed of the filter media portions of the used glovebox or HEPA filters that contain recoverable plutonium. Insoluble plutonium remains embedded in the media even after acid processing.

- **IDC 490, HEPA Filters, Not Acid Contaminated**—This IDC is the same as IDC 342, except that it is wet with liquids other than acids. These liquids may be water, caustic, or organics. This IDC was generated in Buildings 374, 771, 774, 776, and 777 and contains mixed and nonmixed residues.

Table B–25 shows the total bulk and plutonium concentrations for the filter media residues.

Table B–25 Filter Media Residues That Are Evaluated in this EIS

IDC	Residue	Kg of Total Bulk of this IDC	Kg of Pu in Total Bulk	Kg Bulk Requiring Processing	Kg of Pu in Bulk Requiring Processing	STL Pu Weight %	Bulk % > STL	Pu % > STL
331	Filter, Ful Flo, Not from Incinerator	3,452	32.2	800	19.6	1.0	23.2	60.9
335	Absolute Drybox Filters, Not Acid Contaminated	275	2.7	73.0	1.33	1.0	26.5	49.3
338	Filter Media	2,297	92.5	1,705	90.6	1.0	74.2	98.0
342	Absolute Drybox Filters, Acid Contaminated	637	2.5	35	0.470	1.0	5.5	18.8
376	Processed Filter Media	868	2.3	0.423	0.074	1.0	0.05	3.2
490	HEPA Filters (24X24), Not Acid Contaminated	45.0	0.30	16.0	0.17	1.0	35.6	56.7

Pu = Plutonium STL = Safeguards Termination Limit HEPA = high-efficiency particulate air

The number and types of packages for each IDC are given in **Table B–26.**

Table B–26 Number and Types of Packages of Filter Media Residues

IDC	Description	55-Gallon Drums (Total)	Other (Total)	55-Gallon Drums (Above STL)	Other (Above STL)
331	Filter, Ful Flo	192	2	74	1
335	Drybox Filters	17	0	6	0
338	Filter Media	203	7	195	6
342	Drybox Filters	29	0	4	0
376	Proc. Filter Media	33	1	1	1
490	HEPA Filters	2	0	1	0

STL = Safeguards Termination Limit HEPA = high-efficiency particulate air
Note: Database did not provide a complete indication of container type. This EIS assumes that containers are drums unless specifically identified in the database as belonging in the "other" category.

B.3.7 Combustible Residues

See Attachment 1
Figure B–10 shows the sources and types of combustible residues generated at Rocky Flats.

Combustible residues consist of aqueous- and organic-contaminated combustibles and dry combustibles. The aqueous and organic combustible materials were wetted in the normal course of processing plutonium-bearing materials. Dry combustible materials are residues that have been staged for processing by incineration. Dry materials include paper, rags, cloth, plastics, personal protection equipment, latex gloves, and gaskets. The Item Description Codes (IDCs) within this category are 330, 336, 337, and 341. They are described in the following paragraphs:

- **IDC 330, Combustibles, Dry**—The materials in IDC 330 were generated in all plutonium processing buildings. These residues were generated during processing activities and maintenance and inventory operations. The residues include paper, rags, cloth, plastic, personal protective equipment, wood, personal protective equipment, and gaskets and may be contaminated with solvents. These materials have been segregated from liquids. The dry residues may be either mixed or nonmixed residues.

- **IDC 336, Combustibles, Wet**—IDC 336 is composed of combustible materials such as cloth, paper, rags, coveralls, rubber, wood, and other miscellaneous materials; it may contain small amounts of liquid. This

material was generated mainly from cleanup activities in gloveboxes in Buildings 371, 374, 559, 707, 771, 774, 776, 777, and 779 in plutonium operations.

- **IDC 337, Plastics**—The materials in IDC 337 residues were generated in all plutonium processing buildings. These IDC residues are composed of plastics (e.g., Teflon, Kynar, polyvinyl chloride, polyethylene) used in various plutonium processes in routine production, cleanup, and inventory operations.

- **IDC 341, Leaded Drybox Gloves, Acid Contaminated**—Gloves are fabricated with three layers: a neoprene layer, a lead oxide layer, and a Hypalon layer. The surface of the glove exposed to the glovebox atmosphere (the Hypalon layer) is contaminated with plutonium and acids, bases, solvents, or oils from processing operations. IDC 341 materials are leaded drybox gloves that have been used as part of the personnel barrier in plutonium operations. Leaded gloves are used where gamma exposures are high from americium concentrations and additional personnel protection is required. These materials are acid contaminated and were generated in every residue building.

Table B–27 shows the total bulk and plutonium concentrations for the combustible residues.

Table B–27 Combustible Residues That Are Evaluated in this EIS

IDC	Residue	Kg of Total Bulk of this IDC	Kg of Pu in Total Bulk	Kg Bulk Requiring Processing	Kg of Pu in Bulk Requiring Processing	STL Pu Weight %	Bulk % > STL	Pu % > STL
330	Combustibles, Dry	5,037	23.3	398	6.24	1.0	7.9	26.8
336	Combustibles, Wet	7,194	32.7	664	11.6	1.0	9.2	35.5
337	Plastics (e.g., Teflon, polyvinyl chloride, polyethylene)	1,542	6.4	57.4	3.23	1.0	3.7	50.5
341	Leaded Drybox Gloves, Acid Contaminated	477	1.4	21.0	0.270	1.0	4.4	19.3

Pu = Plutonium STL = Safeguards Termination Limit

The number and types of packages for each IDC are given in **Table B–28**.

Table B–28 Number and Types of Packages of Combustible Residues

IDC	Description	55-Gallon Drums (Total)	Other (Total)	55-Gallon Drums (Above STL)	Other (Above STL)
330	Combustibles, Dry	174	0	23	0
336	Combustibles, wet	311	0	38	0
337	Plastic (e.g., Teflon, polyvinyl chloride, polyethylene)	51	0	8	0
341	Leaded Drybox Gloves	8	0	1	0

STL = Safeguards Termination Limit

B.3.8 Glass Residues

The glass residues are materials consisting of ordinary glass, ceramics, leaded glass, and boron-impregnated Raschig rings originating from most plutonium buildings. The Item Description Codes (IDCs) in this category include 440, 441, and 442. They are described in the following paragraphs:

See Attachment 1
Figure B–11 shows the sources and types of glass residues generated at Rocky Flats.

- **IDC 440, Glass (Except Raschig Rings)**—Glass residues that make up IDC 440 were generated mainly in Buildings 371, 559, 771, and 779. These residues consist of ceramics and glassware in irregularly shaped pieces. The glass residues in this IDC are characterized as nonmixed residues.

- **IDC 441, Unleached Raschig Rings**—Raschig ring residues under IDC 441 originated from the Process Vent Scrubber System in Building 371 and in production tanks used for processing plutonium solutions in Building 771. Other buildings also may contribute to the Raschig ring residue inventory. Raschig rings are hollow borosilicate glass cylinders, 1-1/2" long by 1-1/2" in diameter by 3/16" thick, used to absorb neutrons and thus prevent criticality in large process tanks. These rings are homogeneous and are coated with insoluble plutonium compounds.

- **IDC 442, Leached Raschig Rings**—IDC 442 residues are Raschig rings. These rings are the same as IDC 441 but have been leached in an attempt to remove solid insoluble plutonium residues from the ring surfaces.

Table B–29 shows the total bulk and plutonium concentrations for the glass residues.

Table B–29 Glass Residues That Are Evaluated in this EIS

IDC	Residue	Kg of Total Bulk of this IDC	Kg of Pu in Total Bulk	Kg Bulk Requiring Processing	Kg of Pu in Bulk Requiring Processing	STL Pu Weight %	Bulk % > STL	Pu % > STL
440	Glass (Except Raschig Rings)	1,334	7.0	116	3.20	1.0	8.7	45.7
441	Unleached Raschig Rings	117	1.11	7.29	0.948	1.0	6.2	85.4
442	Leached Raschig Rings	474	1.9	10.9	0.917	2.0	2.3	48.0

Pu = Plutonium STL = Safeguards Termination Limit

The number and types of packages for each IDC are given in **Table B–30**.

Table B–30 Number and Types of Packages of Glass Residues

IDC	Description	55-Gallon Drums (Total)	Other (Total)	55-Gallon Drums (Above STL)	Other (Above STL)
440	Glass (Except Raschig Rings)	40	1	8	0
441	Unleached Raschig Rings	5	3	1	0
442	Leached Raschig Rings	11	0	1	0

STL = Safeguards Termination Limit

B.3.9 Graphite Residues

Graphite residues are materials consisting of graphite materials generated during plutonium foundry operations in Buildings 776 and 707 and firebrick material removed during maintenance operations on the residue recovery incinerator in Buildings 771 and 371. The Item Description Codes (IDCs) in this category include 300, 303, 312, and 377. They are described in the following paragraphs:

See Attachment 1
Figures B–1, B–2, and B–12 show the sources and types of graphite residues generated at Rocky Flats.

- **IDC 300, Graphite Molds**—The material in IDC 300 was generated in Buildings 707 and 776 (before 1969) after the cast product was removed from the graphite mold in plutonium foundry operations. These residues consist of large graphite pieces and were packaged for scarfing. The surfaces usually are coated with calcium fluoride to act as a barrier to prevent molten plutonium metal from reacting with the graphite. Plutonium, calcium, or magnesium metals may be present on the coated mold surface.

- **IDC 303, Scarfed Graphite Chunks, and IDC 312, Graphite, Coarse**—The materials in IDC 303 and IDC 312 residues were generated in Buildings 371, 707, 771, and 777. These residues are the coarse graphite material resulting from the scarfing operations from IDC 300. They consist of various oddly sized chunks of graphite mold containing some calcium fluoride mold coating and contaminated with plutonium metal and plutonium metal oxide. These residues are characterized as nonmixed residues.

- **IDC 377, Firebrick, Coarse**—The materials in IDC 377 consist of chunks of unpulverized firebrick material and were generated in Building 371 during incinerator stripout operations and in Building 771 during maintenance operations of the residue recovery incinerator. These materials consist of bricks and chunks of bricks resulting from the scarfing process to remove plutonium from the surface of the firebricks. The firebrick is composed of high-density alumina ceramic firebrick material and is coated with a glaze containing plutonium and americium formed during the incineration process. Residues from IDC 377 are characterized as mixed residues.

Table B–31 shows the total bulk and plutonium concentrations for the graphite residues.

Table B–31 Graphite Residues That Are Evaluated in this EIS

IDC	Residue	Kg of Total Bulk of this IDC	Kg of Pu in Total Bulk	Kg Bulk Requiring Processing	Kg of Pu in Bulk Requiring Processing	STL Pu Weight %	Bulk % > STL	Pu % > STL
300	Graphite Molds	8,525	12	90.7	2.52	1.0	1.1	21.0
303	Scarfed Graphite Molds	468	0.72	5.85	0.477	1.0	1.3	66.3
312	Graphite, Coarse	2,273	95.3	1,779	93.0	1.0	78.3	97.6
377	Firebrick, Coarse	2,800	19.0	3.28	1.41	5.0	0.1	7.4

Pu = Plutonium STL = Safeguards Termination Limit

The number and types of packages for each IDC are given in **Table B–32**.

Table B–32 Number and Types of Packages of Graphite Residues

IDC	Description	55-Gallon Drums (Total)	Other (Total)	55-Gallon Drums (Above STL)	Other (Above STL)
300	Graphite Molds	125	13	6	12
303	Scarfed Graphite Molds	6	0	1	0
312	Graphite, Coarse	116	27	99	25
377	Firebrick, Coarse	38	4	0	2

STL = Safeguards Termination Limit

B.3.10 Inorganic (Metals and Others) Residues

Inorganic residues are materials consisting of various metals, crucibles, and insulation generated in production, maintenance, and construction operations. The Item Description Codes (IDCs) included in this category are 197, 320, 360, 370, 438, and 480. IDCs in this category are described in the following paragraphs:

See Attachment 1
Figures B–4, B–5, B–6, B–8, and B–12 show the sources and types of inorganic residues generated at Rocky Flats.

- **IDC 197, Tantalum Target and Sub-Target, To Be Leached**—The materials in IDC 197 are metal targets, tantalum equipment, and other miscellaneous metals used during production operations in Buildings 707 and 777. These metal components were reused in plutonium operations until they reached failure or end of life. Plutonium penetrates the metal surfaces during these operations. These residues are characterized as nonhazardous.

- **IDC 320, Heavy Non-Special Source Metal (Tantalum, Tungsten, Platinum)**—The materials in IDC 320 were generated in various processes in Buildings 371, 707, 771, 776, and 779 for periodic replacement of the original equipment. This IDC is considered homogeneous except for the surface layer of plutonium. The materials are in the form of tantalum, tungsten, and platinum equipment (e.g., vessels, pans, and rods) that was contaminated with plutonium on the surface. Some materials are corroded or coated with pyrochemical salts as well as plutonium metal and oxide. This IDC residue can be mixed or nonmixed.

- **IDC 360, Aluminum Oxide Crucible**—Aluminum oxide crucibles were used to contain the molten chloride salts used in pyrochemical processing and in pyrochemical development work in Buildings 771, 776, and 779. Typically, after cooling to room temperature, the crucible would be broken and its contents removed. The broken crucible pieces are identified as IDC 360 and consist of irregularly shaped pieces of aluminum oxide coated with pyrochemical salts (and, possibly, such reactive metals as calcium, magnesium, and plutonium).

- **IDC 370, LECO Crucible**—The material in IDC 370 was generated in the analytical laboratories of Buildings 559 and 771. LECO crucibles were used for carbon analyses of plutonium metals and oxides and for calibration purposes. The LECO crucible consists of aluminum silicate-based ceramic with approximately 0.5 percent chromium. IDC 370 will have plutonium oxide fused onto the crucible along with an accelerator, such as tin.

- **IDC 438, Insulation**—The material in IDC 438 is insulation composed of aluminum oxide and silicon dioxide generated during maintenance, strip-out, and repair operations. Other waste that may be included in this IDC includes sweepings from insulation work cleanup.

- **IDC 480, Light Metal**—The material in IDC 480 was generated in all plutonium processing buildings and consists of stainless steel, aluminum, copper, iron, brass, galvanized metal, mild steel, and other common metals. These residues include tools, piping, cables, and valves generated during maintenance and construction operations.

Table B–33 shows the total bulk and plutonium concentrations for the inorganic residues.

Table B–33 Inorganic Residues That Are Evaluated in this EIS

IDC	*Residue*	*Kg of Total Bulk of IDC*	*Kg of Pu in Total Bulk*	*Kg Bulk Requiring Processing*	*Kg of Pu in Bulk Requiring Processing*	*STL Pu Weight %*	*Bulk % > STL*	*Pu % > STL*
197	Tantalum Target and Sub-Target, to be Leached	113	1.37	113	1.37	0.2	100	100
320	Heavy Non-Special Source Metal (Tantalum, Tungsten, Platinum)	2,550	15.5	237	4.59	1.0	9.3	29.6
360	Aluminum Oxide Ceramic Crucible	42.1	0.2	20.5	0.1	0.2	48.7	50.0
370	LECO Crucible	8,223	137	19.7	7.46	5.0	0.24	5.4
438	Insulation	26.8	0.082	26.8	0.082	0.2	100	100
480	Light Metal	4,311	11.2	46.1	4.08	1.0	1.1	36.4

Pu = Plutonium STL = Safeguards Termination Limit

The number and types of packages for each IDC are given in **Table B–34**.

Table B–34 Number and Types of Packages of Inorganic Residues

IDC	Description	55-Gallon Drums (Total)	Other (Total)	55-Gallon Drums (Above STL)	Other (Above STL)
197 [a]	Tantalum Target and Sub-Target, to be Leached	0	22	0	22
320	Heavy Non-Special Source Metal (Tantalum, Tungsten, Platinum)	54	4	9	1
360	Aluminum Oxide Ceramic Crucible	3	0	1	0
370	LECO Crucible	160	0	8	0
438	Insulation	2	0	2	0
480	Light Metal	76	41	2	40

STL = Safeguards Termination Limit

[a] Packaging type was not indicated in the Rocky Flats Database; therefore, the packaging type is placed under the category of "Other" rather than "55-Gallon Drums."

B.3.11 Scrub Alloy

See Attachment 1

Figures B–4 and B–5 show the sources and types of scrub alloy generated at Rocky Flats.

The scrub alloy category includes approximately 700 kg (1,540 lb) of material containing approximately 200 kg (440 lb) of plutonium. The scrub alloy is a distinct category of plutonium-bearing material. Scrub alloy is a mixture of magnesium, aluminum, americium, and plutonium alloy generated during the salt scrub processing of molten salt extraction salts and the anode alloy processing of electrorefining anode heels. Scrub alloy consists of Item Description Codes (IDCs) 025, 600, 602, 603, 604, and 620. These IDCs were grouped together because of their chemical likeness or the similar way in which they will be processed and repackaged. The entire total scrub alloy inventory will require processing to put it in a form suitable for disposition. Safeguards Termination Limits do not apply to scrub alloy.

The primary hazard associated with scrub alloys is worker exposure from gamma radiation. The radiation hazard is caused by the presence of americium, which is 50 times more radioactive than plutonium. Americium also emits low energy gamma radiation, which is very intense if not adequately shielded. The high americium content provides approximately 1 rem/hour dose rate from the surface of the scrub alloy. Current packaging of the scrub alloys was not intended for long-term storage. IDCs in this category are described in the following paragraphs:

- **IDC 025, Aluminum Alloy Anode Heel for Savannah River Site, and IDC 620, Aluminum Alloy Buttons**—IDCs 025 and 620 are metal alloys generated when anode heel from electrorefining was alloyed with aluminum to generate a scrub alloy. IDC 025 has less americium and more other impurities than IDC 620. IDCs 025 and 620 are characterized as products for shipment to the Savannah River Site.

- **IDC 600, Molten Salt Extraction Scrub Alloy**—The material in IDC 600 is a metal alloy generated during the salt scrub process that strips plutonium and americium from the molten salt extraction salts using magnesium to reduce to plutonium metal and aluminum to alloy the metal. Sodium chloride, potassium chloride, and magnesium chloride salt matrix were the major molten salt extraction salt inputs to the salt scrub process. IDC 600 is characterized as a product for shipment to the Savannah River Site.

- **IDC 602, Calcium Chloride/Cesium Chloride Scrub Alloy**—The material in IDC 602 is a metal alloy generated since 1989, when the molten salt extraction production process was changed to use dicesium hexachloroplutonate as the extractant and calcium chloride as the diluent (see Section B.3.3.3 of this appendix). IDC 602 is characterized as a product for shipment to the Savannah River Site.

- **IDC 603, Cerium/Calcium Scrub Alloy**—The material in IDC 603 is a metal alloy generated since 1989, when calcium was the reductant and gallium was being investigated as an alloying agent. IDC 603 is characterized as a product for shipment to the Savannah River Site.

- **IDC 604, Gallium/Calcium Scrub Alloy**—The material in IDC 604 is a metal alloy generated since 1989, when calcium and cerium were being investigated as the alloying agents in the salt scrub process. IDC 604 is characterized as a product for shipment to the Savannah River Site.

Table B–35 shows the number of packages for IDCs 025, 600, 602, 603, 604, and 620.

Table B–35 Number of Packages of Scrub Alloy

IDC	*Description*	*Number of Items*
025	Aluminum Alloy Anode Heel for Savannah River Site	93
600	Molten Salt Extraction Scrub Alloy	146
602	Calcium Chloride/Cesium Chloride Scrub Alloy	4
603	Cerium/Calcium Scrub Alloy	6
604	Gallium/Calcium Scrub Alloy	23
620	Aluminum Alloy Buttons	4

B.4 REFERENCES

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ATTACHMENT 1: FLOW DIAGRAMS

The figures in this attachment are flow diagrams that show the sources and types of the various residues presented in Appendix B. The Item Description Codes given on the figures are described and tabulated in Appendix B.

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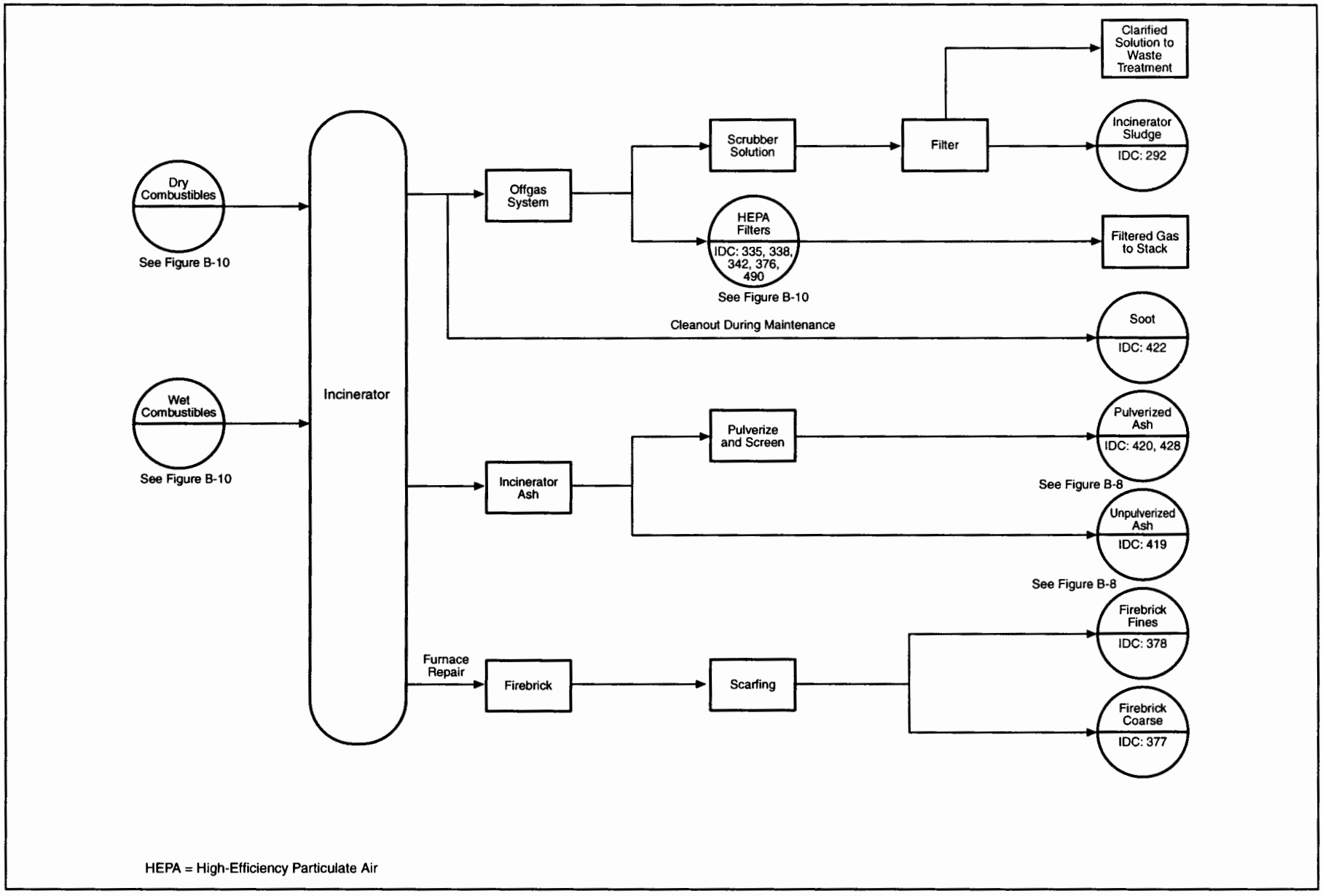


Figure B–1 Ash Residues—Building 771

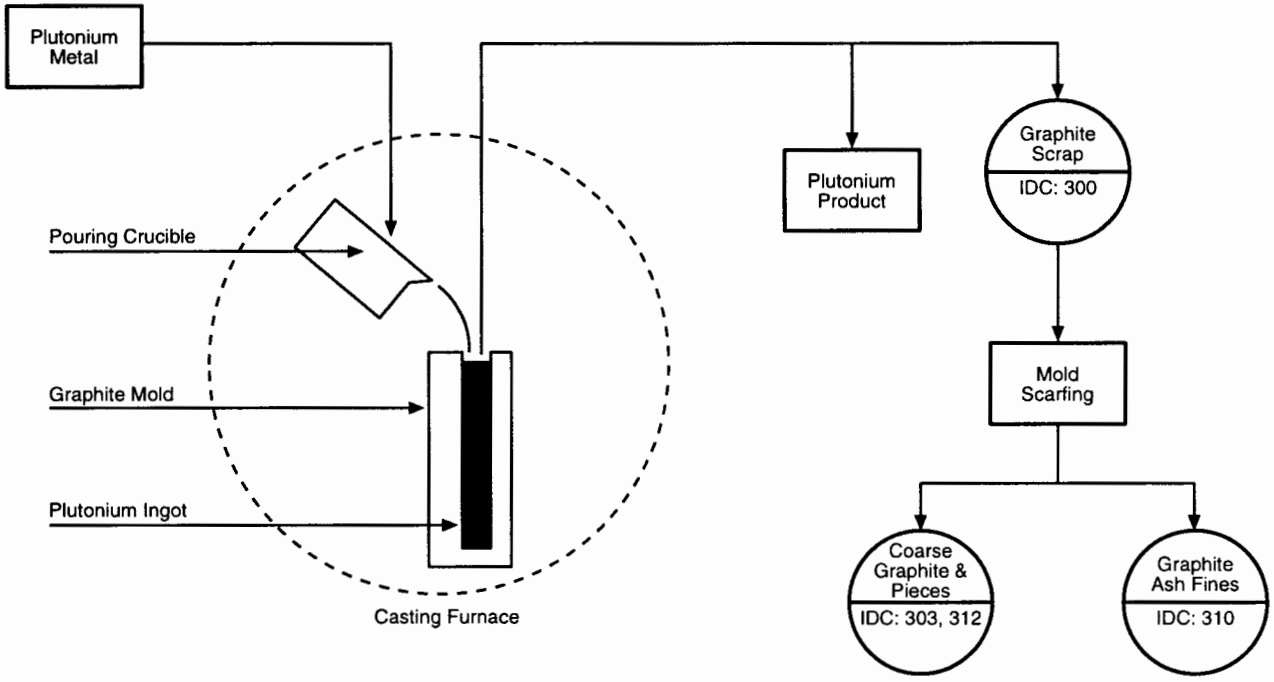
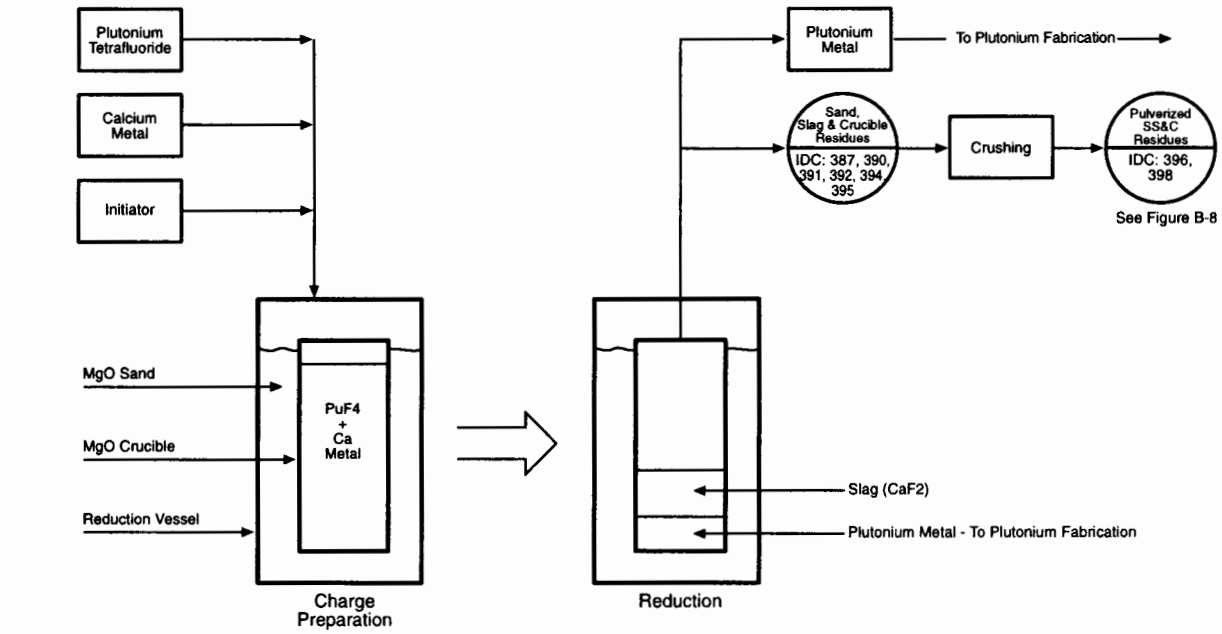


Figure B–2 Graphite and Graphite Ash Fines Residues—Buildings 371, 707, 771, and 777



MgO = Magnesium Oxide
PuF4 = Plutonium Tetrafluoride
Ca = Calcium
CaF2 = Calcium Fluoride
SS&C = Sand, Slag, and Crucible

Figure B–3 Sand, Slag, and Crucible Residues—Buildings 371, 771, and 779

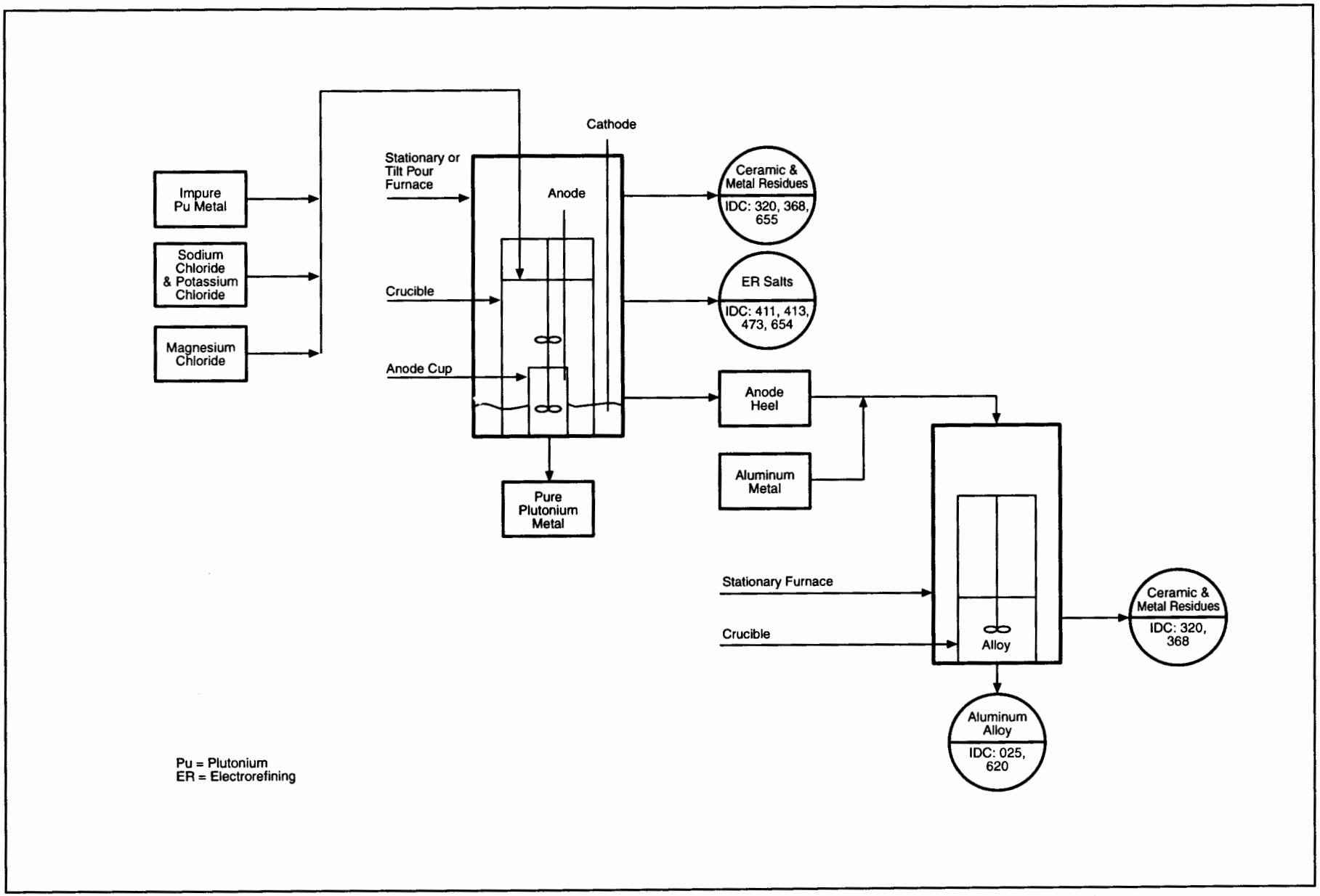


Figure B–4 Electrorefining Salt and Anode Alloy Process Residues—Buildings 371, 776, and 779

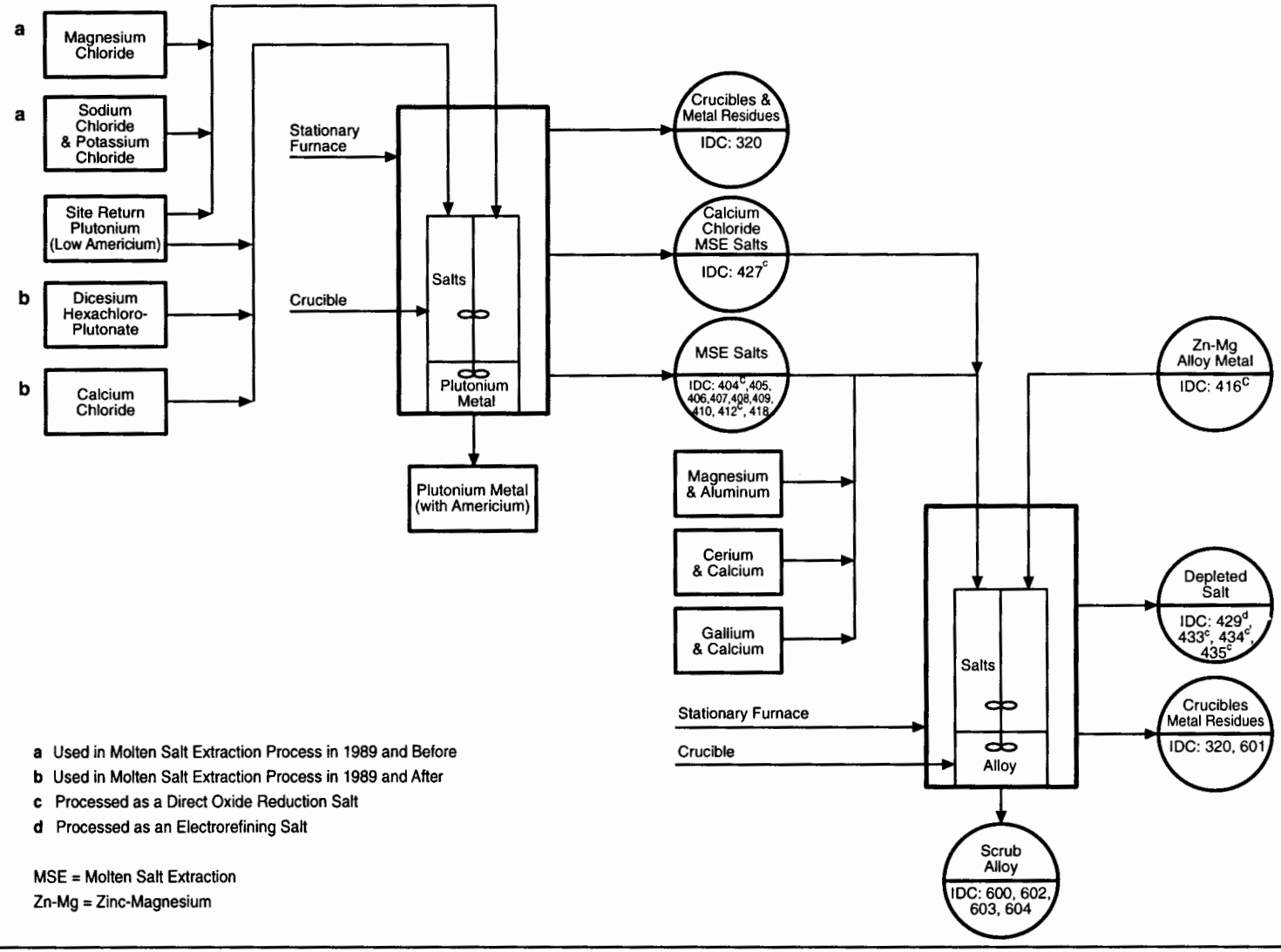
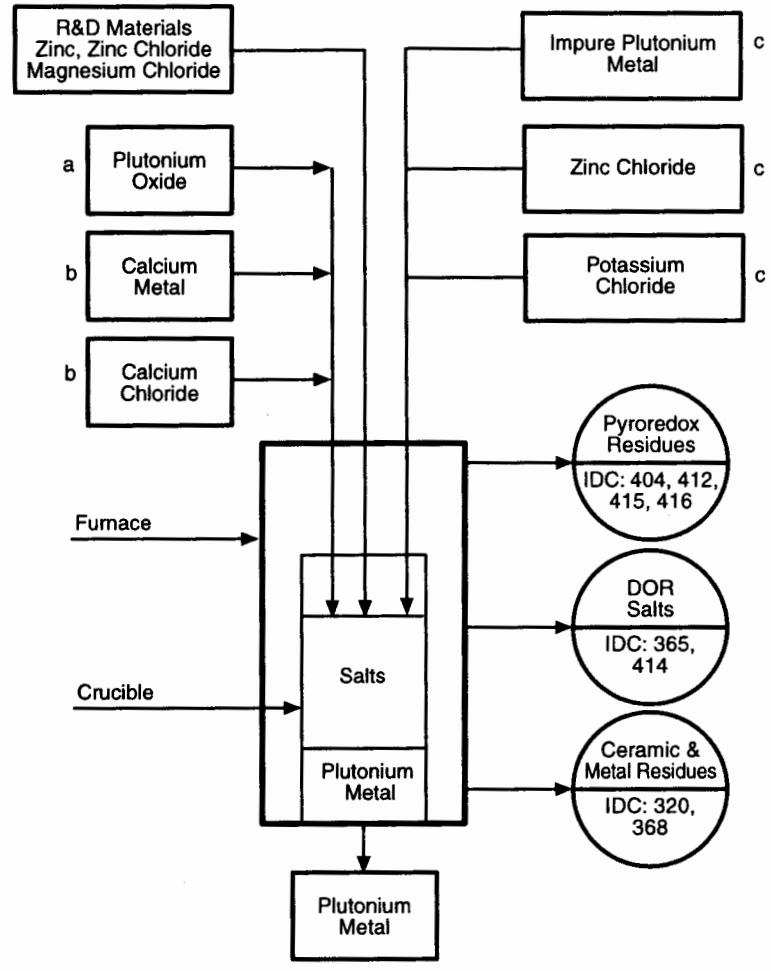


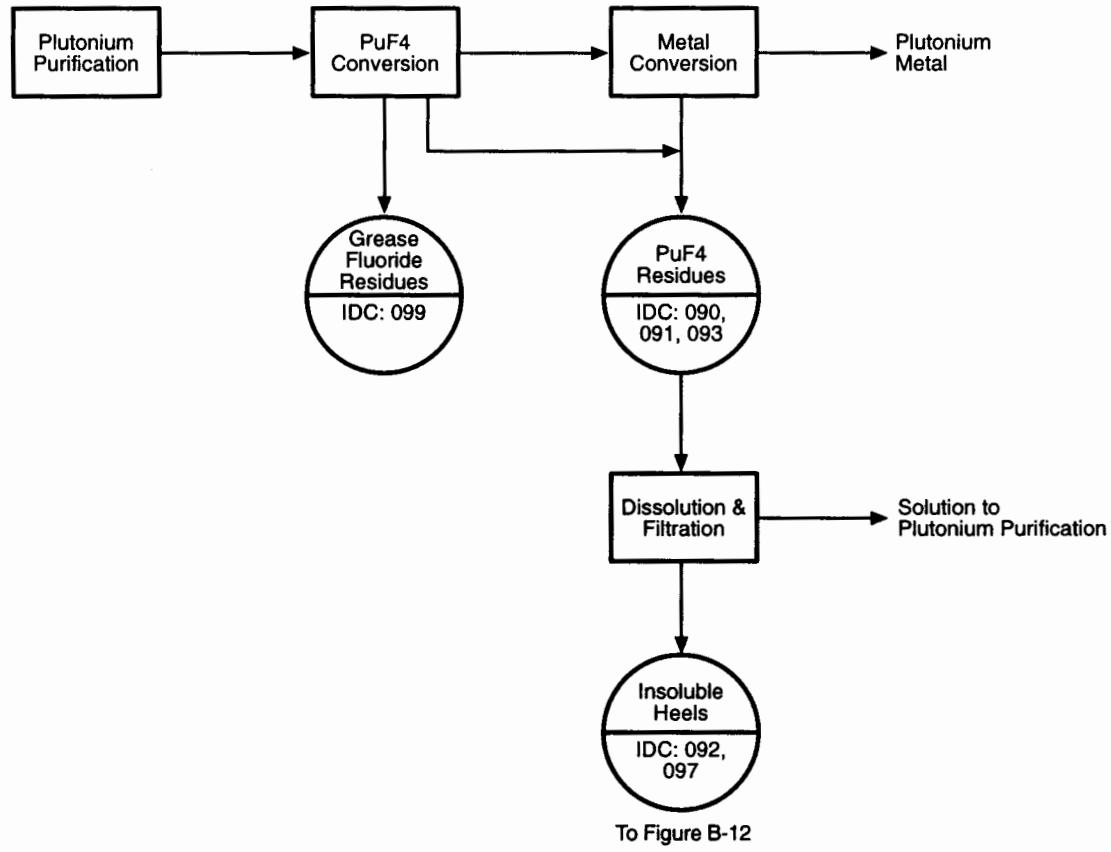
Figure B–5 Molten Salt Extraction Residues and Scrub Alloy—Buildings 776 and 779



a = Reagents in the Direct Oxide Reduction Process
b = Reagents common to both the Direct Oxide Reduction and Pyroredox Processes
c = Reagents in the Pyroredox Process

R&D = Research and Development
DOR = Direct Oxide Reduction

Figure B–6 Direct Oxide Reduction Residues—Buildings 776 and 779



PuF4 = Plutonium Tetrafluoride

Figure B–7 Plutonium Fluoride Residues—Buildings 371 and 771

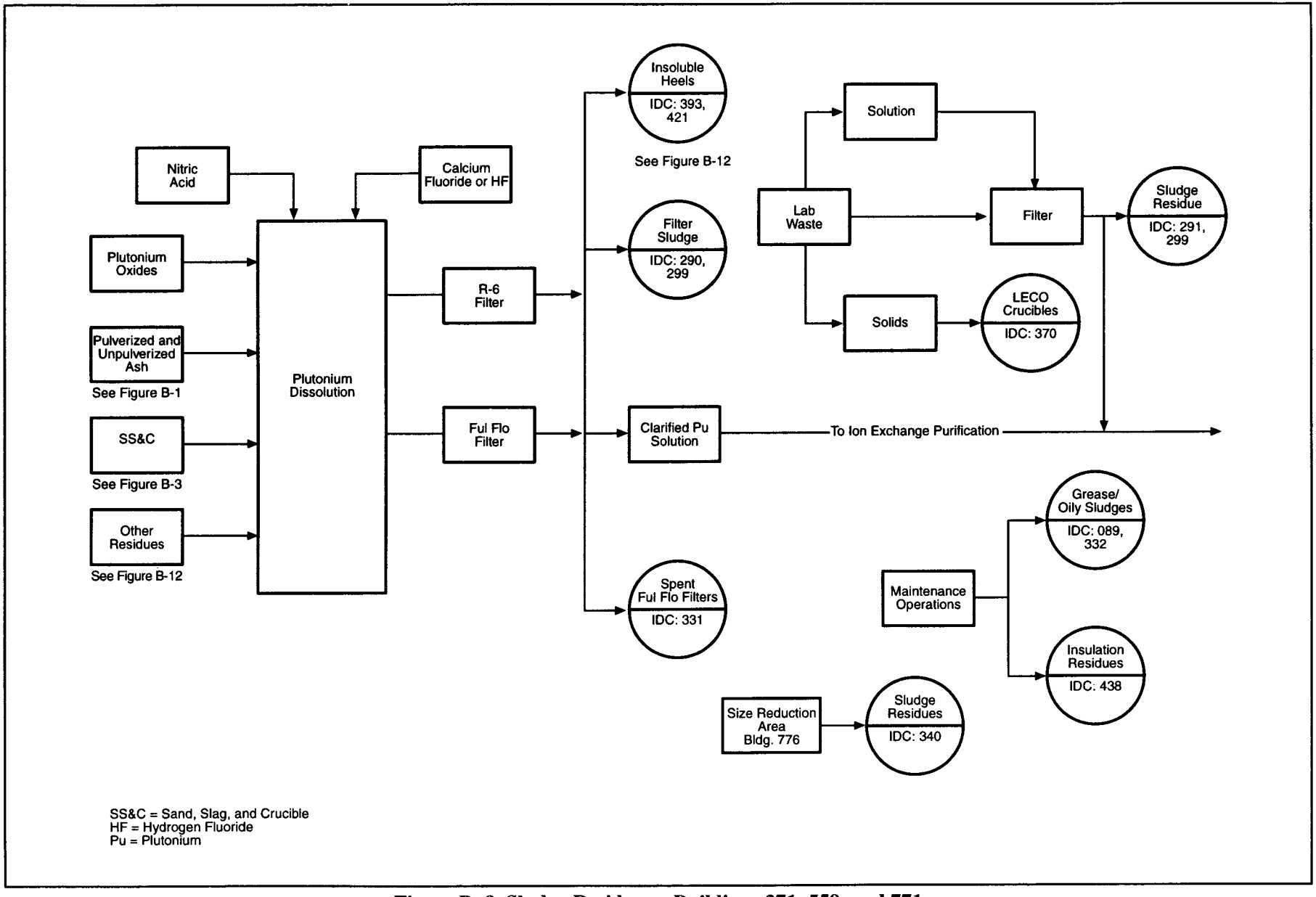


Figure B–8 Sludge Residues—Buildings 371, 559, and 771

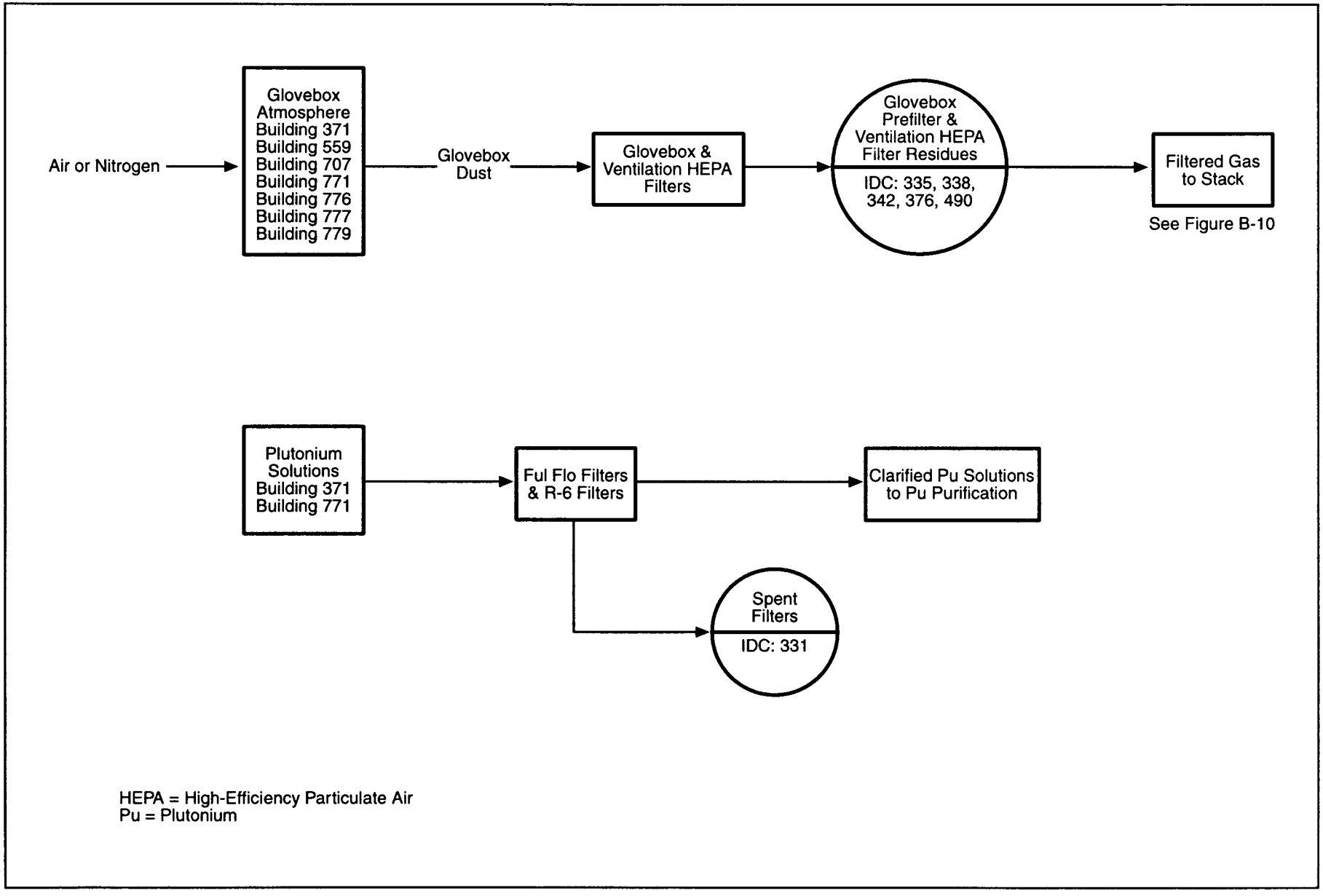
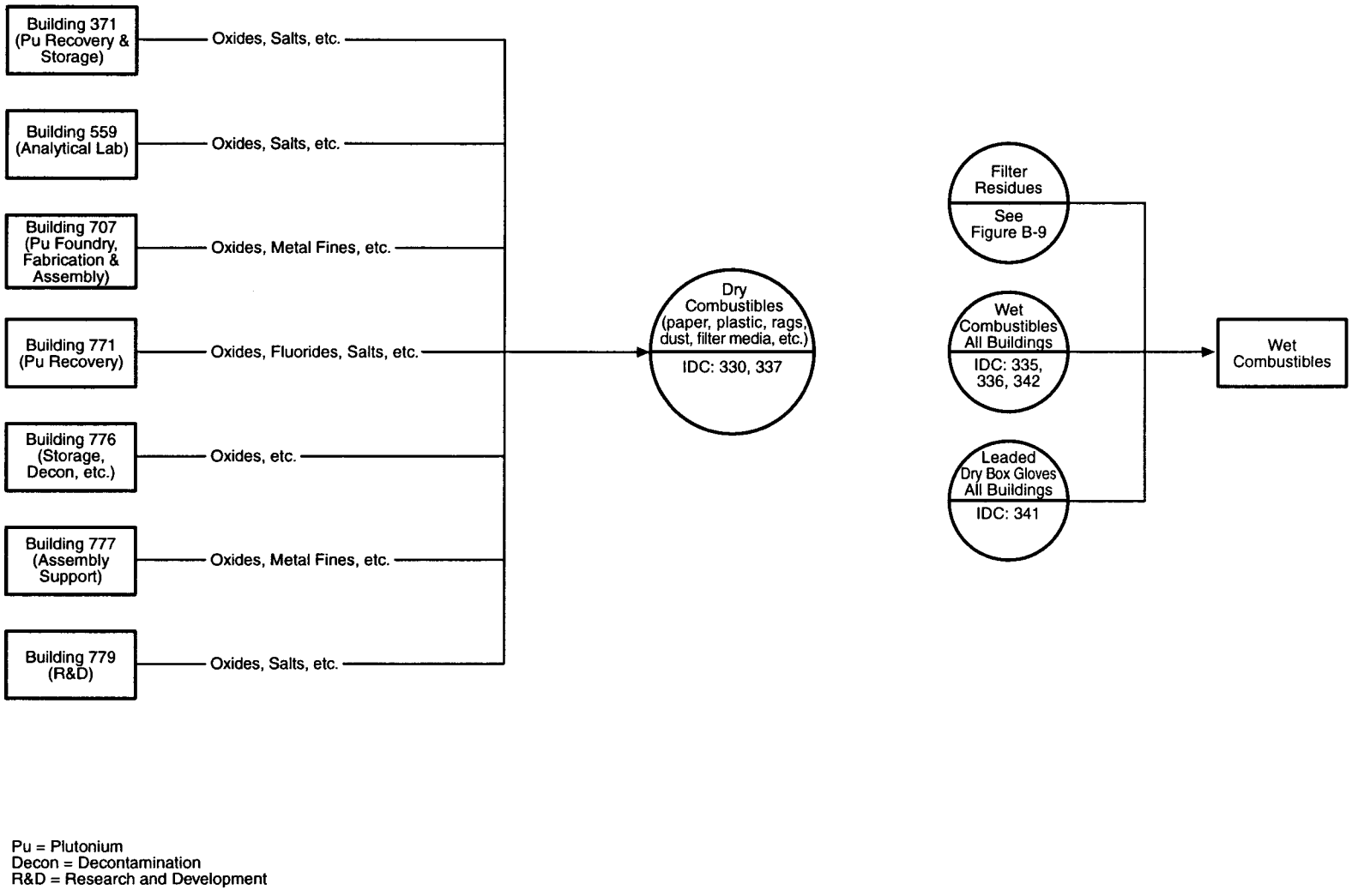


Figure B–9 Filter Residues



Pu = Plutonium
Decon = Decontamination
R&D = Research and Development

Figure B–10 Combustible Residues

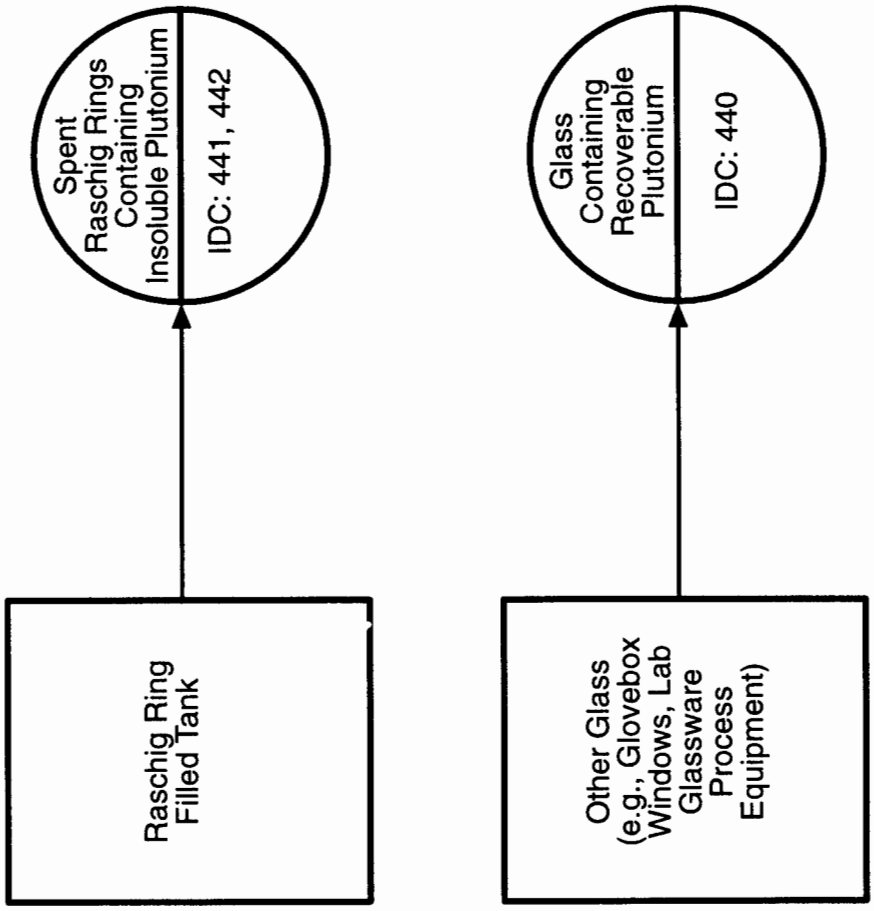


Figure B–11 Glass Residues

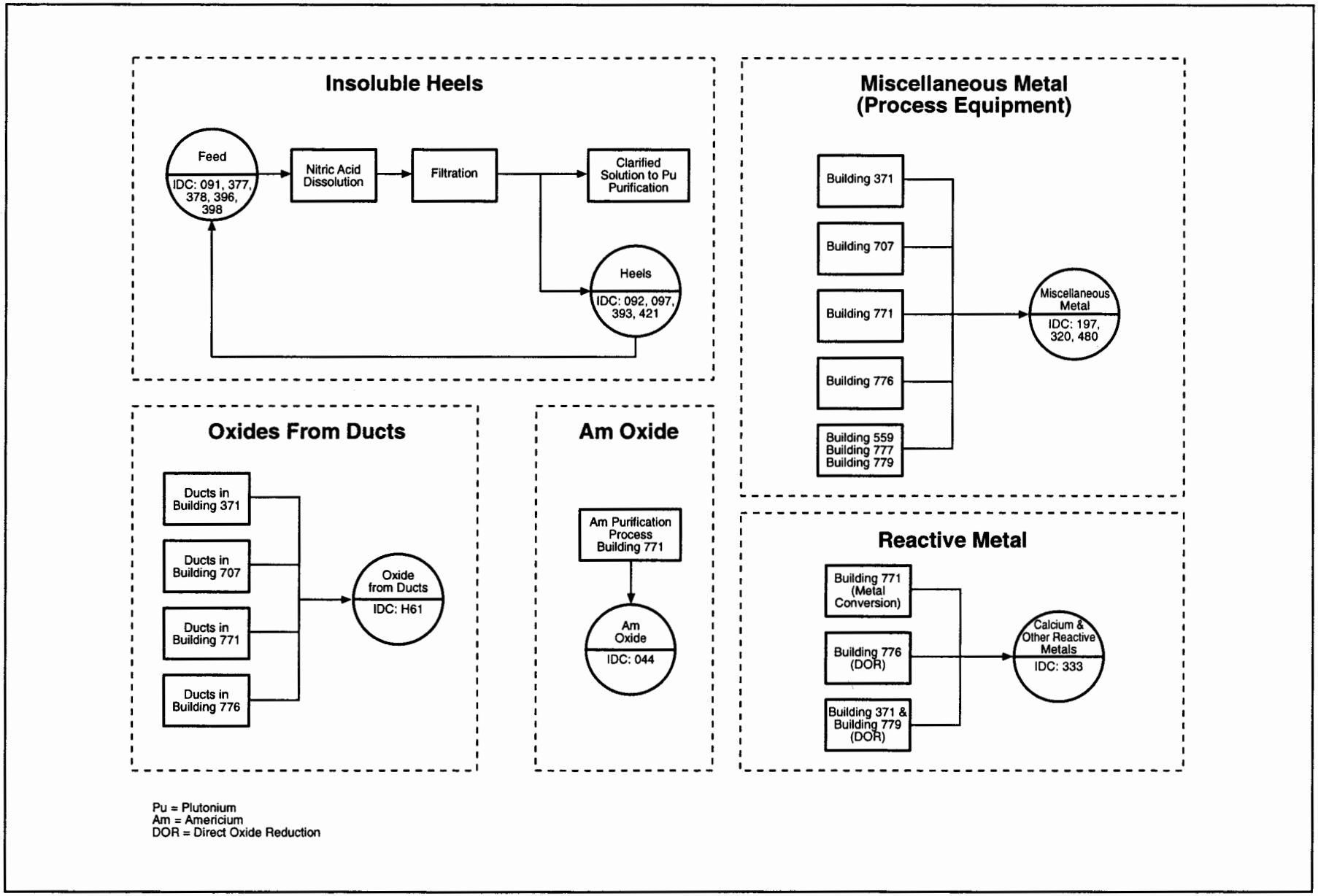


Figure B–12 Other Residues

Appendix C

Description of Processing Technologies

APPENDIX C
DESCRIPTION OF PROCESSING TECHNOLOGIES

C.1 INTRODUCTION

This appendix presents detailed descriptions of the technologies evaluated in the Environmental Impact Statement (EIS) for the processing of certain plutonium residues and scrub alloy stored at the Rocky Flats Environmental Technology Site (Rocky Flats) so that they are brought into compliance with safeguards termination limits for ultimate disposition. The chronological development of the safeguards termination limits as a part of overall safeguards protection is presented in a series of memos and letters. The most relevant of these are included in Attachment 1 to this appendix. This appendix also describes the screening process and approach used to select and evaluate the most suitable processing technologies for these materials in the proposed action. Processing technologies discussed include those that do not remove plutonium from the material (e.g., immobilization technologies) and those that separate plutonium from the material (e.g., acid dissolution technologies). No Action Alternative processing technologies that were analyzed in the *Environmental Assessment, Finding of No Significant Impact, and Response to Comments-Solid Residue Treatment, Repackaging, and Storage* (DOE 1996d), or Solid Residue Environmental Assessment, are also presented in this appendix.

C.2 SCREENING AND EVALUATION APPROACH

The U.S. Department of Energy (DOE) used a screening process to identify a reasonable set of technologies for detailed evaluation in this EIS. In selecting these technologies, a number of factors were considered, including the following:

- Direct applicability of the technology to the particular material type
- Maturity and timing of the technology so that processing could be accomplished in the 2002-2006 time frame within reasonable cost
- Potential impact of processing technology implementation to ongoing mission activities at the site
- Experience of the DOE site in employing the technology and availability of facilities and equipment
- Minimization of the number of process steps to reduce worker exposures
- Amount of secondary wastes generated and appropriate secondary waste disposition methods.

The initial screening process began with the assessment of a wide range of potential processing technologies that were identified in the following DOE studies and during the public scoping process.

- **Trade Studies (DOE 1995, 1996a, 1996b, 1996e, 1996f, and 1997a)**—DOE conducted a series of trade studies to identify the best possible technologies for stabilizing plutonium residues to an end state suitable for disposition. The trade studies were developed by the DOE Nuclear Material Stabilization Task Group, which comprised representatives from the DOE sites that store plutonium residues or have capabilities in treating the residues, as well as DOE Headquarters and other interested individuals. The trade studies

resulted in a technical assessment of various approaches and a bounding of the range of alternative stabilization approaches for further consideration.

- **Environmental Assessment**—DOE prepared the Solid Residue Environmental Assessment (DOE 1996d) to address the environmental impacts associated with stabilizing the entire 106,600 kilogram (kg) (235,000 pound [lb]) inventory of Rocky Flats plutonium residues to allow for safe storage pending final disposition. This environmental assessment addressed stabilization technologies that would provide for safe storage. It did not address technologies for the further processing needed to comply with safeguards termination limits required for ultimate disposition because the environmental assessment was prepared before the safeguards termination limits were developed and implemented. The "no action" alternatives in this EIS are based on the technologies identified in the Solid Residue Environmental Assessment.

- **The Rocky Flats Residue Rebaselining Study**—Rocky Flats prepared a study entitled *Residue Rebaselining for Combustibles, Fluorides, Ash, and Miscellaneous Residues* (DOE 1997b) to identify the most viable options for removal of residues from the site. This study resulted in proposed paths and alternative technologies for preparing the residues for final disposition (i.e., to meet or exceed the safeguards termination limits).

- **Public Scoping Comments**—Public scoping comments were received by DOE during the November 1996 to January 1997 time frame and were considered during the screening process. Many of the comments included preferences for certain technology paths and locations for stabilization.

After the initial screening process, DOE Headquarters requested the candidate processing sites (Rocky Flats, the Savannah River Site, Los Alamos National Laboratory, and Lawrence Livermore National Laboratory) to assess the technologies identified in the initial screening process from a site-specific perspective, considering the screening and evaluation factors described previously. Each site provided input on which technologies could be implemented at their site, taking into account their respective capabilities, facilities, and equipment. Working sessions were held between DOE candidate site and Headquarters representatives to review the benefits and constraints of processing technologies at each site and to reach consensus on the sites and technologies that should to be evaluated in this EIS.

The technologies described herein were determined to be technologically mature enough to be considered as viable options for stabilization of the various residue materials at Rocky Flats.

A further discussion of the screening process is given in Sections 2.3 and 2.9 of this EIS.

C.3 Stabilization Options for Rocky Flats Plutonium Residues and Scrub Alloy

The following sections give detailed descriptions of the candidate processing technologies for each of the material categories discussed in Appendix B of this EIS. The proposed technologies are presented by material category in **Table C–1**. Each material has a No Action processing technology, a processing technology without plutonium separation, and a processing technology with plutonium separation.

Table C–1 Candidate Process Technologies by Material Category

Residue Material	*No Action Stabilization*	*Stabilization Without Plutonium Separation*	*Stabilization With Plutonium Separation*
Ash			
Incinerator Ash	Calcination and cementation	Calcination and vitrification	Purex with ash fusion preprocessing
		Blend down	Mediated electrochemical oxidation with preprocessing
Sand, Slag, and Crucible	Calcination and cementation	Vitrification	Purex with preprocessing
		Blend Down	
Graphite Fines	Calcination and cementation	Vitrification	Mediated electrochemical oxidation with preprocessing
		Blend Down	
Ash-Contaminated Inorganics	Calcination and cementation	Vitrification	
		Blend Down	
Salts			
Electrorefining Salts	Pyro-oxidation	Pyro-oxidation and blend down	Pyro-oxidation and salt distillation
			Pyro-oxidation and water leach with plutonium oxide recovery
			Salt Scrub with Purex processing of newly created alloy
Molten Salt Extraction	Pyro-oxidation	Pyro-oxidation and blend down	Pyro-oxidation and salt distillation
			Pyro-oxidation and water leach with plutonium oxide recovery
			Salt scrub with Purex processing of newly created scrub alloy
Direct Oxide Reduction	Pyro-oxidation	Pyro-oxidation and blend down	Water leach with plutonium oxide recovery
			Salt scrub with Purex processing of newly created alloy
Combustibles			
	Aqueous-contaminated: neutralization and drying	Sonic wash	Mediated electrochemical oxidation
	Organic-contaminated: thermal desorption and steam passivation	Catalytic chemical oxidation	
		Fluidized-bed incineration	
	Dry: repackaging		
		Blend down	
Plutonium Fluorides			
	Acid dissolution with plutonium oxide recovery	Blend down	Acid dissolution with plutonium oxide recovery
			Purex with plutonium metal or oxide recovery
Filter Media	Neutralization	Vitrification (HEPA filters only)	Mediated electrochemical oxidation
		Blend down	
		Fluidized-bed incineration	
		Sonic wash	
Sludge	Filtration and drying	Vitrification	Acid dissolution with plutonium oxide recovery
		Blend down	
Glass	Neutralization and drying	Vitrification	Mediated electrochemical oxidation
		Blend down	
		Sonic wash	

Residue Material	*No Action Stabilization*	*Stabilization Without Plutonium Separation*	*Stabilization With Plutonium Separation*
Graphite	Repackaging	Cementation Vitrification Blend down	Mediated electrochemical oxidation
Inorganic	Repackaging	Vitrification Blend down	Mediated electrochemical oxidation
Scrub Alloy (not a residue)	Repackaging	Vitrification	Purex with plutonium metal or oxide recovery

HEPA = high-efficiency particulate air

The technology descriptions consist of a summary of the technology process; flow chart diagrams; and a description of each process step. The proposed technologies are as follows:

❒ No Action Processing Technologies

- Calcination and cementation of ash residues
- Pyro-oxidation of pyrochemical salts
- Neutralization and drying of aqueous-contaminated combustibles
- Thermal desorption and steam passivation of organic-contaminated combustibles
- Repackaging of dry combustibles
- Acid dissolution and plutonium oxide recovery of plutonium fluorides
- Neutralization of filter media
- Filtration and drying of sludge residues
- Neutralization and drying of glass residues
- Repackaging of graphite residues, inorganic residues, and scrub alloy.

❒ Technologies Without Plutonium Separation

- Immobilization (vitrification)
- Immobilization (cementation)
- Blend down
- Pyro-oxidation and blend down of pyrochemical salts
- Sonic wash
- Catalytic chemical oxidation of combustibles
- Fluidized-bed incineration of combustibles and filter media.

❒ Processing Technologies With Plutonium Separation

- Purex process with plutonium metal or oxide recovery
- Mediated electrochemical oxidation
- Salt distillation
- Water leach with plutonium oxide recovery
- Salt scrub with Purex processing of newly created scrub alloy
- Acid dissolution with plutonium oxide recovery.

For each technology, it is necessary to perform a nondestructive assay after the packaging process to ensure compliance with interim safe storage criteria, Waste Isolation Pilot Plant (WIPP)/Waste Acceptance Criteria, and TRUPACT II shipping requirements. The WIPP/Waste Acceptance Criteria are summarized in Table 2–5 of this EIS. One of the criteria limits the amount of packaged fissile gram equivalents to 200 per drum. The

assay allows for maximizing the amount of container loadings, which in turn minimizes the number of drums destined for interim site storage and disposal. The assay will be performed using either neutron multiplicity counters in concert with gamma-ray isotopic spectrometers or by using segmented gamma scanners.

For shipment to WIPP, there are criteria that must be followed in using the TRUPACT II shipping container. Based on these criteria, the residues, where necessary, are packaged according to the maximum allowable plutonium—83.5 grams (g) (2.9 ounces [oz])—per individual packing container. Since there are two containers per drum, this assures that the 200-g limit per drum will not be exceeded. For other residues, where the quantity of plutonium per package is too low to be of concern regarding packaging, the weight of each individual package becomes a concern for handling within a glovebox. An estimated 9.1 kg (25 lb) was used as a basis for this type of packaging. These values are used throughout this appendix, where appropriate.

C.4 Detailed Process Descriptions for No Action Processing Technologies

C.4.1 Calcination and Cementation of Ash Residues

The proposed cement-based immobilization process is an adaptation of a cement-based waste immobilization process that has been used within the DOE complex and the commercial nuclear industry. This process was approved by the U.S. Environmental Protection Agency (EPA) as a best demonstrated available technology for use in waste stabilization. At Rocky Flats, cement-based waste immobilization processes have been operated successfully for several years and have produced thousands of cubic yards of solidified waste. The process has been used for the solidification of low-level waste (saltcrete) in Building 374 and for the solidification of transuranic waste in Building 774 (bottlebox process). The cement-based ash residue solidification process will take place in either Building 707 or Building 371, and it will be an in-container solidification process that cements all ash residues to meet the safeguards termination limit.

Calcination of powdered or granular materials in muffle furnaces is considered to be a proven technology. Capabilities necessary to satisfy all alternatives are currently being installed at Rocky Flats as part of the ongoing stabilization programs, and should be operational within several months of issuance of the draft EIS. Cementation of materials necessary to immobilize fines and to form an acceptable solid is considered to be a proven technology, although optimization studies are routinely performed to improve specific characteristics. Rocky Flats would have to install or remodel gloveboxes to provide additional area for the curing step, so approximately one year would be required after the issuance of the Record of Decision before the cementation capability would be fully operational. The specific location of the cementation processing is uncertain, although the process would be consistent with either Building 371 or Building 707.

The cement-based immobilization process is shown in **Figure C–1**. The process steps are drum unloading and bag-in, feed preparation for calcination, calcination, feed preparation for cementation, in-line nondestructive assay, cement mixing station, curing and bag-out, and final drum packaging and storage.

Cement-based immobilization blends cement and water with the prepared ash residues. The advantage of cement-based immobilization technology is its proven performance. Well-established protocols, when followed, ensure an acceptable final product. Elements included within these protocols include waste characterization, both physical and chemical, treatability formula development, bench scale testing, pilot scale studies, and detailed project planning for full-scale operations.

A cement-based immobilization process has several disadvantages associated with it. The mixing of the cement and water components produces heat during the curing process. Any active metals remaining in the residue stream after calcination may react with water to produce hydrogen gas. Also, during mixing, curing, and after final packaging, the potential for hydrogen generation exists due to both radioalysis and hydrolysis of the water of hydration by the radiological and reactive metal components, respectively.

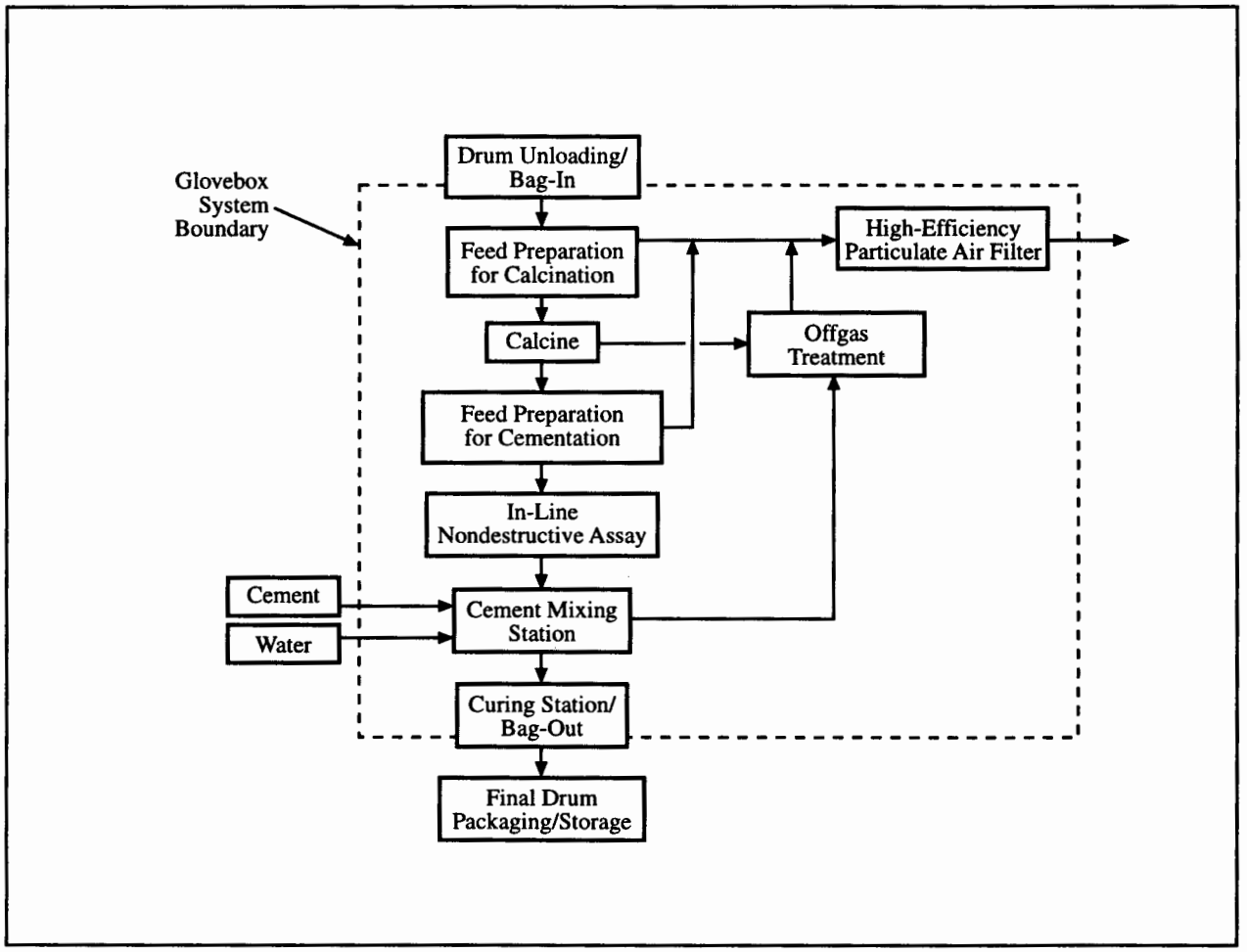


Figure C–1 Cement-Based Immobilization Process for Ash Residues

Two waste streams will be generated in addition to the cemented residue product stream. The first waste stream will be a solid transuranic waste stream consisting of size-reduced steel containers, plastic containers and plastic bags. The second waste stream will be a gaseous effluent stream consisting primarily of water vapor, nitrogen, hydrogen, carbon dioxide and particulates. Any tramp material removed from the waste before size-reduction either will be combined with the solid transuranic waste stream or will be placed into a cemented waste container before curing.

❒ Detailed Process Description

208-liter (L) (55-gallon [gal]) drums will be transferred from storage into a contamination control enclosure. The contamination control enclosure is designed to control airflow in the event of a bag failure within a drum. The drums will be opened and the integrity of the packaging will be checked. If the packaging has not been compromised, the containers will be transferred into the glovebox. The containers will be removed from the drums and bagged into the glovebox. If the integrity of the packaging has been compromised, the package will be overpacked with a new plastic bag before transfer to the glovebox.

After bag-in, the Item Description Codes (IDCs) of the residue containers will be verified and the original residue containers will be transferred to a residue sorting and loading station, which will provide local dust control and will contain a 1/8" sieve that will be used to separate all oversized residue and tramp material (e.g., nuts, bolts). The sieved residue fines will be transferred into burn boats. Tramp material will be

separated and transferred for transuranic waste size reduction and packaging or placed into cemented waste containers before curing. Oversized residue will be crushed and fed back to the loading station for sieving. Each burn boat will be filled to contain approximately 83.5 g (2.9 oz) of plutonium. After the filling step, the burn boats will be transferred to a furnace for calcination.

Calcination is required to high-fire the incinerator ash residue which will remove the reactive characteristics in the residue stream. Each batch will be calcined at 900 degrees Celsius (°C) [1,650 degrees Fahrenheit (°F)] for 4 hours, which will oxidize carbon and organic to carbon dioxide and eliminate water, thereby increasing the bulk density of the ash residue. After cooling, the residue will be transferred for feed preparation for cementation.

The burn boats containing the calcined residue will be transferred to a residue sorting and loading station. As described previously, the residue will be sieved and the residue fines will be loaded into metal containers. As required, oversized residue will be crushed and loaded into the containers. Each container will be filled to contain approximately 83.5 g (2.9 oz) of plutonium. After the filling step, the containers will be transferred to an in-line nondestructive assay station.

Following nondestructive assay, the container will be moved to the mixing station. Then, measured quantities of water and cement will be blended into the residue containers. The material will be mixed until all of the water has been absorbed by the cement and the mixture thickens. Because of the potential for heat generation, provisions for actively cooling the container during and after mixing may be required for certain residue IDCs. During mixing, there is a potential for vapor generation produced by an exothermic reaction associated with the hydration of the cement and through hydrogen gas generation produced from radioalysis and hydrolysis. Therefore, provisions will be incorporated as necessary for the collection and extraction of these vapors in both the mixing station and curing station.

The container will be moved from the mixing station into a set of curing gloveboxes and set aside for a 24-hour curing period. After curing has been completed, the cans will be bagged-out of the glovebox. Assayed, cemented residue containers will be transferred for final drum packaging and then placed in interim storage until a final disposition decision is made.

C.4.2 Pyro-Oxidation of Pyrochemical Salts

Pyro-oxidation technology converts reactive metals in salt residues to nonreactive oxides. The resulting products will be stored as stabilized plutonium salts at Rocky Flats. This technology will be used on all three types of pyrochemical salt residues, including electrorefining salts, molten salt extraction salts, and direct oxide reduction salts. The pyro-oxidation process will be conducted inside gloveboxes located in Module A of Building 707 or in Building 371.

Pyro-oxidation of salts in stationary furnaces is considered to be a proven technology, although specific process variables are being evaluated in an attempt to make the pyro-oxidation process more compatible with a pyro-distillation follow-on processing step. Pyro-oxidation of reactive salts is part of the Rocky Flats response to Defense Nuclear Facilities Safety Board Recommendation 94-1 to stabilize potentially higher-risk or reactive materials. Rocky Flats has the capability to support the ongoing stabilization programs, and operations are pending. While not a technology risk for the pyro-oxidation process, the salts, once pyro-oxidized, cannot be subsequently salt scrubbed, which is the only current process to allow plutonium separation using the Purex process. The on-going stabilization program trades the technical and programmatic risk of not using a proven Savannah River Site residue disposition approach (Purex) against the reduction of an immediate safety risk. The pyro-oxidation process is, however, a prerequisite step for both salt distillation and aqueous distillation.

The pyro-oxidation process for pyrochemical salts is shown in **Figure C–2**. The salt residues will be sorted and batched in preparation for pyro-oxidation. The residues will be pyro-oxidized to convert reactive metals to oxides. After pyro-oxidation, the oxidized plutonium salts will be packaged for storage. The packaged material will be removed from the glovebox, nondestructively assayed for accountability purposes, and transferred to plutonium storage.

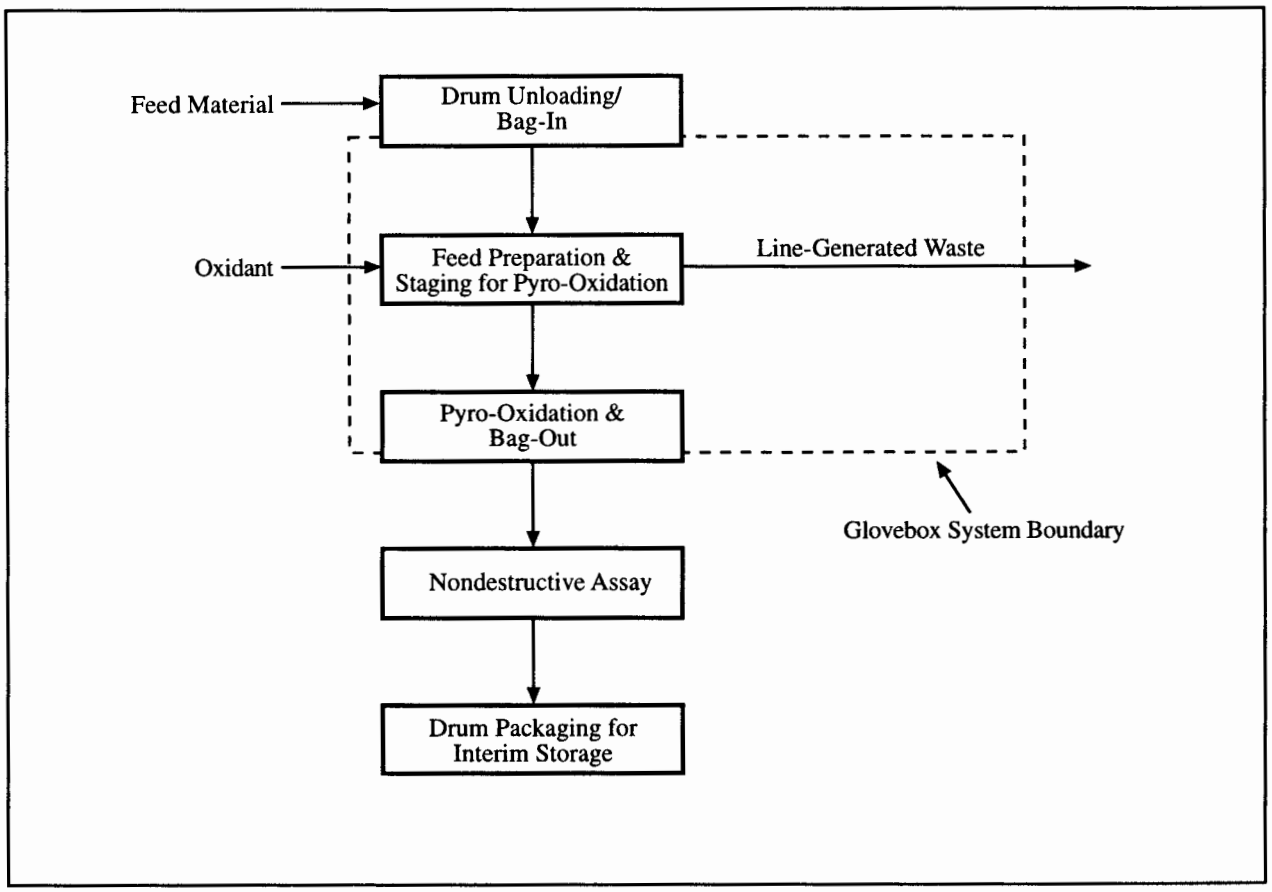


Figure C–2 Pyro-Oxidation Process for Pyrochemical Salts

❒ Detailed Process Description

Drums will be manually transferred into a contamination control enclosure and unpacked. This step is to contain any contamination which could result from an individual package containment damaged by radiolysis, or physical damage to the package during storage. Any unnecessary packaging materials will be removed to limit the amount of packaging introduced into the salt feed preparation glovebox.

The salt feed will be introduced into the glovebox, one stream at a time, and the IDC verified. The individual packages will be opened and loaded into a crucible in preparation for pyro-oxidation. Sodium carbonate or another oxidant will also be added to the crucible at this time. Combustible packaging materials from the individual packages will be bagged out of the glovebox and managed as transuranic waste. Other materials will be bagged out and managed appropriately.

Once the crucible is loaded with salt feed, it will be placed in a glovebox furnace and heated to approximately 800°C (1,470°F) with sodium carbonate or another oxidant as a reagent for 2 to 3 hours, stirring continuously (8-hour cycle time). The product will be a stabilized plutonium salt matrix. Pyro-oxidation can be applied both to a sodium chloride/potassium chloride matrix and to a calcium chloride

matrix. This process converts reactive metals (such as calcium and sodium) to oxides. When the furnace has cooled to below 100°C (212°F), the crucible will be removed from the furnace. During the heating, stirring, and cooling phases, argon will flow through the furnace. During the last part of the heating phase, argon will be replaced by a mixture of air and argon.

Once the crucible is removed from the furnace, it will be allowed to cool. Because metal crucibles are used, the pyro-oxidized salt will remain in the crucibles to be sealed and bagged out directly in nominal 2.5–kg (5.5 lb) bulk (net) batches. The material will then be bagged from the glovebox and placed into containers for plutonium storage.

Nondestructive assay will be performed to ensure requirement limits are met and to obtain data to ensure that required accountability procedures are followed. Nondestructive assay methods will be selected to ensure that the best accountability data are obtained. Assayed product packages containing the plutonium-bearing salt matrix will be transported to appropriate plutonium storage areas.

C.4.3 Neutralization and Drying of Aqueous-Contaminated Combustibles

Aqueous-contaminated combustible residues include acidic liquids and generally do not have free liquid present. They were generated from an aqueous process and some degree of moisture will be present. The neutralization and drying process for aqueous-contaminated combustible residues removes the nitric acid from the organic matrix, eliminating a possibly unstable condition. The residue consists of materials, such as cloth, paper, rags, coveralls, rubber, wood, and other miscellaneous materials, some of which is above the safeguards termination limit for combustibles. The neutralization and drying process is not intended to remove the plutonium from the residue. As a result, this process would preclude ultimate shipment to WIPP unless the residue is subjected to further processing. This process will be conducted in Room 3701 of Building 371.

The neutralize-dry process, consisting of washing materials in alkaline solutions, allowing them to drain or partially dry, and mixing the resulting solids with water-absorbing materials, is considered to be a proven technology. The capability for Rocky Flats is being installed to support the disposition of below-safeguards termination limit materials, and should be available several months after the issuance of the draft of the EIS. Activities are underway to optimize the process and reduce the quantity of water-absorbing materials required for meeting disposal requirements.

The neutralization and drying process for aqueous-contaminated combustible residues is shown in **Figure C–3**. The process steps are drum unloading and bag-in, feed preparation, the neutralization and decant/filtration, oven drying, and packaging and bag-out. Nondestructive assay will be performed and the drums will be packaged for interim site storage.

❒ Detailed Process Description

Fifty-five-gallon drums will be transferred from storage into a contamination control enclosure and unpacked. The contamination control enclosure is designed to control airflow in the event of a bag failure within a drum. The drums will be opened and the integrity of the packaging will be checked. If the packaging has not been compromised, the package will be transferred into the glovebox. Any unnecessary packaging materials, will be removed to limit the amount of packaging introduced into the glovebox. If the integrity of the primary packaging has been compromised, the package will be overpacked with a new plastic bag before transfer to the glovebox.

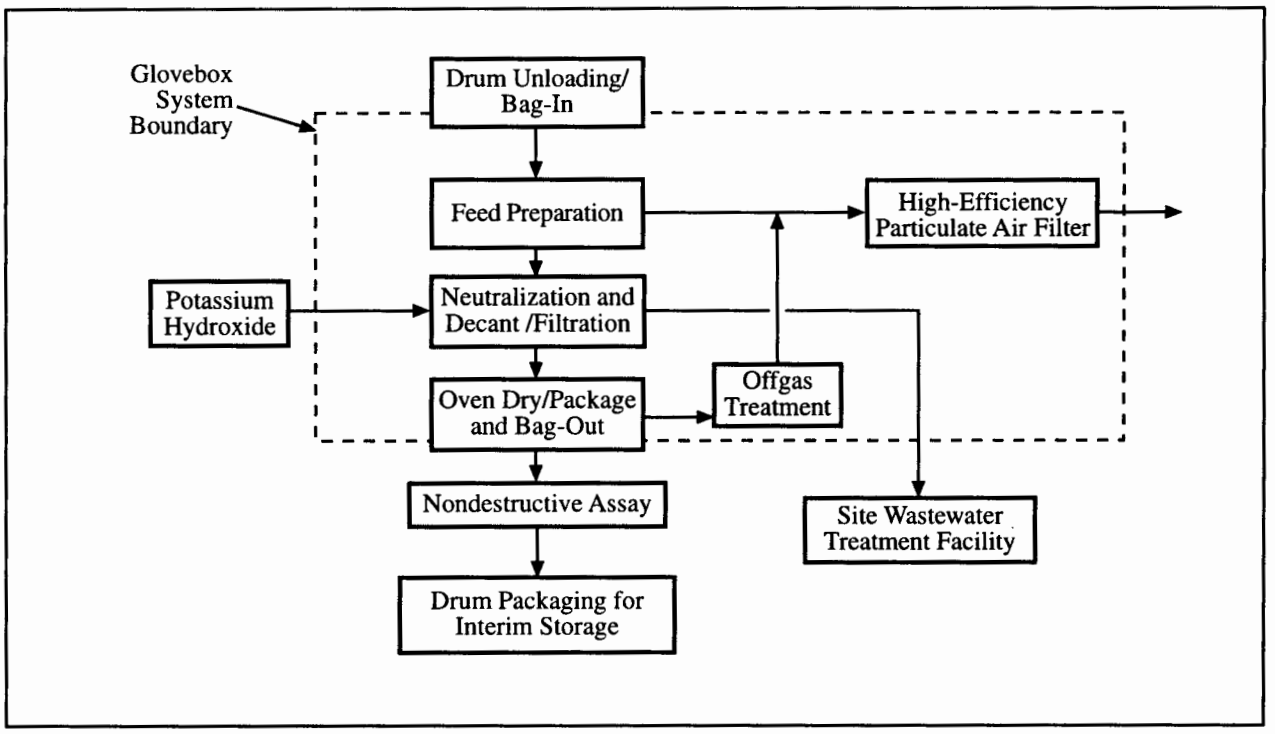


Figure C–3 Neutralization and Drying Process for Aqueous-Contaminated Combustible Residues

Following bag-in, the IDCs will be verified and the plastic bags will be unpacked and the residue sorted. Each bag will be opened to remove any tramp metal or other unwanted materials. This material will be bagged out of the glovebox and managed appropriately. Following the sorting, the residue feed material will be shredded and batched to 5-kg (11-lb) batches for neutralization.

Neutralization is intended to remove the nitrate contamination from the combustible waste and to neutralize any residual nitric acid contained within the residue. The 5-kg (11-lb) batches of combustible will be washed with 50 L (13.2 gal) of water containing 10 percent excess potassium hydroxide. After 2 hours, the acid will be neutralized, forming potassium nitrate and water. None of the plutonium will be removed from the residue during the neutralization process. The combustible solids will be separated from the nitrate solution and processed through decanting and filtration. The combustible solids will contain approximately 20 percent solution by weight with a proportionate quantity of nitrates. These solids will be transferred to a drying pan. The neutralization solution will be sent, at intervals, to Building 374 for evaporation using the site wastewater treatment process.

The combustible residue that was neutralized and transferred to a drying pan will then be placed into a drying oven. The residue will be dried under a vacuum at 80°C (176°F) for 2 hours. Offgas from drying will be treated before high-efficiency particulate air (HEPA) filtration. After cooling, the combustible residue will be weighed, and the quantity of plutonium estimated as the waste is transferred to 8.2-L (2.2-gal) containers. Each container will contain approximately 44.6 g (1.6 oz) of plutonium with the container loading based on an approximate bulk density of the solids of 0.3 kg/L (2.5 lb/gal). These containers would be bagged-out of the glovebox and packaged into convenience cans. None of the plutonium will be removed in the neutralization; therefore, the plutonium remaining in the combustibles will be above the safeguards termination limit and would preclude shipment and disposal of this population at WIPP.

Nondestructive assay will be performed, and then the assayed and repackaged residue containers will be transported for drum packaging. Two containers will be loaded into a pipe component staged inside of a

55-gallon drum. These drums cannot be shipped to WIPP because the percentage of plutonium in the waste exceeds the safeguards termination limit. The drums would remain in the interim site storage until subjected to an appropriate stabilization process that would reduce the plutonium content below the safeguards termination limit.

C.4.4 Thermal Desorption and Steam Passivation of Organic-Contaminated Combustibles

Thermal desorption and steam passivation removes residual organic contaminants from organic-contaminated combustible residues and converts plutonium fines in the residue to plutonium oxide. Organic-contaminated combustible residues consist of materials, including wet and dry combustibles and leaded rubber gloves, some of which are above the safeguards termination limit for combustibles. The thermal desorption and steam passivation process and the repackaging of this material will satisfy the requirements for safe interim site storage. This process will be conducted in Room 3701 of Building 371.

Thermal desorption/steam passivation to remove volatile organics and oxidize plutonium fines is considered to be a proven technology; however, the processing times are currently under investigation as are final process parameters. The capability for Rocky Flats is being installed to support the disposition of below-safeguards termination limit materials, and should be available several months after the issuance of the draft of the EIS.

The thermal desorption and steam passivation process for organic-contaminated combustible residues is shown in **Figure C–4**. The process steps include drum unloading/bag-in and feed preparation, followed by thermal desorption and steam passivation. Absorbent is added and the material repackaged and bagged-out. After nondestructive assay is performed, the final drum packaging and storage take place.

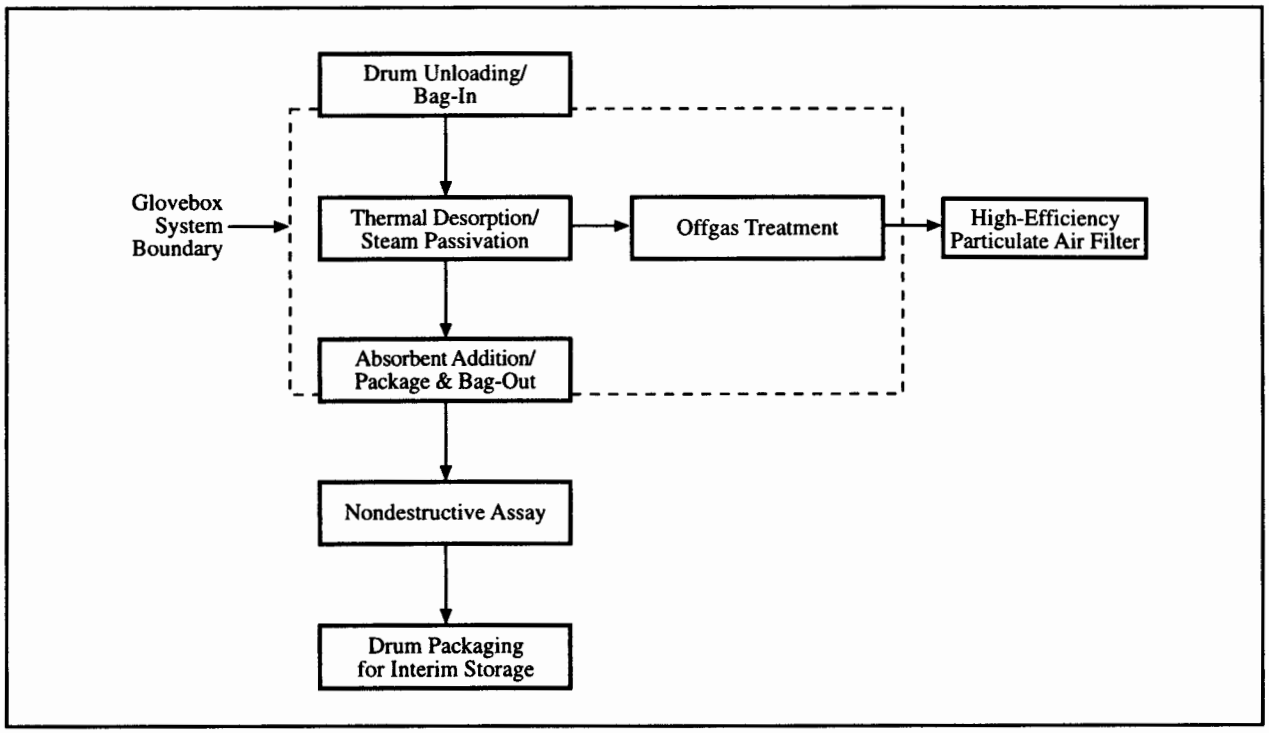


Figure C–4 Thermal Desorption/Steam Passivation Process for Organic-Contaminated Combustible Residues

❒ Detailed Process Description

Fifty-five-gallon drums will be transferred from storage into a contamination control enclosure and unpacked. The contamination control enclosure is designed to control airflow in the event of a bag failure within a drum. The drums will be opened and the integrity of the packaging will be checked. If the packaging has not been compromised, the package will be transferred into the glovebox. Any unnecessary packaging materials will be removed to limit the amount of packaging introduced into the glovebox. If the integrity of the primary packaging has been compromised, the package will be overpacked with a new plastic bag before transfer to the glovebox.

Following bag-in, the IDCs will be verified and the plastic bags will be unpacked and the residue sorted. Each bag will be opened to remove any tramp metal or other unwanted materials. This material will be bagged out of the glovebox and managed appropriately. Following the sorting, the residue feed material will be shredded and batched to 1 kg (2.2 lb) for thermal desorption/steam passivation.

Thermal desorption is intended to remove the organic solvent contaminants from the combustible residue. The 1-kg (2.2-lb) batches of combustible residue will be heated to 80°C (176°F) for 2 hours under reduced pressure to volatilize the organic solvent contaminants. The offgases will be collected on granulated activated charcoal. Then, low temperature steam will be injected for 1 hour to oxidize any plutonium fines present in the residue.

The processed combustible residue will be allowed to cool to room temperature and approximately 1 kg (2.2 lb) of dry absorbent will be added to dry the wet matrix. The residue will then be batched to approximately 4 kg (8.8 lb) and placed into an 8.2-L (2.2-gal) container. The 4-kg (8.8-lb) batch is based on the volume of shredded combustible waste and absorbent that may reasonably fit into an 8.2-L (2.2-gal) container. The can will be sealed, taped, and bagged-out of the glovebox and placed into a 30.5-centimeter (cm) (12-inch [in]) convenience can. Each can will contain approximately 37.8 g (1.3 oz) of plutonium.

Nondestructive assay will be performed and the assayed and repackaged residue containers will be transported for final drum packaging. The containers will be transferred for final drum packaging and then placed in interim storage until a final disposition decision is made.

C.4.5 Repackaging of Dry Combustibles

Repackaging of dry combustibles will be performed to achieve the criteria for safe interim site storage. Dry combustible residue consists of such materials as paper, rags, cloth, plastic, wood, surgical gloves, tape, paper coveralls, booties, personal protective equipment waste, full-face masks, v-belts, polyvinyl chloride, polyethylene, polypropylene, supplied-air suits, and gaskets, some of which are above the safeguards termination limit for combustibles. After repackaging, the combustible residues above the safeguards termination limit will remain above the limit. This will preclude ultimate shipment of this material to WIPP unless it is subjected to further processing. Preparation of direct repackage residues will be conducted within glovebox lines in Modules D, E and F of Building 707.

Repackaging to package and assay appropriate residues is considered to be a proven technology. The capability for Rocky Flats is being installed to support the disposition of below-safeguards termination limit materials, and should be available several months after the issuance of the draft of the EIS.

The direct repackage process is shown in **Figure C–5**. The process steps include drum unloading and bag-in, feed preparation and repackaging, and bag-out. Nondestructive assay will be performed and the drums will be packaged for interim site storage.

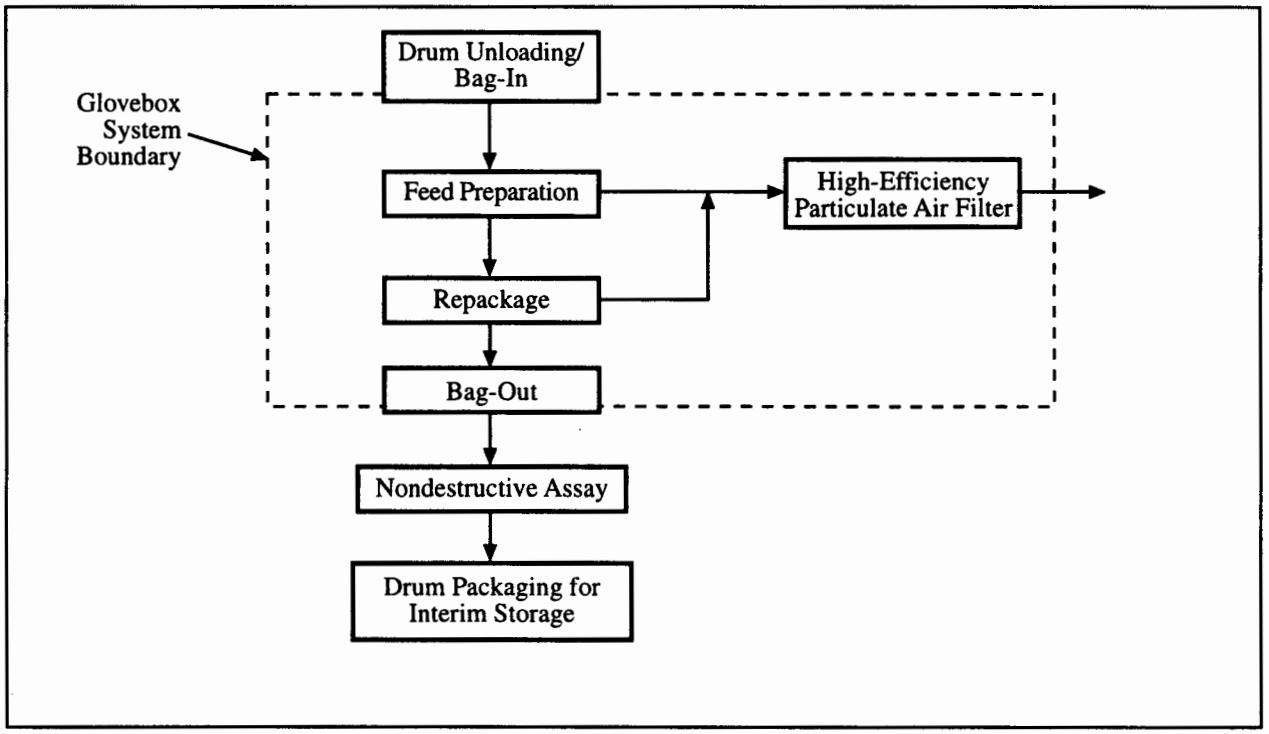


Figure C–5 Direct Repackaging Process for Dry Combustibles

❒ Detailed Process Description

Fifty-five-gallon drums will be transferred from storage into a contamination control enclosure in Module D of Building 707. The contamination control enclosure is designed to control airflow in the event of a bag failure within a drum. The drums will be opened and the integrity of the packaging will be checked. If the packaging has not been compromised, the package will be transferred into the glovebox in Module E of Building 707. Other packaging materials will be removed from the drum and bagged into the glovebox. If the integrity of the packaging has been compromised, the package will be overpacked with a new plastic bag before transfer to the glovebox.

Following bag-in, the plastic bags will be unpacked and the residue sorted. The residue will then be repackaged into metal containers. If the material requires size-reduction and/or compaction to minimize the volume of the repackaged residue, the sorted residue will be transferred to a size-reduction station. The residue will be shredded and repackaged into metal containers. If required, the repackaged material will be compacted within the metal containers to gain additional volume reduction, which will reduce the number of drums requiring shipment to WIPP. Each repackaged container will be filled to approximately 83.5 g (2.9 oz) of plutonium. After the container filling step, the sealed container will be bagged-out and transferred to nondestructive assay.

Nondestructive assay will be performed and the assayed and repackaged residue containers will be transported into Module F of Building 707 for drum packaging. Two containers will be loaded into a pipe component which will be staged inside of a 55-gallon drum. These drums cannot be shipped to WIPP because the percentage of plutonium in the waste exceeds the safeguards termination limit. The drums will remain in interim site storage until subjected to an appropriate stabilization process that will reduce the plutonium content below the safeguards termination limit.

C.4.6 Acid Dissolution and Plutonium Oxide Recovery of Plutonium Fluorides

The acid dissolution of plutonium fluorides involves dissolution of the fluorides, followed by precipitation and filtration of plutonium oxalate, and calcination to plutonium oxide for storage. The filtrate from the oxalate precipitation is treated with magnesium hydroxide to precipitate the plutonium remaining in the solution. That precipitate is then filtered, calcined, repackaged, and placed in interim site storage until a final disposition decision is made. The dissolution process will be conducted inside gloveboxes located in Room 3701 of Building 371.

The acid dissolution/plutonium oxide recovery process is considered to be a proven technology. The process to be used for the limited quantities of materials identified in these categories will be consistent with equipment and activities that can be performed in the neutralize-dry process area. Thus, the capability for Rocky Flats is currently being installed to support the disposition of below-safeguards termination limit materials, and should be available several months after the issuance of the draft of the EIS. However, the use of this equipment for Acid Dissolution will generally be preceded by the neutralize-dry processing of the combustible residues required by the Defense Nuclear Facilities Safety Board Recommendation 94-1 stabilization program, and may not be able to start until 4 years after issuance of the Record of Decision.

The plutonium fluoride acid dissolution process is shown in **Figure C–6**. The feed materials will be unpacked and batched for acid dissolution. The dissolved fluorides will be sent through precipitation to form plutonium oxalate precipitate in slurry form, which will then be filtered to separate the effluent solution from the precipitate. The oxalate will be calcined, nondestructively assayed, calcined again for long-term storage, again nondestructively assayed, and then packaged for storage. Magnesium hydroxide will be mixed into the oxalate precipitation effluent to precipitate the remaining plutonium, and the effluent filtered to form magnesium hydroxide and effluent. The magnesium hydroxide will be calcined and packaged. The packaged magnesium hydroxide product will be removed from the glovebox and nondestructively assayed for accountability purposes, packaged in the final transport/storage container, and placed in interim storage. The last filtration effluent will be sent for evaporation at the Rocky Flats wastewater treatment facility.

Most of the fluoride residues are located in the Building 371 storage vault, and will be transferred from the vault into the glovebox system by a remote handling system through an input/output station. Other fluoride packages will be manually transferred and bagged into the feed preparation glovebox.

❒ Detailed Process Description

The residue feed will be introduced into the glovebox, and the IDC will be verified. The materials will then be removed from the containers and batched to a maximum of 200 g (7 oz) of plutonium in preparation for nitric acid dissolution. Combustible packaging materials from the individual containers will be bagged out of the glovebox and sent to a combustible handling process. Other unwanted materials will be bagged out of the glovebox and managed appropriately.

The contents of the residue cans will be transferred to one of two heated stirrers. The operator will add 7N nitric acid (HNO_3) and 60 percent aluminum nitrate ($Al(NO_3)_3$) solution to each dissolver before stirring. $Al(NO_3)_3$ is added to complex residue ions during dissolution. The slurry will be heated to approximately 80°C (176°F) and stirred until dissolution is achieved. Vented fumes will be cooled in a condenser, and then piped to the process vent system. The batch will be filtered to remove any undissolved solids and then split into two equal amounts and transferred to the adjacent heated stirrers for precipitation.

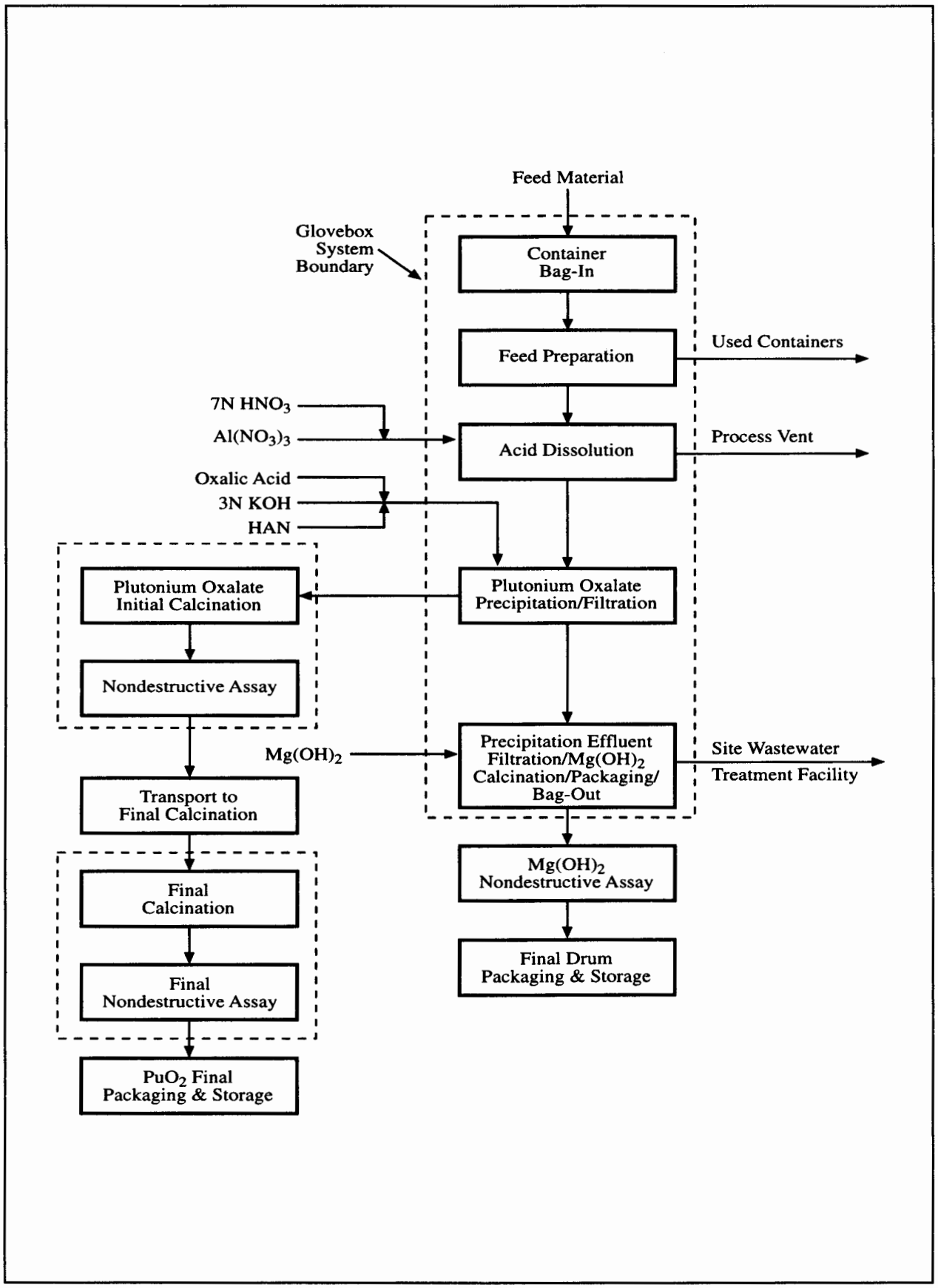


Figure C–6 Acid Dissolution Process for Plutonium Fluorides

For plutonium oxalate precipitation, 3N potassium hydroxide (KOH) will be added to each can to adjust the normality to 0.75N nitric acid. Hydroxylamine nitrate (HAN) will then be added as a 1.9M solution to adjust the plutonium valence to +3. After these adjustments have been made, solid oxalic acid will be added to form plutonium oxalate precipitate. The solution will be heated to approximately 80°C (176°F) and stirred to form a slurry.

The slurry from the two stirrer assemblies will be poured onto an R-4 filter. Filtration of plutonium oxalate will be achieved by pulling a vacuum through the filter and drawing effluent liquids into a filtrate tank. The plutonium oxalate precipitate will be scooped into a filter boat in preparation for calcining.

The plutonium oxalate will require calcining at 450°C (840°F) to convert the oxalate into the oxide form. In this process, the filter boat will be placed on a pneumatic lift, placed into the calcination furnace, and the precipitate will be heated to 450°C (840°F). Glovebox air will be drawn down through the precipitate at a rate of approximately 0.10 cubic meter (m^3) (3.5 cubic feet [ft^3]) per minute during the heating cycle. After a cooling cycle, the calcined oxide will be transferred from the filter boat back into a can, batched to 1,000 g (2.2 lb), sealed, and sent to calorimetry.

The plutonium oxide can will be assayed for plutonium content based on its rate of thermal generation using calorimeters and gamma-ray isotopic spectrometer equipment. This activity is required to maintain accountability within the acid dissolution material balance area. After assay, the containers are ready for final calcination. The cans containing the plutonium oxide will be placed into appropriate outer containers and transferred to the Building 371 loading dock. The containers will then be transported to the Building 707 loading dock by intra-site truck transportation, and moved to appropriate vault storage pending final calcination.

The plutonium oxide cans will be transferred from the Building 707 storage vault to Module J and bagged into the plutonium stabilization and packaging system. The plutonium oxide will be removed from the cans, placed into furnaces, and calcined at 1,000°C (1,830°F) for 8 hours. The material, now suitable for long-term storage or transportation, will be weighed, characterized, and placed into a 3013 inner container. This container is then removed from the glovebox by the bagless transfer process and sent to calorimetry. The plutonium oxide package is assayed for plutonium content based on its rate of thermal generation using calorimeters and gamma-ray isotopic spectrometer equipment. After assay, the containers will be placed into vault storage, pending a final disposition decision.

Magnesium hydroxide, $Mg(OH)_2$, 30 percent by weight, will be added to the effluent liquid in the filtrate tank from the precipitation filtration step, and the tank will be mixed by sparging. The liquid and precipitate will then be drained onto an R-4 filter. Filtration will be achieved by pulling a vacuum through the R-4 filter and drawing effluent liquids into the transfer tank. The magnesium hydroxide precipitate will then be scooped into a filter boat in preparation for calcining. The magnesium hydroxide will be calcined at 450°C (840°F). In this process, the filter boat will be placed on a pneumatic lift, placed into the calcination furnace, and the precipitate will be heated to 450°C (840°F). Glovebox air will be drawn down through the precipitate at a rate of approximately 0.10 m^3 (3.5 ft^3) per minute during the heating cycle. After a cooling cycle, the calcined hydroxide will be transferred from the filter boat back into a can, batched to 9.1 kg (20 lb), sealed, and bagged out into convenience cans.

Nondestructive assay of the magnesium hydroxide will be performed to ensure requirements limit are met and to obtain data to ensure that required accountability procedures are followed. Nondestructive assay methods will be selected to ensure that the best accountability data are obtained. Assayed product packages will be selected for final packaging to minimize the number of shipping containers and placed in interim storage pending a final disposition decision. Selected packages will be loaded into an inner container and sealed before placing the container into the final outer shipping container.

C.4.7 Neutralization and Drying of Filter Media

The neutralization and drying process for filter media residues treats the nitric acid contaminant on the residue to eliminate the potential flammable hazard. The neutralization and drying process is not intended to remove the plutonium from the residue. As a result, this would preclude ultimate shipment to WIPP unless the residue is subjected to further stabilization processing. This process will be conducted in Room 3710 of Building 371.

The neutralize-dry process, consisting of washing materials in alkaline solutions, allowing them to drain or partially dry, and mixing the resulting solids with water-absorbing materials, is considered to be a proven technology. The capability for Rocky Flats is being installed to support the disposition of below-safeguards termination limit materials, and should be available several months after the issuance of the draft of the EIS. Activities are underway to optimize the process and reduce the quantity of water-absorbing materials required for meeting disposal requirements.

The neutralization and drying process for filter media residues is shown in **Figure C–7**. The process steps are drum unloading and bag-in, feed preparation, the neutralization and decant/filtration, oven drying, packaging, and bag-out. Nondestructive assay will be performed, and the drums will be packaged for interim site storage.

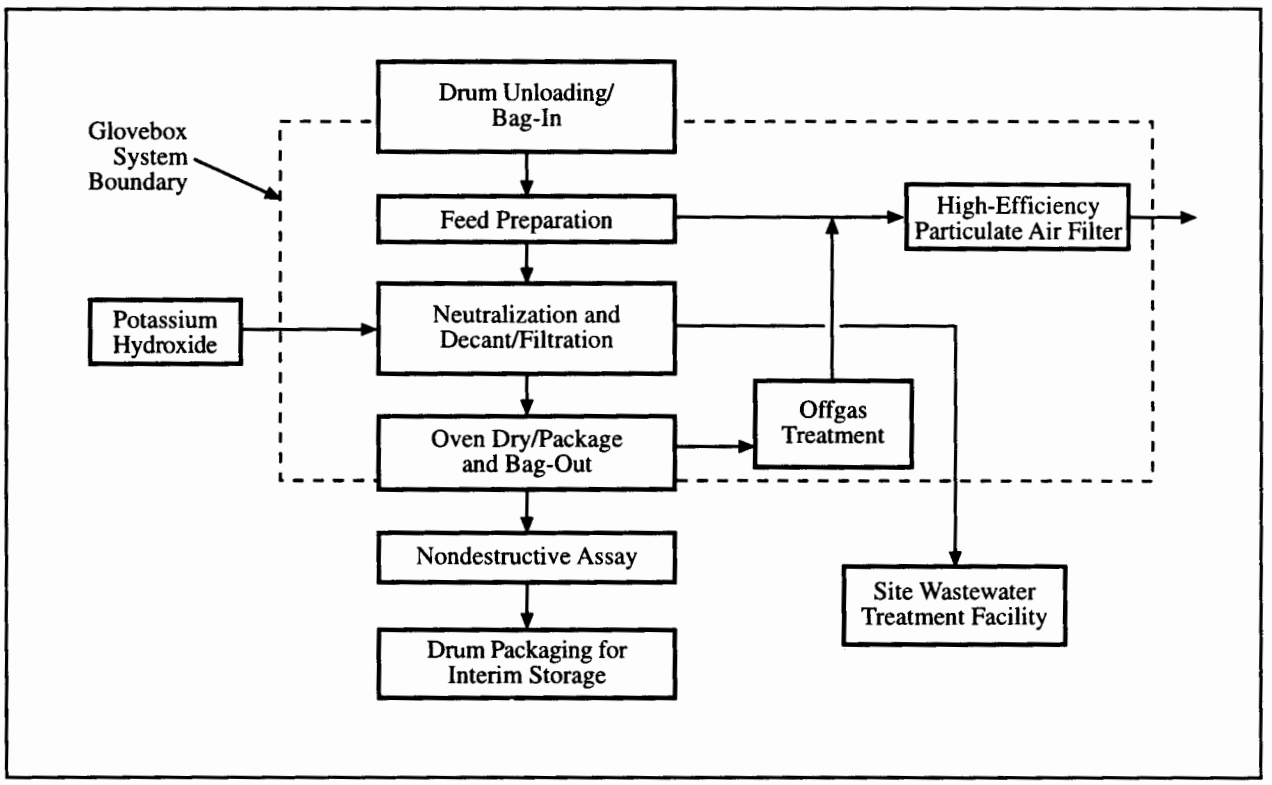


Figure C–7 Neutralization and Drying Process for Filter Media

❒ **Detailed Process Description**

Fifty-five-gallon drums will be transferred from storage into a contamination control enclosure and unpacked. The contamination control enclosure is designed to control airflow in the event of a bag failure within a drum. The drums will be opened and the integrity of the packaging will be checked. If the packaging has not been compromised, the package will be transferred into the glovebox. Any unnecessary packaging materials, will be removed to limit the amount of packaging introduced into the glovebox. If the integrity of the primary packaging has been compromised, the package will be overpacked with a new plastic bag before transfer to the glovebox.

Following bag-in, the IDCs will be verified and the plastic bags will be unpacked and the residue sorted. Each bag will be opened to remove any tramp metal or other unwanted materials. HEPA filter frames and stiffeners will be separated from the filter media. These materials will be bagged out of the glovebox and managed appropriately. Following the sorting, the residue feed material will be shredded and batched to 5-kg (11-lb) batches for neutralization.

Neutralization is intended to remove the nitrate contamination from the combustible waste and to neutralize any residual nitric acid contained within the residue. The 5-kg (11-lb) batches of combustible residues will be washed with 50 L (13.2 gal) of the water containing 10 percent excess potassium hydroxide. After 2 hours, the acid will be neutralized forming potassium nitrate and water. None of the plutonium will be removed from the residue during the neutralization process. The combustible solids will be separated from the nitrate and plutonium containing solution by decanting and filtration. The combustible solids will contain approximately 20 percent solution by weight with a proportionate quantity of nitrates and transferred to a drying pan. At intervals, as required during the process, the neutralization solution would be sent to Building 374 for evaporation using the site wastewater treatment process.

The filter media residue that had been neutralized and transferred to the drying pan will then be placed into a drying oven. The residue will be dried under a vacuum at 80°C (176°F) for 2 hours. Offgas from drying will be treated before HEPA filtration. After cooling, the residues will be weighed, and the quantity of plutonium estimated as the waste is transferred to 8.2-L (2.2-gal) containers. Each container will hold approximately 83.5 g (2.9 oz) of plutonium. The containers will be bagged-out of the glovebox and packaged into convenience cans for transfer to nondestructive assay.

Nondestructive assay will be performed and the assayed and packaged residue containers will be transported for drum packaging. These drums cannot be shipped to WIPP because the percentage of plutonium in the waste exceeds the safeguards termination limit. The drums would reside in interim site storage until subjected to an appropriate stabilization process that would reduce the plutonium content below the safeguards termination limit.

C.4.8 Filtration and Drying of Sludge Residues

The filtration and drying process for sludge residues filters off any excess liquid and drys the remaining material by mixing it with an absorbent. After drying and repackaging, the sludge residues would be placed in interim storage pending a final disposition decision. This process will be conducted in Room 3701 of Building 371.

The filter-dry process, consisting of allowing wet materials to drain and partially dry, and mixing the resulting solids with water-absorbing materials, is considered to be a proven technology. The capability for Rocky Flats is being installed to support the disposition of below-safeguards termination limit materials, and should be available several months after the issuance of the draft of the EIS. Activities are underway to optimize the process and reduce the quantity of water-absorbing materials required for meeting disposal requirements.

The filtration and drying process for sludge residues is shown in **Figure C–8**. The process steps are drum unloading and bag-in, feed preparation and decant/filtration, absorbent addition, and bag-out. Nondestructive assay will be performed, followed by drum packaging for interim site storage.

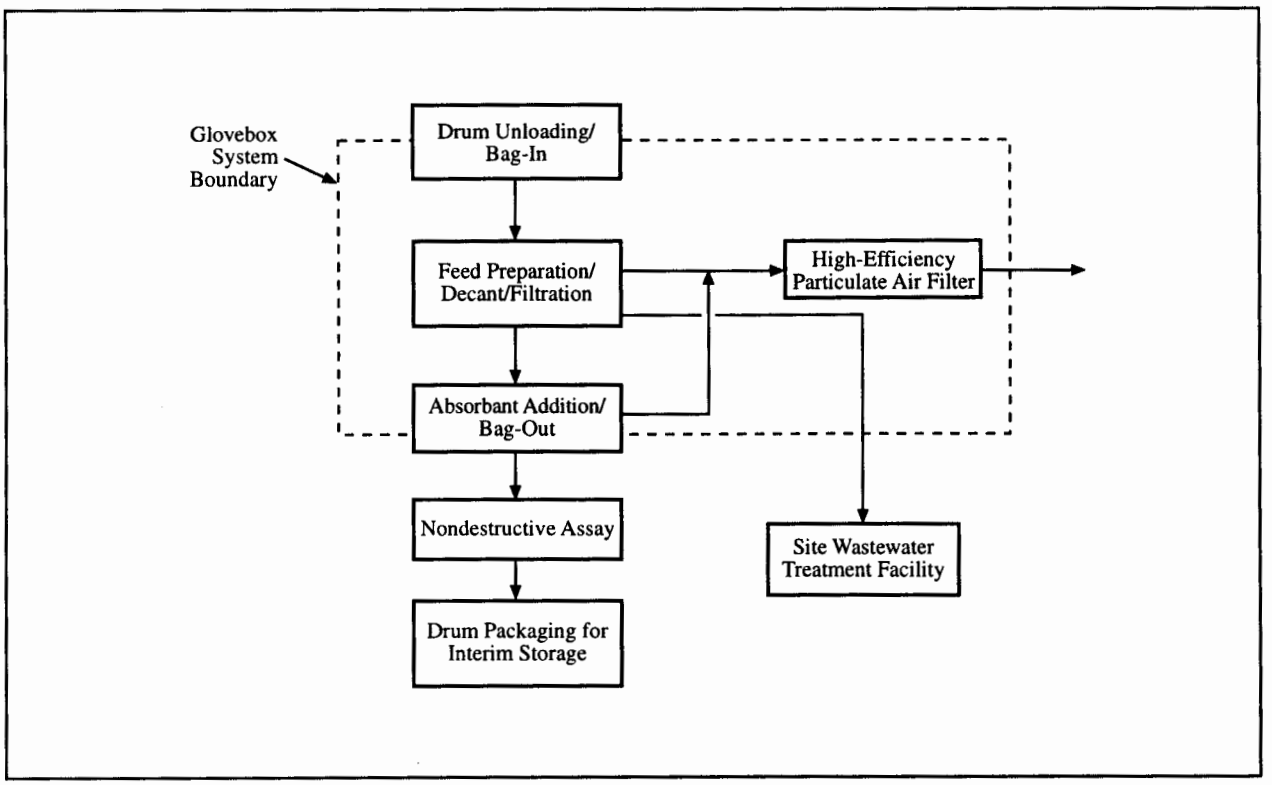


Figure C–8 Filtration and Drying Process for Sludge Residues

❒ Detailed Process Description

Fifty-five-gallon drums will be transferred from storage into a contamination control enclosure and unpacked. The contamination control enclosure is designed to control airflow in the event of a bag failure within a drum. The drums are opened and the integrity of the packaging is checked. If the packaging has not been compromised, the package is transferred into the glovebox. Any unnecessary packaging materials, will be removed to limit the amount of packaging introduced into the glovebox. If the integrity of the primary packaging has been compromised, the package will be overpacked with a new plastic bag before transfer to the glovebox.

Following bag-in, IDCs will be verified, containers will be unpacked, and the residues will be sorted. Any unwanted materials found in the sludge, such as plastics or metals, will be bagged-out of the glovebox and managed appropriately. As required, free liquids will be decanted and vacuum filtered to collect any suspended solids. At intervals, as required during the process, the decanted and filtered liquids will be sent to the site wastewater treatment process in Building 374 for evaporation. After decanting, the sludge will be removed from the container and the resulting packaging materials will be bagged-out of the glovebox and managed appropriately. The sorted residue material will be weighed into 8.2-L (2.2 gal) containers. The amount of residue added to the container is based on the total weight of the container, after absorbent addition, being 9.09 kg (20.0 lb) or less to meet physical handling constraints. Dry absorbent will be blended with the wet sludge residue for absorbent addition at a ratio of 4 parts absorbent to 1 part sludge, by weight. After blending, the containers will be sealed with a lid and bagged-out of the glovebox. The containers are placed in convenience cans, sealed and taped, and sent to nondestructive assay.

The assayed and packaged residue containers will be transported for drum packaging. The drums will be transferred to interim storage until a final disposition decision is made.

C.4.9 Neutralization and Drying of Glass Residues

The neutralization and drying process for glass residues treats the nitric acid contaminant on the residue. This process may remove up to 99 percent of the plutonium from the residue based on results from washing Raschig rings. This process will be conducted in Room 3701 of Building 371.

The neutralize-dry process, consisting of washing materials in alkaline solutions, allowing them to drain or partially dry, and mixing the resulting solids with water-absorbing materials, is considered to be a proven technology. The capability for Rocky Flats is being installed to support the disposition of below-safeguards termination limit materials, and should be available several months after the issuance of the draft of the EIS. Activities are underway to optimize the process and reduce the quantity of water-absorbing materials required for meeting disposal requirements.

The neutralization and drying process for glass residues is shown in **Figure C–9**. The process steps are drum unloading and bag-in, feed preparation, neutralization and decant/filtration, and oven drying, packaging, and bag-out. Nondestructive assay will be performed, followed by drum packaging for interim site storage.

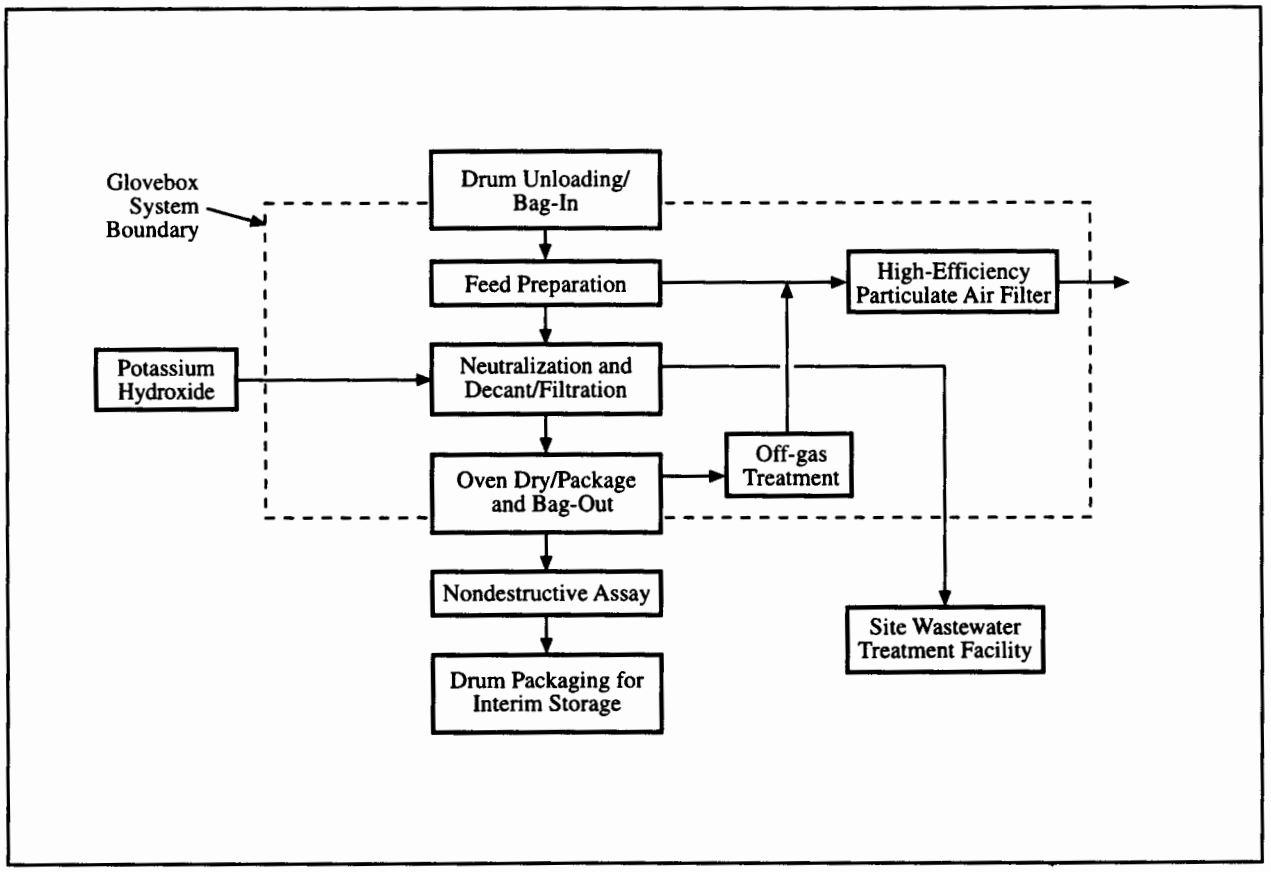


Figure C–9 Neutralization and Drying Process for Glass Residues

❒ Detailed Process Description

Fifty-five-gallon drums will be transferred from storage into a contamination control enclosure and unpacked. The contamination control enclosure is designed to control airflow in the event of a bag failure within a drum. The drums are opened and the integrity of the packaging is checked. If the packaging has not been compromised, the package is transferred into the glovebox. Any unnecessary packaging materials will be removed to limit the amount of packaging introduced into the glovebox. If the integrity of the

primary packaging has been compromised, the package is overpacked with a new plastic bag before transfer to the glovebox.

Following bag-in, the IDCs will be verified, and the containers will be unpacked and the residue sorted. Any unwanted materials will be bagged-out of the glovebox and managed appropriately. As required, the sorted residue material will be size-reduced by crushing and batched to 5-kg (11-lb) batches for neutralization.

Neutralization is intended to remove the nitrate contamination from the glass waste and to neutralize any residual nitric acid on the residue. The 5-kg (11-lb) batches of residue will be washed with 50 L (13 gal) of water containing 10 percent excess potassium hydroxide. After 2 hours, the acid will be neutralized forming potassium nitrate and water. The neutralization process should remove approximately 99 percent of the plutonium from the residue. The residue solids will be separated from the nitrate and plutonium-containing solution by decanting and filtration. The residue, after neutralization, will contain approximately 0.5 percent neutralization solution by weight with a proportionate quantity of nitrates and transferred to a drying pan. At intervals, as required during the process, the neutralization solution with the removed plutonium would be sent to the site wastewater treatment process in Building 374 for evaporation.

The glass residue, neutralized and transferred to the drying pan, would then be placed into a drying oven. The residue will be dried under a vacuum at 80°C (176°F) for 2 hours. Off-gas from drying will be treated before HEPA filtration. After cooling, the residue will be weighed and the quantity of plutonium estimated as the waste is transferred to plastic bags. These bags would be bagged-out of the glovebox and packaged in 8.2-L (2.2-gal) containers to approximately 42.9 g (1.5 lb) of plutonium per container based on a maximum container weight of 9.09 kg (20.0 lb) because of physical handling constraints. After being removed from the glovebox, the containers will be packaged into convenience cans.

Nondestructive assay will be performed, and the assayed and packaged residue containers will be transported for drum packaging. The drums will be transferred to interim storage until a final disposition decision is made.

C.4.10 Repackaging of Graphite Residues, Inorganic Residues, and Scrub Alloy

Repackaging of graphite and inorganic residues and scrub alloy will be performed to achieve the criteria for safe interim site storage. For the graphite and inorganic residues, after repackaging, the residues will remain above the safeguards termination limits, which will preclude ultimate shipment to WIPP unless the material is subjected to further stabilization. Preparation of direct repackage residues for all three materials will be conducted within glovebox lines in Modules D, E and F of Building 707.

Repackaging to package and assay appropriate residues is considered to be a proven technology. The capability for Rocky Flats is being installed to support the disposition of below-safeguards termination limit materials, and should be available several months after the issuance of the draft of the EIS.

The direct repackage process is shown in **Figure C–10**. The process steps are drum unloading and bag-in, feed preparation (for graphite and inorganic), container examination and verification (for scrub alloy), repackaging, and bag-out. Nondestructive assay will be performed, followed by drum packaging for interim site storage.

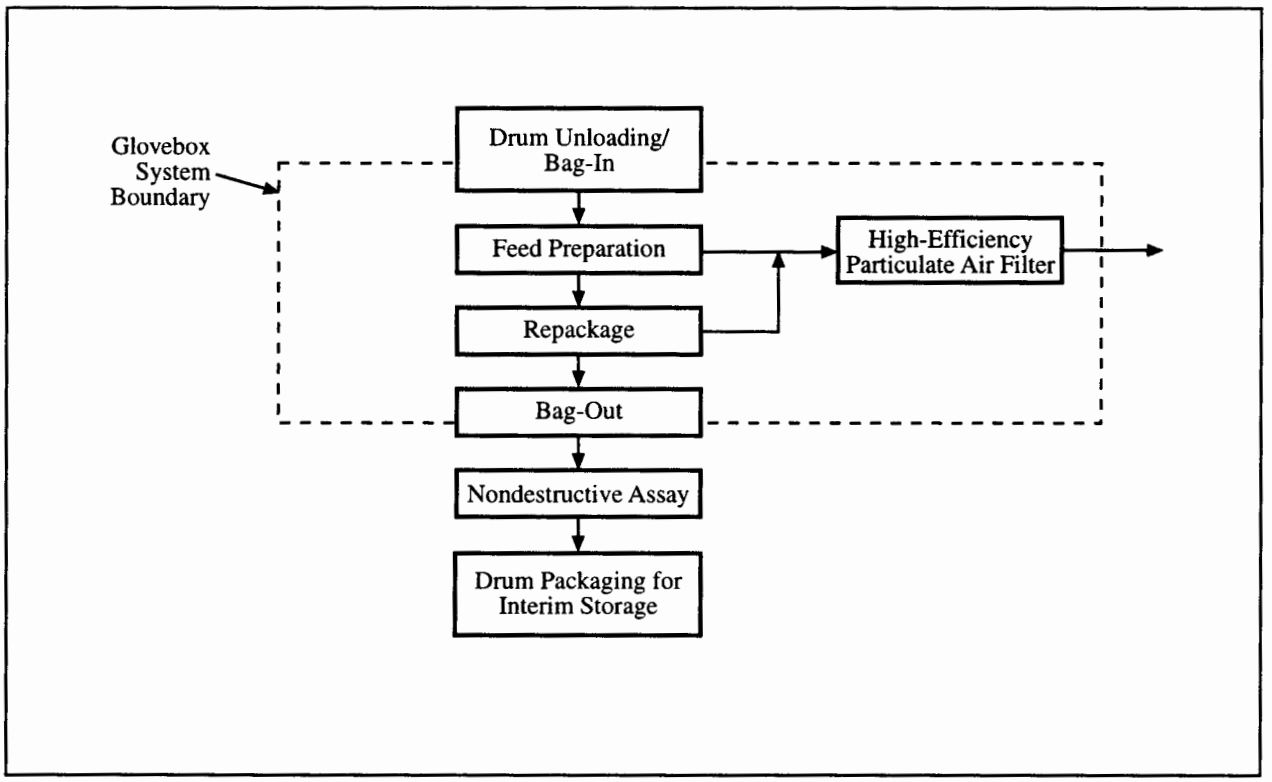


Figure C–10 Direct Repackaging Process for Graphite and Inorganic Residues

❒ Detailed Process Description

Fifty-five-gallon drums will be transferred from storage into a contamination control enclosure in Module D of Building 707. The contamination control enclosure is designed to control airflow in the event of a bag failure within a drum. The drums will be opened and the integrity of the packaging will be checked. If the packaging has not been compromised, the containers will be transferred into the glovebox in Module E of Building 707. The containers, including outer packaging materials, will be removed from the drum and bagged into the glovebox. If the integrity of the packaging has been compromised, the package will be overpacked with a new plastic bag before transfer to the glovebox.

For the graphite and inorganic residues, following bag-in, the plastic bags will be unpacked and the residue sorted. The residue will then be repackaged into metal containers. If the material requires size-reduction and/or compaction to minimize the volume of the repackaged residue, the sorted residue will be transferred to a size-reduction station, after which the residue will be repackaged into metal containers. If required, the repackaged material will be compacted within the metal containers to gain additional volume reduction. Each repackaged container will be filled to approximately 83.5 g (2.9 oz) of plutonium. After the container filling step, the sealed container will be bagged-out and transferred to nondestructive assay. The assayed and repackaged residue containers will then be transported into Module F of Building 707 for drum packaging. The containers will be loaded into a 55-gallon drum. These drums cannot be shipped to WIPP because the percentage of plutonium in the waste exceeds the safeguards termination limit. The drums would reside in interim site storage until subjected to an appropriate stabilization process that will reduce the plutonium content below the safeguards termination limit for graphite and inorganic residues.

For the scrub alloy, following bag-in, the containers housing the scrub alloy buttons will be unpacked. The residue will then be repackaged into metal containers meeting the safe storage standard. After the scrub

alloy button is repackaged, the sealed container will be bagged-out and transferred to nondestructive assay. The assayed and repackaged residue containers will then be transported to Building 371 for safe interim site storage. These containers cannot be placed into pipe components, drummed, and shipped to WIPP because the percentage of plutonium exceeds storage limits. The containers will reside in interim site storage until subjected to an appropriate stabilization process.

C.5 Detailed Process Descriptions for Processing Technologies Without Plutonium Separation

C.5.1 Immobilization (Vitrification)

For ash, HEPA filter media, sludge, glass, graphite, and inorganic residues, the proposed vitrification immobilization process uses a furnace vitrification technology similar in concept to calcination. This process has been proposed for interim processing to allow safe interim storage at Rocky Flats until shipment to WIPP is approved. The process will be conducted in gloveboxes located in Module D, E, and F of Building 707 using muffle furnaces to heat the residue material to approximately 700 to 1,300°C (1,300 to 2,400°F) for 4 hours. The end product consists of a solidified monolith contained inside a 20-cm (8-in) diameter by 25.4-cm (10-in) high metal can.

Calcination of powdered or granular materials in muffle furnaces is considered to be a proven technology. Capabilities necessary to satisfy all alternatives are being installed at Rocky Flats as part of the ongoing stabilization programs, and should be operational within several months after issuance of the draft EIS. The vitrification process is also considered to be a proven technology for most residue types to which it may be applied. A technical development program is underway for the vitrification of ash residues. The muffle furnace capability for Rocky Flats is being installed to support the disposition of below-safeguards termination limit materials, and should be available several months after the issuance of the draft of the EIS. Activities are underway to optimize the process and reduce the steps necessary to achieve an acceptable waste form.

The vitrification process for residues is shown in **Figure C–11**. The process steps are drum unloading, feed preparation, vitrification, and bag-out. Nondestructive assay will be performed, followed by final drum packaging and storage.

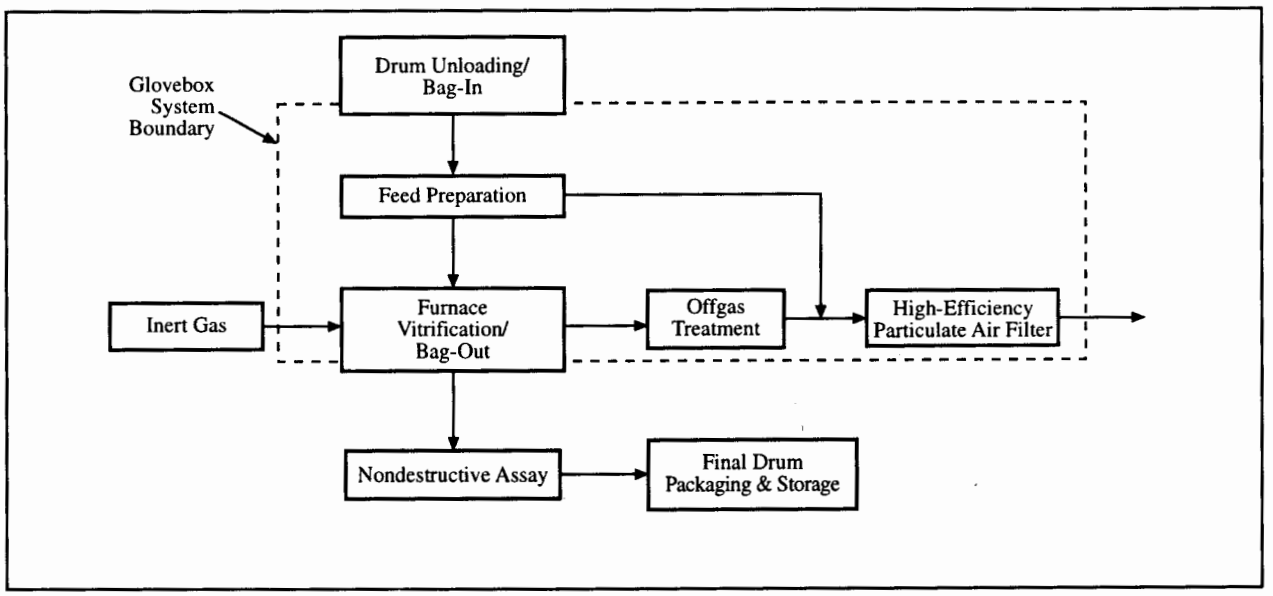


Figure C–11 Furnace Vitrification Process for Residues

The proposed vitrification for scrub alloy requires a two-step heating process. First, the scrub alloy will be converted to an oxide by calcining at 600°C (1,100°F) and 1,000°C (1,800°F), respectively. Then, calcined scrub alloy will be blended with frit and vitrified using the furnace vitrification process. This entire process will be conducted in gloveboxes located in Modules D, E, and F of Building 707, similar to the residues. The calcining and vitrification steps will use identical muffle furnaces.

Since the calcination of powdered or granular materials in muffle furnaces is considered to be a proven technology and plutonium metals and other alloys have been routinely burned in the past, calcination of scrub alloy is considered to be a low-risk technology although not specifically proven in this context. Capabilities necessary to satisfy all alternatives are being installed at Rocky Flats as part of the ongoing stabilization programs, and should be operational within several months of issuance of the draft EIS. The vitrification process is considered a proven technology for most residue types for which it may be applied. The muffle furnace capability for Rocky Flats is being installed to support the disposition of below-safeguards termination limit materials, and should be available several months after the issuance of the draft of the EIS. The disposition of scrub alloy through a calcination and vitrification process was not envisioned as a disposal approach at the time of the WIPP EIS and therefore was not included in the WIPP Baseline Inventory Report. In the event that this technology was to be implemented, the resulting Transuranic waste, although of satisfactory composition and form, might be subject to delays in disposal due to the necessity of revising regulatory documentation. Since this material has historically been considered "War Reserve" material, its final disposition to WIPP has not been programmatically evaluated. As such, DOE considers the calcination and vitrification of scrub alloy at Rocky Flats a "nonpreferred" processing option.

The process to vitrify scrub alloy residues is shown in **Figure C–12**. The process steps are container bag-in, feed preparation for calcination, calcination, feed preparation for vitrification, and vitrification and bag-out. Nondestructive assay will also be performed, followed by final drum packaging and storage.

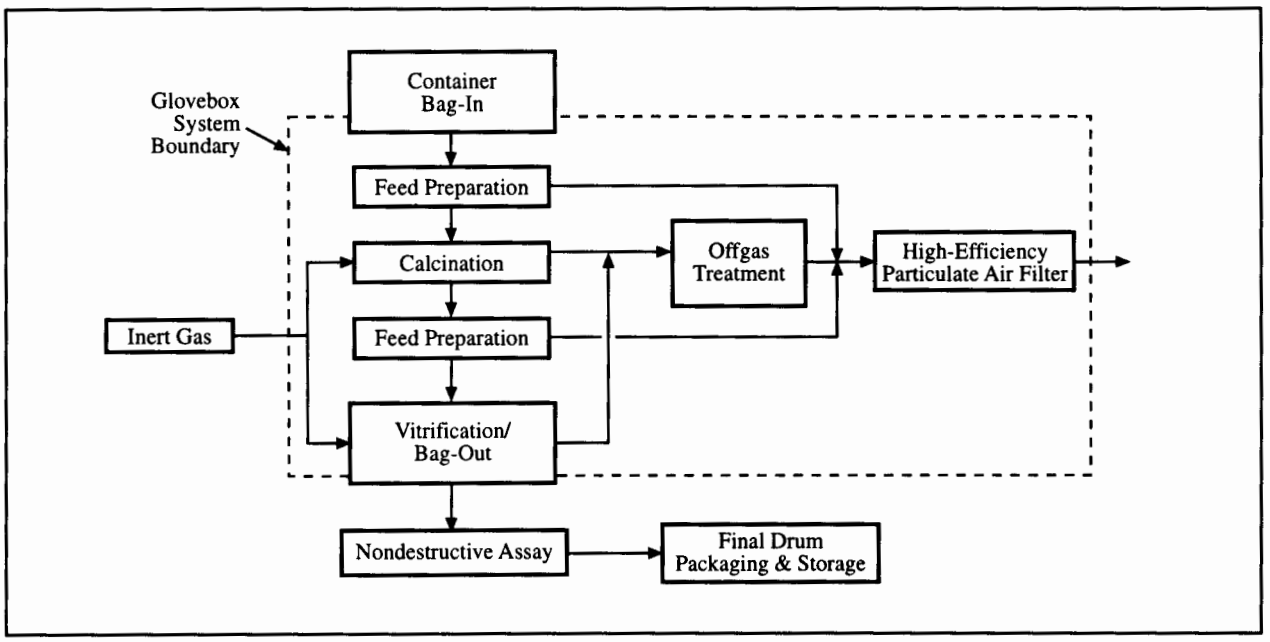


Figure C–12 Furnace Vitrification Process for Scrub Alloy

Furnace vitrification involves the addition of siliceous material called "frit" to the residues or scrub alloy followed by heating at 700 to 1,300°C (1,300 to 2,400°F) to produce a glass matrix. Two waste streams may be generated in addition to the vitrified product stream. The first waste stream will be a solid transuranic waste stream consisting of size-reduced stainless steel cans, plastic containers, plastic bags and containers. The second waste stream will be a gaseous effluent stream consisting primarily of one or more of the following, depending on the residue or scrub alloy type: nitrogen, oxygen, trace acid gases, carbon dioxide, nitrous oxide,

water, and/or particulates. The offgas stream will be configured to cool the effluents and remove acids and particulates before discharge into the glovebox exhaust HEPA filter system.

❒ Detailed Process Description for Residues

Fifty-five-gallon drums will be transferred from storage into a contamination control enclosure in Module D of Building 707. The contamination control enclosure is designed to control airflow in the event of a bag failure within a drum. The drums will be opened and the integrity of the packaging will be checked. If the packaging has not been compromised, the containers will be transferred into the glovebox in Module E of Building 707. The containers, including outer bags, clamshells, and other packaging materials, will be removed from the drum and bagged into the glovebox. If the integrity of the packaging has been compromised, the package will be overpacked with a new plastic bag before transfer to the glovebox.

For the residues, after bag-in, the IDCs of residue containers/packages will be verified and the original residue packages will be transferred to a residue sorting and loading station or to a crushing station, either of which will provide local dust control. For most residue types, the sorting and loading station will contain a sieve to sort and to separate out oversized residue and tramp material (e.g., nuts, bolts). Tramp material and large pieces of residue will be collected on the sieve. The sieved residue fines will be collected in the new containers. The tramp material will be separated and transferred for transuranic waste size-reduction and packaging. Oversized residue pieces, will be sent through a size-reduction process and either mechanically crushed or shredded. Once size-reduced, the residues will be fed back to the loading station. HEPA filter frames will be separated out and shredded for size-reduction and sorted glass residues will be crushed, then both will be loaded into new metal containers for the vitrification process. Sorted sludge residue materials will be loaded directly into a new metal container for the vitrification process.

The residues will be batched with an average of 83.5 g (2.9 oz) of plutonium per container. For all of the residues, following batching, a blending step will be required wherein the materials will be blended and diluted with low melting temperature frit. Each material stream to be immobilized by the vitrification process will be analyzed to determine the appropriate proportions of material and frit to meet the WIPP/Waste Acceptance Criteria requirements. The material containers will then be ready for vitrification.

After a container is charged and blended, it will be positioned into the heating chamber of the muffle furnace. The furnace will be energized and there will be a gradual ramp-up in temperature within the chamber. The temperature range for the vitrification process will be between 700 and 1,300°C (1,300 and 2,400°F). The actual vitrification temperature will be determined for each specific type of residue before vitrification.

Engineering investigations are underway to identify the most effective method to extract and capture the offgases generated by the heating process. Various constituents may be generated during vitrification depending on the residue type, including one or more of the following: water vapor, carbon dioxide, nitrous oxide, trace quantities of acid gases, organic, and/or particulates. This description assumes the use of a dry scrubber using potassium carbonate for offgas treatment. A concern with residual organic contaminants in the residue feed stream subsequently volatilizing during the heating process necessitated an investigation into the incorporation of a design modification which will continuously purge the heating chamber with inert gas during the processing of the residues.

The heating process will be approximately 4 hours in duration. The container will be allowed to cool to 100°C (212°F) before removal from the furnace. After final cooling, the container will be sealed with a lid and bagged out of the glovebox for nondestructive assay.

Post-vitrification nondestructive assay will be performed on all material containers to determine the amount of fissile material present. Following nondestructive assay, residue containers that meet the WIPP/Waste Acceptance Criteria fissile material limits will be transferred into Module F of Building 707 for final drum packaging. Two containers will be loaded into a pipe component staged inside a 55-gallon drum. The sealed drums will be placed into interim site storage awaiting shipment to WIPP.

❒ **Detailed Process Description for Scrub Alloy**

Stainless-steel containers of scrub alloy will be transferred from storage and bagged directly into the glovebox. After bag-in, the alloy buttons will be unpacked and placed in a burn boat in a muffle furnace and calcined at approximately 600°C (1,100°F) for 2 hours to convert the scrub alloy to an oxide. After cooling, the powdery oxide will be transferred to another muffle furnace and calcined at 1,000°C (1,800°F) for 2 hours. After being allowed to cool, the boats will be transferred to the loading station. At this point in the process, oversized scrub alloy pieces will be sent back through the calcination process and transferred again to the loading station.

The scrub alloy will be batched to average 18.1 g (0.64 oz) of plutonium per container. Following batching, a blending step will be required wherein the materials will be blended and diluted with low-melting-temperature frit. The material stream to be immobilized by the vitrification process will be analyzed to determine the appropriate proportions of material and frit to meet the WIPP/Waste Acceptance Criteria requirements. The material containers will then be ready for vitrification.

After a container is charged and blended, it will be positioned into the heating chamber of the muffle furnace. The furnace will be energized and there will be a gradual ramp-up in temperature within the chamber. The temperature range for the vitrification process will be between 700 and 1,300°C (1,300 and 2,400°F). The actual vitrification temperature will be determined for each specific type of material before vitrification.

Engineering investigations are underway to identify the most effective method to extract and capture the offgases generated by the heating process. This description assumes the use of a dry scrubber using potassium carbonate for offgas treatment. A concern with residual organic contaminants in the feed stream subsequently volatilizing during the heating process necessitated an investigation into the incorporation of a design modification that will continuously purge the heating chamber with inert gas during the processing of the scrub alloy.

The heating process will be approximately 4 hours in duration. The container will be allowed to cool to 100°C (212°F) before removal from the furnace. After final cooling, the container will be sealed with a lid and bagged out of the glovebox for nondestructive assay.

Post vitrification nondestructive assay will be performed on all material containers to determine the amount of fissile material present. Following nondestructive assay, containers that meet the WIPP/Waste Acceptance Criteria fissile material limits will be transferred into Module F of Building 707 for final drum packaging. Two containers will be loaded into a pipe component staged inside a 55-gallon drum. The sealed drums will be placed into interim site storage awaiting shipment to WIPP.

C.5.2 Immobilization (Cementation) of Graphite Residues

The proposed cement-based immobilization process is an adaptation of a Portland cement-based waste immobilization process that has been used within DOE and the commercial nuclear industry. This process was approved by EPA as a best demonstrated available technology for use in waste stabilization. At Rocky Flats, cement-based waste immobilization processes have been operated successfully for several years and have

produced thousands of cubic yards of solidified waste. The process has been used for the solidification of low-level waste (saltcrete) in Building 374 and for the solidification of transuranic waste in Building 774 (bottlebox process). The graphite residue cement solidification process will be located in either Building 707 or Building 371 and will involve the cementation of graphite molds, scarfed graphite molds, coarse graphite, and coarse firebrick as feed materials.

Cementation of materials necessary to immobilize fines and to form an acceptable solid is considered to be a proven technology, although optimization studies are routinely performed to improve specific characteristics. Rocky Flats would have to install or remodel gloveboxes to provide additional area for the curing step, so approximately one year would be required after the issuance of the Record of Decision before the cementation capability would be fully operational. The specific location of the cementation processing is uncertain, although the process would be consistent with either Building 371 or Building 707.

The cement-based immobilization process is shown in **Figure C–13**. The process steps are drum unloading and bag-in, feed preparation for calcination, calcination, feed preparation for cementation, in-line nondestructive assay, process mixing, curing and bag-out, and final drum packaging and storage.

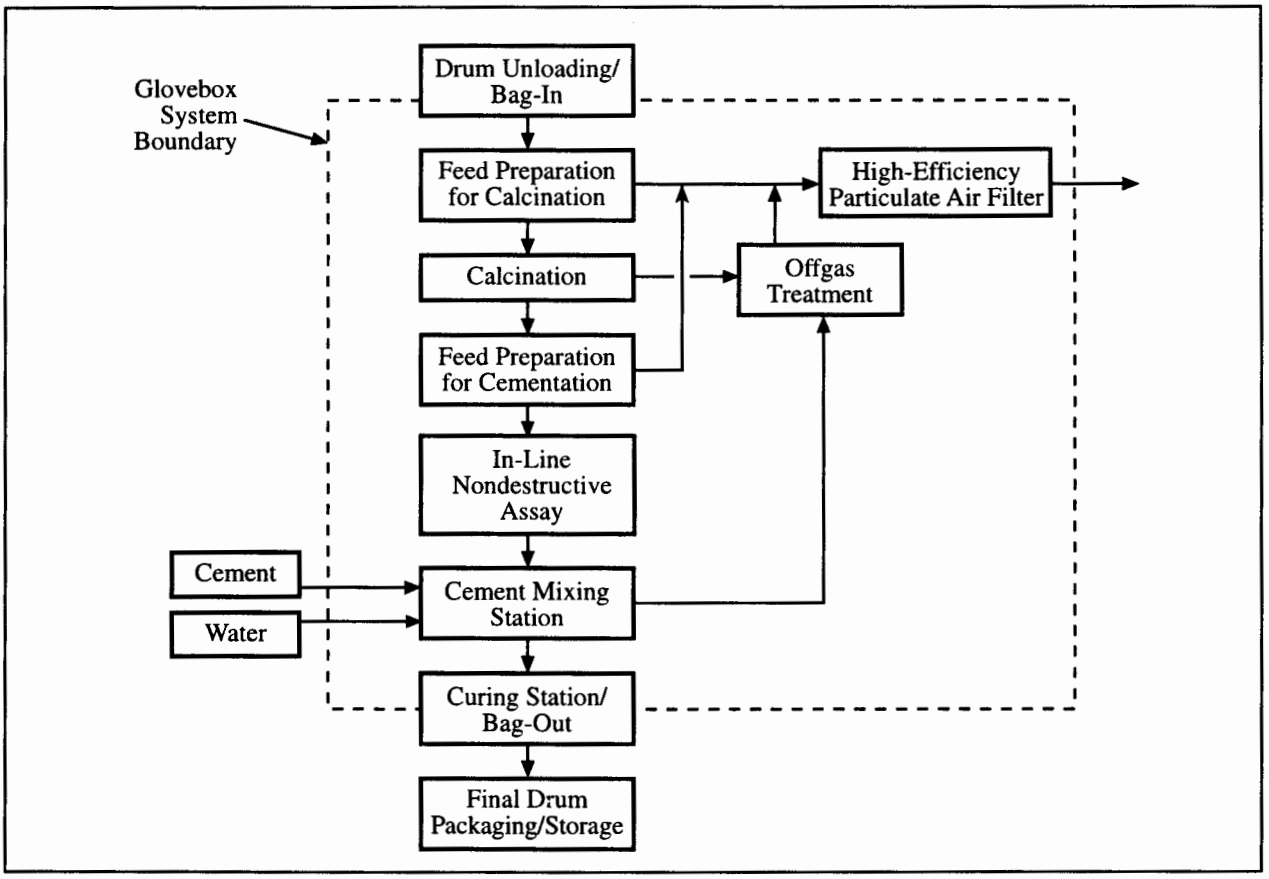


Figure C–13 Cement-Based Immobilization Process for Graphite Residues

Cement-based immobilization blends cement and water with the prepared graphite residues. The advantage of cement-based immobilization technology is its proven performance. When well-established protocols are followed, a WIPP acceptable final product will be ensured. Elements included within these protocols include waste characterization, both physical and chemical; treatability formula development; bench scale testing; pilot scale studies; and detailed project planning for full-scale operations.

There are several disadvantages associated with a cement-based immobilization process. First, unrecognized variability in the waste feed stream can compromise the acceptability of the final product in meeting the WIPP/Waste Acceptance Criteria. Second, the mixing of the cement and water components produces heat during the curing process, and the active metals in the waste stream react with water to produce hydrogen gas. Third, during mixing, curing, and after final packaging, there is a potential for hydrogen generation due to both radiolysis and hydrolysis of the water of hydration by the radiological and reactive metal components, respectively. This allows for less transuranic material to be transported per shipment to WIPP.

In addition to the cemented-residue product stream, there will be two waste streams generated. The first waste stream will be a solid transuranic waste stream consisting of size-reduced steel containers, plastic containers and plastic bags. The second waste stream will be a gaseous effluent stream consisting primarily of nitrogen, water vapor, carbon dioxide, hydrogen, and particulates. Any tramp material removed from the waste will be either combined with the solid transuranic waste stream or placed into a cemented waste container before curing.

❒ Detailed Process Description

Fifty-five-gallon drums will be transferred from storage into a contamination control enclosure. The contamination control enclosure is designed to control airflow in the event of a bag failure within a drum. The drums will be opened and the integrity of the packaging will be checked. If the packaging has not been compromised, the containers will be transferred into the glovebox. The containers, including outer bags, clamshells and other packaging materials, will be removed from the drum and bagged into the glovebox. If the integrity of the packaging has been compromised, the package will be overpacked with a new plastic bag before transfer to the glovebox. There would be approximately five containers in each drum.

After bag-in, the IDCs of the residue containers will be verified and the original residue containers will be transferred either to a residue sorting and loading station or, for the large sized residue such as graphite molds, directly to a crusher. Both the sorting and loading station and crusher will provide local dust control. The sorting and loading station will contain a 0.32-cm (1/8-in) sieve that will be used to separate oversized residue and tramp material (e.g., nuts, bolts). The sieved residue fines will be transferred into burn boats. Tramp material will be separated and transferred for transuranic waste size reduction and packaging or placed into the cemented waste before curing. Oversized residues will be crushed and fed back to the loading station. Each container will be filled to contain approximately 83.5 g (2.9 oz) of plutonium. After the filling step, the burn boats will be transferred to the muffle furnace for calcination.

Calcination is required to high-fire the residue, which will remove the reactive characteristics in the residue stream. Each batch will be calcined at 900°C (1,650°F) for 4 hours, which will oxidize carbon and organic to carbon dioxide and eliminate water, thereby increasing the bulk density of the residue. After cooling, the residue will be transferred for feed preparation for cementation.

The burn boats containing the calcined residue will be transferred to a residue sorting and loading station. As described previously, the residue will be sieved and the residue fines will be loaded into metal containers. As required, oversized residues will be crushed and loaded into the containers. Each container will be filled to contain approximately 83.5 g (2.9 oz) of plutonium. After the container filling step, the containers will be transferred to an in-line nondestructive assay station.

Nondestructive assay will be performed, after which, the container will be moved to the mixing station. Then, measured quantities of water and cement will be manually blended into the residue containers. The material will be mixed until all of the water has been absorbed by the cement and the mixture thickens. Because of the potential for heat generation, provisions for actively cooling the container during and after mixing may be required for certain residue IDCs. During mixing, there is a potential for vapor generation

produced by an exothermic reaction associated with the hydration of the cement and through hydrogen gas generation produced from radiolysis and hydrolysis. Therefore, provisions will be incorporated as necessary for the collection and extraction of these vapors in both the mixing station and curing station. The container will then be removed from the mixing station into a set of curing gloveboxes and set aside for a 24-hour curing period. After curing has been completed, the cans will be bagged-out of the glovebox.

Assayed, cemented residue containers that meet the WIPP/Waste Acceptance Criteria will be transferred for final drum packaging. Two containers will be loaded into a pipe component already staged inside of a 55-gallon drum. The sealed drums will be placed into interim site storage awaiting shipment to WIPP.

C.5.3 Blend Down

Blend down technology involves mixing residues with other materials to reduce plutonium concentrations below safeguards termination limits. The blending process will be conducted inside a glovebox located in Module E of Building 707 for all residues except salts or in Room 3701 of Building 371. Uranium oxide and other nonradioactive materials, such as magnesium oxide sand, have been proposed as the blending diluent. Most uranium oxide currently at Rocky Flats has been classified as Resource Conservation and Recovery Act hazardous waste and a decision on its use must be made. Uranium oxide imported from another site, such as Savannah River Site, may be required.

Blending of granular or powdered residue materials with inert or lower-assay powdered residues, and the subsequent packaging and assaying, is considered to be a proven technology. Capabilities necessary to satisfy all alternatives are being installed at Rocky Flats as part of the ongoing stabilization programs, and should be operational within several months of issuance of the draft EIS. The specific location of the blending process is uncertain, although the process would be consistent with either Building 371 or Building 707.

The blend down process for all residues is shown in **Figure C–14**. For most of the residues, the feed materials will be sorted and size-reduced to enhance uniform mixing with the diluent. Calcination will be required for ash residues (except for graphite fines) in order to convert reactive metals to unreactive oxides and to meet the high-fired qualification. The feed materials will then be blended with the diluent. For plutonium fluorides, the feed materials will be unpacked and then blended with the diluent without size reduction. The packaged residue product for each residue will be removed from the glovebox, nondestructively assayed for accountability purposes, packaged in the final transport/storage container, and placed in interim storage.

❒ Detailed Process Description

Drums and containers will be manually transferred from storage into a contamination control enclosure and examined for damage. The contamination control enclosure is designed to control airflow in the event of damage or a bag failure within a drum or container. The drum or container will be opened and the integrity of the packaging will be checked. If the packaging has not been compromised, the drum/container will be transferred to the glovebox. Any unnecessary packaging materials will be removed to limit the amount of packaging introduced into the feed preparation glovebox. If the integrity of the packaging has been compromised, the packaging will be overpacked with a new plastic bag before transfer to the glovebox. All individual drums/containers will be bagged into the feed preparation glovebox.

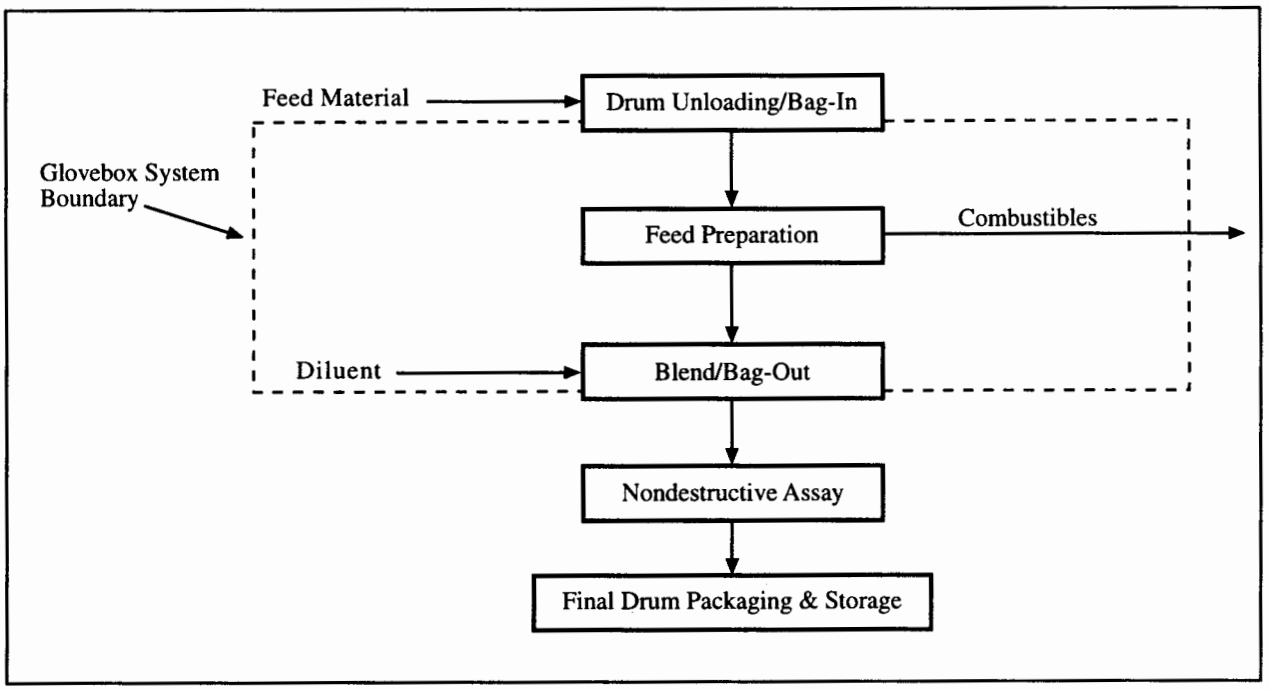


Figure C–14 Blend Down Process for All Residues Except Salts

For most residues, the feed will be introduced into the glovebox, the IDC verified, and each package/bag will be opened and sorted/sieved to remove any tramp metal and other unwanted materials. Following the sorting/sieving, combustible and filter media residue feed materials will be shredded, and ash, sludge, glass, graphite, and inorganic residue feed materials will be crushed and sieved to produce a particle size for uniform mixing with the blending diluent. The crushed feed will again be sieved with a finer mesh screen and any large chunks will be returned to the crusher for reprocessing. Both the shredded and crushed materials will then be batched so that each new container will average 83.5 g (2.9 oz) of plutonium, except sand, slag, and crucible, which will be batched to 18.1 g (0.64 oz) of plutonium because of the high ratio of diluent to residue matrix required. Calcination will be required to high-fire the incinerator ash residues and firebrick fines. It may also be required for certain feeds, such as sand, slag, and crucible, with reactive characteristics. Further study must be completed to ensure that dilution of the feed will negate reactivity characteristics in the feed streams. Each batch will be calcined at 900°C (1,650°F), which will oxidize carbon and organic materials to carbon dioxide and eliminate water, and increase the bulk density of the ash residues. Crushing may be required after calcination. After crushing, the batches are available for blending.

For plutonium fluorides, the materials will be removed directly from containers and will be batched so each new container will average 18.1 g (0.64 oz) of plutonium, due to its high ratio of diluent to residue matrix. It will be necessary to batch the fluorides with 18.1 g (0.64 oz) plutonium per package to maintain the final package weight at less than 9 kg (20 lb) to allow for physical handling within the glovebox. The batching used for each residue will allow for maximum packaging flexibility during the final packaging step after nondestructive assay has been completed and accountability data has been analyzed. Combustible packaging materials from the individual containers will be bagged out of the glovebox and sent to a combustible handling process. Any metals or other unwanted materials will be bagged out of the glovebox and managed appropriately.

Blending may be done manually or mechanically using a blender. In either case, blending will be a hands-on operation, whether the addition of the diluent to the batched feed and subsequent mixing is accomplished in small batches manually or whether loading and unloading steps must be accomplished for use of a mechanical blender. If Rocky Flats uranium oxide is used as the diluent, it will be calcined and

sieved in another location to convert it to a uniformly sized powdery oxide form. If uranium oxide is imported from the Savannah River Site, this step will not be necessary. Additional or different stabilization processings may be needed if salt, magnesium oxide sand, or other blending material is used as a diluent instead of, or in addition to, uranium oxide. This will ensure that the diluent material, when added to the crushed and sieved feed materials, will blend uniformly. The blended material will then be bagged from the glovebox and placed in a convenience container for safe handling.

Nondestructive assay will be performed to ensure requirement limits are met and to obtain data to ensure that required accountability procedures are followed. Nondestructive assay methods will be selected to ensure that the best accountability data are obtained. Assayed product packages will be selected for final packaging to minimize the number of shipping containers required to be shipped to WIPP. Selected packages will be loaded into an inner container and sealed before placing of the container into the final outer shipping container.

C.5.4 Pyro-Oxidation and Blend Down of Pyrochemical Salts

The pyro-oxidation and blend down process removes reactive metals from the salts and mixes them with a matrix to reduce the plutonium concentration to below the safeguards termination limit for pyrochemical salts. This technology can be used on electrorefining salts, molten salt extraction salts, and direct oxide reduction salts. The pyro-oxidation and blending processes will be conducted inside gloveboxes located in Module E of Building 707 or in Room 3701 of Building 371. Uranium oxide and other nonradioactive materials, such as magnesium oxide sand, have been proposed as the blending diluent. Most uranium oxide currently at Rocky Flats has been classified as Resource Conservation and Recovery Act hazardous waste and a decision on its use must be made. Uranium oxide imported from another site, such as the Savannah River Site, may be required.

Pyro-oxidation of salts in stationary furnaces is considered to be a proven technology, although specific process variables are being evaluated in an attempt to make the pyro-oxidation process more compatible with a pyro-distillation follow-on processing step. Pyro-oxidation of reactive salts is part of the Rocky Flats response to Defense Nuclear Facilities Safety Board Recommendation 94-1 to stabilize potentially higher-risk or reactive materials. Rocky Flats has the capability to support the ongoing stabilization programs, and operations are pending. While not a technology risk for the pyro-oxidation process, the salts, once pyro-oxidized, cannot be subsequently salt scrubbed, which is the only current process to allow plutonium separation using the Purex process. The on-going stabilization program trades the technical and programmatic risk of not using a proven Savannah River Site residue disposition approach (Purex) against the reduction of an immediate safety risk. The pyro-oxidation process is, however, a prerequisite step for both salt distillation and aqueous distillation. Blending of granular or powdered residue materials with inert or lower-assay powdered residues, and the subsequent packaging and assaying, is considered to be a proven technology. Capabilities necessary to satisfy all alternatives are being installed at Rocky Flats as part of the ongoing stabilization programs, and should be operational within several months of issuance of the draft EIS. The specific location of the blending process is uncertain, although the process would be consistent with either Building 371 or Building 707.

The pyro-oxidation and blending process steps for pyrochemical salt residues are shown in **Figure C–15**. The salt residues will be sorted and batched in preparation for pyro-oxidation. The salts will be pyro-oxidized to convert reactive metals to oxides. After pyro-oxidation, the oxidized salts and plutonium oxide will be size-reduced. They will then be blended with the diluent. The packaged product will be removed from the glovebox and nondestructively assayed for accountability purposes, packaged in the final transport/storage container, and placed in interim storage.

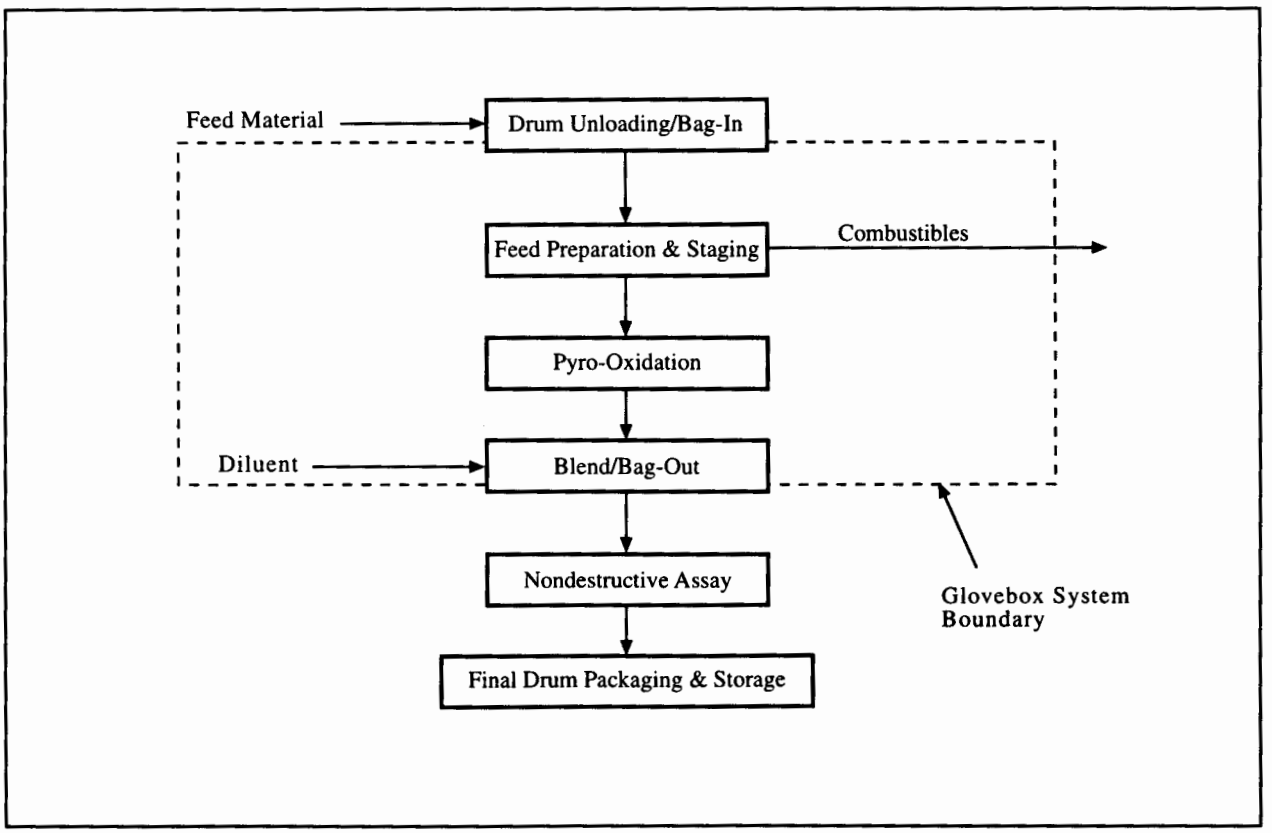


Figure C–15 Pyro-Oxidation and Blend Down Process for Pyrochemical Salt Residues

❒ Detailed Process Description

As required, drums will be manually transferred from storage into a contamination control enclosure. The contamination control enclosure is designed to control airflow in the event of a bag failure within a drum. The drum will be opened and the integrity of the packaging will be checked. If the packaging has not been compromised, the containers will be transferred to the glovebox. Any unnecessary packaging materials will be removed to limit the amount of packaging introduced into the salt feed preparation glovebox. If the integrity of the packaging has been compromised, the packaging will be overpacked with a new plastic bag before transfer to the glovebox.

The salts will be introduced into the glovebox, one package at a time, and the IDC verified. The individual packages will be opened and loaded into a magnesium oxide crucible in preparation for pyro-oxidation. Combustible packaging materials from the individual packages will be bagged out of the glovebox and sent to a combustible handling process. Other materials will be bagged out and managed appropriately.

Once the crucible is loaded with salt feed, it will be placed in a glovebox furnace and heated to approximately 800°C (1,500°F) with an oxidant, such as sodium carbonate, as a reagent for 2 hours, stirring continuously. The product will be a lower plutonium-bearing salt matrix on top and plutonium oxide bound in a salt matrix at the bottom of the crucible. Pyro-oxidation can be applied to both sodium chloride-potassium chloride and calcium chloride matrices. This process converts reactive metals (calcium and sodium) to oxides. Stirring is discontinued during the cooling phase. When the furnace has cooled to below 100°C (212°F), the crucible will be removed from the furnace. During the heating, stirring, and cooling phases, argon will flow through the furnace. During the last part of the stirring phase, argon will be replaced by a mixture of air and argon.

Once the crucible is removed from the furnace, it will be allowed to completely cool before breakout. The salt matrix and plutonium oxide will then be removed from the crucible. The crucible will be discarded and treated as inorganic ash residue. At this point, the salt matrix and plutonium oxide will be screened and sent through a crusher in order to achieve a uniform size for blending with diluent, and placed in containers in preparation for blending. After the materials are size-reduced, they will be batched to 18.1 g (0.64 oz) or less of plutonium due to the high ratio of diluent to residue matrix required. This will allow for maximum packaging flexibility during the final packaging step after nondestructive assay has been completed and accountability data has been analyzed.

Blending may be done manually or mechanically using a blender. In either case, blending will be a hands-on operation, whether the addition of the diluent to the batched feed and subsequent mixing is accomplished in small batches manually or whether loading and unloading steps must be accomplished for use of a mechanical blender. If Rocky Flats uranium oxide is to be used as the diluent, it will be calcined and sieved in another location to convert it to a uniformly-sized powdery oxide form. If uranium oxide is imported from the Savannah River Site, this step will not be necessary. Additional or different stabilization processings may be needed if salt, magnesium oxide sand, or other blending material is used as a diluent instead of, or in addition to, uranium oxide. This will ensure that the diluent material, when added to the crushed and sieved feed materials, will blend uniformly. The blended material will then be bagged from the glovebox and placed in a convenience container for safe handling.

Nondestructive assay will be performed to ensure requirement limits are met and to obtain data to ensure that required accountability procedures are followed. Nondestructive assay methods will be selected to ensure that the best accountability data are obtained. Assayed product packages will be selected for final packaging to minimize the number of shipping containers required to be shipped to WIPP. Selected packages will be loaded into an inner container and sealed before placing the container into the final outer shipping container.

C.5.5 Sonic Wash

Sonic washing for combustible, filter media, glass, and inorganic residues removes the organic and nitrate contaminants from the residue waste to eliminate the potential flammable hazard and allow for its disposal at WIPP. Along with nitrate removal, the sonic wash process may remove up to 90 percent of the plutonium from the residue waste (up to 99 percent for glass residues). At this removal efficiency, the waste will meet safeguards termination limits for disposal at WIPP. The plutonium and nitrate removed from the residues are vitrified to meet the safeguards termination limit for vitrified waste disposal at WIPP. The sonic washing process will be conducted inside a glovebox located in Room 3701 of Building 371.

Sonic washing of materials, using sound waves to enhance the partition of a residue into a below-safeguards termination limit (washed) component and a concentrated component which is then vitrified to meet safeguards termination limit, has been demonstrated with residue-type materials on a bench scale. Due to the significant effort required to demonstrate a consistent process and develop the procedures and analysis necessary for routine operation, the estimated time required to deploy this operation would be 2 years after the issuance of the Record of Decision.

The sonic washing process for residues is shown in **Figure C–16**. The process steps include drum unloading and package bag-in, feed preparation, thermal desorption and steam passivation (for combustible and filter media residues), sonic washing and decant/filtration, evaporation and water recycle, plutonium vitrification and package bag-out, and oven drying and package bag-out. Nondestructive assay will be performed, followed by final drum packaging and storage.

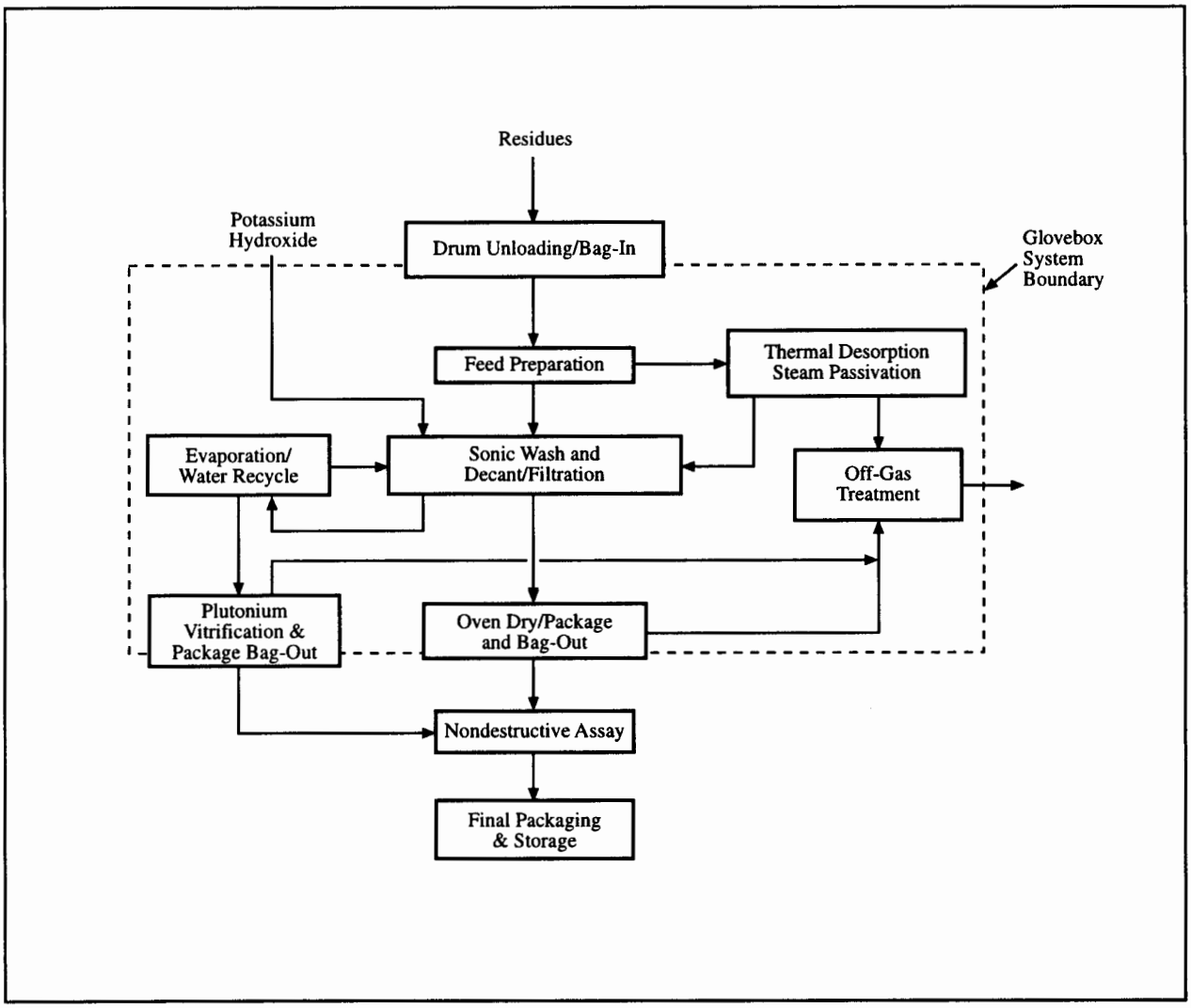


Figure C–16 Sonic Wash Process

❒ Detailed Process Description

Drums will be manually transferred into a contamination control enclosure and unpacked. The contamination enclosure is designed to control airflow in the event of a bag failure within a drum. The drums will be opened and the integrity of the packaging will be checked. If the packaging has not been compromised, the containers will be transferred into the glovebox. Any unnecessary packaging materials will be removed to limit the amount of packaging introduced into the feed preparation glovebox. If the integrity of the packaging has been compromised, the package will be overpacked with a new plastic bag before transfer to the glovebox. Each of the individual bags will be bagged into the feed preparation glovebox.

The residue feed will be introduced into the glovebox and the IDC verified. Each bag will be opened to remove any tramp metal and other unwanted materials, and sorted to separate the organic contaminated residues from the nonorganic contaminated residues. Following the sorting, the feed materials will be shredded and batched to 5 kg (11 lb) of residue in preparation for low temperature thermal desorption and sonic washing. Any metals and other unwanted materials will be bagged out of the glovebox and managed appropriately.

The organic contaminated residues will be fed in 5 kg (11 lb) batches to a low temperature thermal desorption unit which operates under a vacuum at 80°C (176°F). During the 6-hour process, the organic contamination will be volatilized from the residues. The organic containing off-gas will be treated by silent discharge plasma destruction before being vented through a HEPA filter. The resulting residues will then be sonic washed.

Sonic washing is intended to remove both the nitrate and plutonium contamination from the residue waste to meet acceptable waste storage criteria at WIPP. The 5-kg (11-lb) batches of residue from feed preparation will be sonic washed with 50 L (13 gal) of aqueous solution containing 10 percent excess potassium hydroxide to neutralize any residual nitric acid contained within the waste. After 2 hours of sonic washing, the acid will be neutralized forming potassium nitrate and water, and approximately 90 percent of the plutonium will be removed from the residue waste (and 99 percent of the plutonium from glass residues). The residue solids will be separated from the nitrate and plutonium-containing solution by decanting and filtration. The solids will be transferred to a drying pan. The solution from sonic washing will contain approximately 90 percent of the plutonium, as solids, and more than 97 percent of the nitrates, which are dissolved. This solution flows to the evaporation and recycle step.

The nitrate and plutonium bearing solution will be evaporated in a forced circulation evaporator to produce water which may be recycled to the sonic washing step, and dried nitrate and plutonium solids. While the evaporator type has not yet been selected, it will evaporate approximately 50 L (13 gal) of water within a 3-hour period, and will probably operate under a vacuum at a temperature below 100°C (212°F). This will require a heat load of approximately 40,000 Btu (11.7 kilowatts) per hour, and the capability of evaporating the liquid while preventing the collection of the plutonium on the heat transfer surface. After evaporation, the solids are weighed into batches containing an average of 83.5 g (2.9 oz) plutonium and placed into 8.2-L (2.2-gal) containers in preparation for vitrification.

Following batching, a blending step will be required where the residue material will be blended and diluted with low-melting-temperature frit. Each residue stream to be immobilized by the vitrification process will be analyzed to determine the appropriate proportions of residue and frit to meet the WIPP/Waste Acceptance Criteria requirements. The residue containers will then be staged for vitrification. Once the residue container is charged and blended, it will be positioned into the heating chamber of the muffle furnace. The furnace will be energized and there will be a gradual ramp-up in temperature within the chamber. The target temperatures for vitrification will be between 700 and 1,300°C (1,300 and 2,400°F). The actual temperature will be determined for each specific type of residue before vitrification.

Engineering investigations are underway to identify the most effective method to extract and capture the off-gases generated by the heating process. Water vapor, carbon dioxide, nitrous oxide, trace quantities of acid gases, organic, and particulates may be generated during vitrification. This description assumes the use of a dry scrubber using potassium carbonate for off-gas treatment. A concern with residual organic contaminants in the residue feed stream subsequently volatilizing during the heating process necessitated an investigation into the incorporation of a design modification which will continuously purge the heating chamber with inert gas during the processing of the residues.

The heating process will be approximately 4 hours in duration. The container will be allowed to cool to 100°C (212°F) before removal from the furnace. After final cooling, the container will be sealed with a lid and placed into a convenience can before being bagged out of the glovebox for nondestructive assay. The sonic wash technology will produce 8.2-L (2.2-gal) containers of vitrified plutonium/nitrate waste.

The sonic-washed residue waste will be transferred from sonic washing to the drying oven in drying pans. The waste will be dried under a vacuum at 80°C (176°F) for 2 hours, producing a dry waste (containing approximately 1 percent water). Off-gas from drying will be treated before HEPA filtration to capture or

destroy any volatilized contaminants. After cooling, the waste will be weighed, and the quantity of plutonium estimated, as the waste is transferred to 8.2-L (2.2-gal) containers. These containers will be bagged out of the glovebox and packaged into convenience cans. Based on 90 percent of the plutonium being removed in the sonic wash, the plutonium remaining in the waste will be below the safeguards termination limit required for shipment and disposal at WIPP.

Nondestructive assay will be performed to ensure requirement limits are met and to obtain data to ensure that required accountability procedures are followed. Nondestructive assay methods will be selected to ensure that the best accountability data are obtained. Within this single step, 8.2-L (2.2-gal) waste containers from both plutonium vitrification with bagout and residue drying with bagout steps will be analyzed. Assayed product packages will be selected for final packaging from both the vitrified plutonium/nitrate waste and the dried residue waste to minimize the number of shipping containers required to be shipped to WIPP. Selected packages will be loaded into an inner container and sealed before placing the container into the final outer shipping container. The sonic wash technology will produce drums containing pipe components loaded with nitrate-washed combustibles and vitrified plutonium waste.

C.5.6 Catalytic Chemical Oxidation of Combustible Residues

The catalytic chemical oxidation process is a relatively new dissolution process that has been incorporated into a standard aqueous separation process for the processing of plutonium-containing residues. The catalytic chemical oxidation/aqueous process will be used to remove all of the plutonium from the residue matrix material, creating a concentrated plutonium oxide stream and converting the residual material into carbon dioxide and water. Catalytic chemical oxidation processing can be used on combustible residues, including wet and dry combustibles, plastic, and leaded gloves. The catalytic chemical oxidation process will principally be conducted inside gloveboxes located in Room 3701 of Building 371. The catalytic chemical oxidation process for combustible residues is shown in **Figure C–17**.

Catalytic chemical destruction of combustibles at elevated temperatures and pressures, while demonstrated in a commercial environment, is completely unproven as a production process in the size and service required, and for residue material applications. Due to the significant effort required to demonstrate a consistent process and to develop the procedures and analysis necessary for routine operation, the estimated time to deployment of this operation would be 4 years after the issuance of the Record of Decision.

The catalytic chemical oxidation process is a dissolution process to separate plutonium from a residue using a catalyst to enhance the oxidation of liquid or solid organic materials, and dissolve metallic components of the residues. Catalytic chemical oxidation utilizes a hydrochloric acid solution at elevated temperatures and pressures that maintain the solution below its boiling point. As the material is oxidized, the catalyst is regenerated using injected oxygen. Once the plutonium species are dissolved and all of the combustible material is destroyed, the solution is neutralized and the dissolved solids, including plutonium, are precipitated as oxides. The resulting solids are separated and treated for storage and shipment, and the liquids treated in the site wastewater treatment facility.

❒ Detailed Process Description

Drums will be manually transferred into a contamination control enclosure and unpacked. This step will contain any contamination which could result from an individual package containment damaged by radiolysis or other physical damage to the package during storage. Any unnecessary packaging materials will be removed to limit the amount of packaging introduced into the feed preparation glovebox.

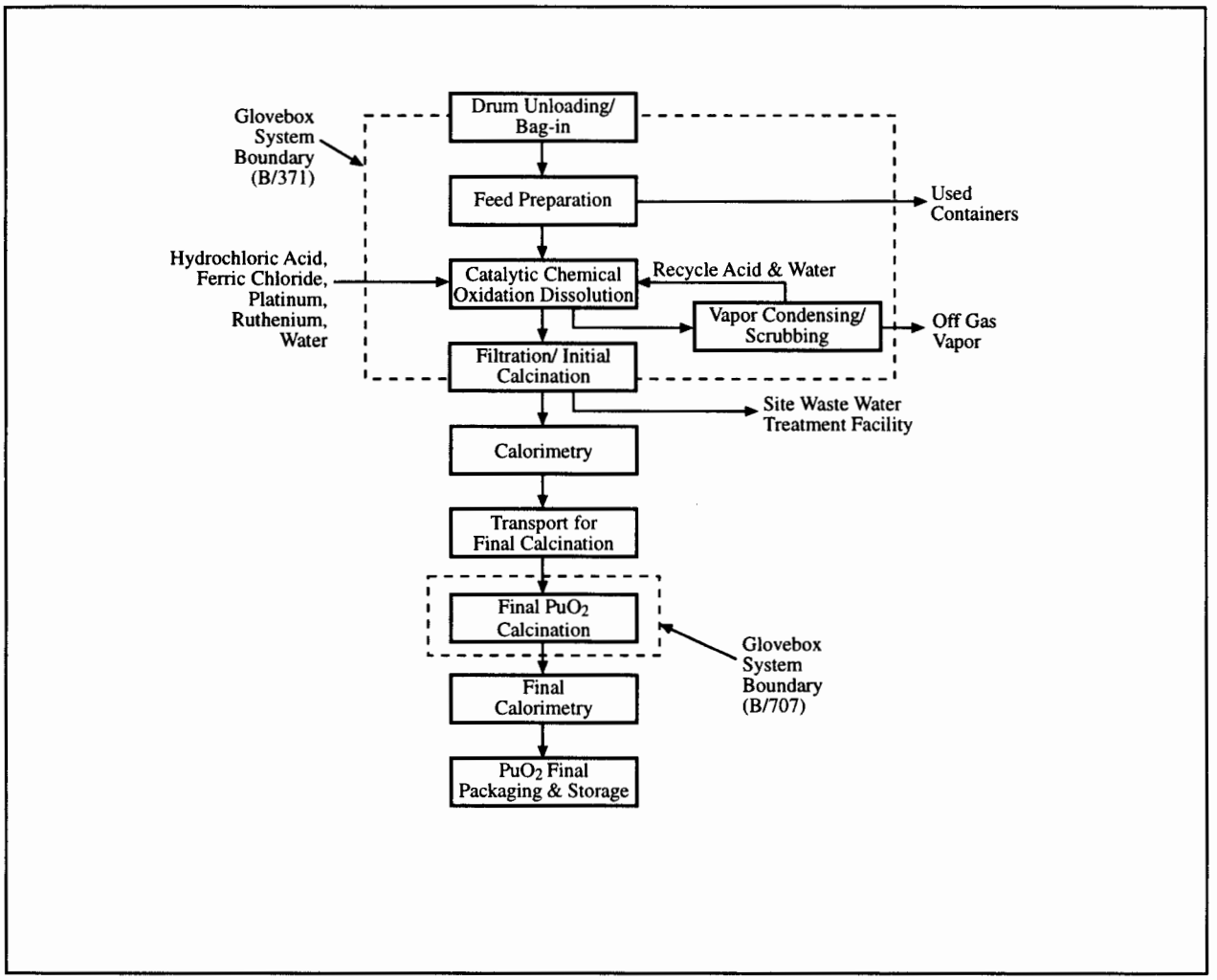


Figure C–17 Catalytic Chemical Oxidation Process for Combustible Residues

After bag-in, the IDCs of the combustible residue containers will be verified. The original residue containers will be transferred to a residue sorting and loading station which will provide local dust control and contain a sorting station to separate all oversized residue and tramp material. As the dissolver will only convert combustible residues, all other material will be sorted out and removed from the glovebox with the tramp material. The combustible residues will be shredded and weighed into dissolver feed containers. Each dissolver feed container will hold a 100-g (3.5-oz) charge of bulk shredded residue, each charge containing an average of 1.87 g (0.066 oz) of plutonium. The dissolver feed containers will be transferred to the dissolver glovebox as required.

The catalytic chemical oxidation dissolution step consists of a 7.6-L (2-gal) catalytic chemical oxidation dissolver, a condenser for off-gas treatment, and piping and tankage to support the equipment. The process will be operated on a batch basis. First, the dissolver tank will be filled with 6M ferric chloride and 1M hydrochloric acid solution. Platinum and ruthenium will also be added from 0.001M solutions of each. The solution will be heated to 175 to 200°C (350 to 390°F) at a pressure of 60 to 110 pounds per square inch gauge (410 to 760 kilopascal gauge) to maintain the solution below boiling. The prepared residue will be fed into the heated solution at one 100-g (3.5-oz) residue charge per hour, and will be agitated to maintain the solution in contact with the solid particles. As each dissolution charge will take 2 hours of active dissolution time, an additional 100-g (3.5-oz) residue charge will be fed to the dissolver every hour until the dissolver contains 100 g (3.5 oz) of plutonium. Each 100-g (3.5-oz) plutonium batch will require approximately 54 100-g (3.5-oz) residue charges. Once the dissolver contains 100 g (3.5 oz) of plutonium,

no further charges will be added to the dissolver. Heat and oxygen will continue to be applied to the unit for an additional hour to vaporize all of the acid and neutralize the solution. As the acid is removed from the solution, the dissolved metals will precipitate as oxides. The solution is cooled and the slurry is pumped from the dissolver to a filter holding tank. All of the carbonaceous materials in the residue feed will be oxidized to carbon dioxide and water.

The slurry will be drained from the filter holding tank into stainless steel filter boats with a sintered metal filter. The liquids will be sucked through the filter, leaving the solid metal precipitate material within the filter boat. The filtrate is collected and sent to the site wastewater treatment facility. These filter solids will include the plutonium, the iron precipitated from the ferric chloride reagent, platinum and ruthenium catalysts, and any other trace metals dissolved and precipitated during the catalytic chemical oxidation reaction. The filter boats will be placed in a calciner and heated to approximately 400°C (750°F) for an hour to convert the plutonium and metal precipitates to plutonium and metal oxides and carbon dioxide. The plutonium oxide will then be consolidated into slip-lid cans, weighed, and bagged out of the glovebox. The package will be loaded into a convenience can, as necessary, before being nondestructively assayed and transported to Building 707 for final calcination.

The plutonium oxide package will be assayed for plutonium content based on its rate of thermal generation using calorimeters and gamma-ray isotopic spectrometer equipment. After assay, the containers will be ready for storage. This activity is required to maintain accountability within the catalytic chemical oxidation material balance area. The cans containing the plutonium oxide will be placed in appropriate outer containers and transferred to the Building 371 loading dock. The containers will then be transported to the Building 707 loading dock by intra-site truck transportation, and moved to appropriate vault storage pending final calcination.

The plutonium oxide cans will be transferred from the Building 707 storage vault to Module J and bagged into the plutonium stabilization and packaging system. The plutonium oxide will be removed from the cans and placed in furnaces, and calcined at 1,000°C (1,800°F) for 4 hours. The material, now suitable for long-term storage or transportation, will be weighed, characterized, and placed in a 3013 inner container. This container will then be removed from the glovebox via the bagless transfer process and sent to calorimetry. The plutonium oxide package will be assayed for plutonium content based on its rate of thermal generation using calorimeters and gamma-ray isotopic spectrometer equipment. After assay, the containers will be placed in vault storage pending DOE decisions on eventual disposition of the plutonium.

The vapors produced during the catalytic chemical oxidation process will be condensed to recover the majority of the acid and water volatilized during the reaction. The condensed acid and water will be returned to a catalytic chemical oxidation feed tank where the amount of acid contained will be determined so the appropriate quantity of recycle and fresh acid can be added to the subsequent catalytic chemical oxidation batch dissolution. The vapor from the condenser is scrubbed to further reduce the quantity of acid and water contained in the discharge vapor.

C.5.7 Thermal Destruction (Fluidized-Bed Incineration) of Combustibles and Filter Media

Fluidized-bed incineration of residues is a two-stage, flameless combustion process for converting residues containing plutonium to a chemically stable, dry ash. Waste volume reductions of 25 to 1 have been demonstrated with this process. The process will remove residual aqueous and organic contaminants in the residue matrix and will convert plutonium fines in the residue to plutonium oxide. The fluidized-bed incineration process is not intended to remove the plutonium from the residue. As a result, this would preclude ultimate shipment to WIPP unless the residue is subjected to further stabilization processing. This process will be conducted in Building 776.

Fluidized bed incineration of combustibles (and by extension other thermal destruction technologies), while demonstrated in previous Rocky Flats operations and at other sites, is undemonstrated under current Clean Air Act permitting standards. Additionally, the location of the facility in Building 776 has significant programmatic risk due to the condition of the facility and its schedule for decommissioning, and other locations for a new incinerator at Rocky Flats have yet to be identified. Due to the significant effort required to develop the analysis necessary for routine operation and the uncertainty of the permitting process for a new or restarted facility, the estimated time to deployment of this operation would be 4 years after the issuance of the Record of Decision. This technology, although technically viable, is not considered by DOE to be a reasonable processing option at Rocky Flats because of the permitting uncertainties and programmatic issues.

The fluidized-bed incineration process for residues is shown in **Figure C–18**. The process steps include drum unloading and bag-in, feed preparation, primary and secondary fluidized-bed incineration, solids collection, repackaging, and bag-out. Nondestructive assay will be performed, followed by final drum packaging and storage.

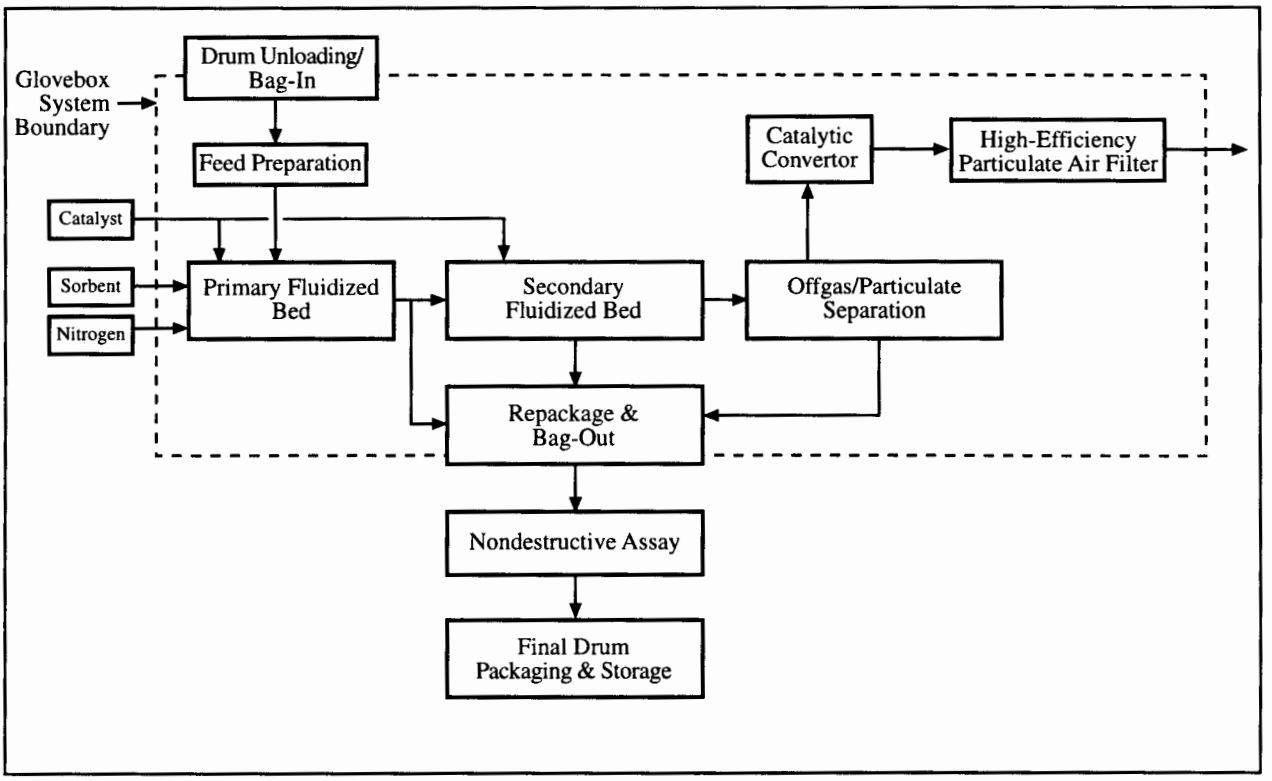


Figure C–18 Thermal Destruction (Fluidized-Bed Incineration Process)

❒ Detailed Process Description

Drums will be transferred from storage into a contamination control enclosure and unpacked. The contamination control enclosure is designed to control airflow in the event of a bag failure within a drum. The drums will be opened and the integrity of the packaging will be checked. If the packaging has not been compromised, the package will be transferred into the glovebox. Any unnecessary packaging materials will be removed to limit the amount of packaging introduced into the glovebox. If the integrity of the primary packaging has been compromised, the package will be overpacked with a new plastic bag before transfer to the glovebox.

Following bag-in, the IDCs will be verified and the plastic bags will be unpacked and the residue sorted. Each bag will be opened to remove any tramp metal or other unwanted materials. This material will be

bagged out of the glovebox and managed appropriately. Solid wastes must enter the fluidized bed as small pieces. Consequently, bulk solids often require shredding to allow the material to be continuously fed into the primary fluidized bed. Fine solids can be fed directly into the bed without size-reduction.

The waste will enter the primary fluidized-bed incinerator by means of a continuous feed screw. In the primary bed, the waste gasifies and pyrolyses at about 550°C (1,000°F) in the presence of heated air, nitrogen, catalyst, and sorbent. Methanol is the fuel used to heat the bed while starting up the system. After start-up, no auxiliary bed heating is required. The heat of the oxidizing waste will maintain the bed temperature. The ratio of air-to-nitrogen fed into the bed controls the rate of waste pyrolysis and heat generation. The catalyst allows pyrolysis to occur at low temperature and helps to stabilize the operating temperature. The sorbent, sodium carbonate, is used to neutralize acidic offgas. Small particles of combustion byproducts, ash and salt, from the pyrolysis reaction, which contain the plutonium from the residue, continuously elutriate out of the bed with the process offgas flow and are removed by a cyclone separator and collected for repackaging.

The offgas from the cyclone separator is fed into the secondary fluidized-bed incinerator which contains catalyst and operates at 650°C (1,200°F). Its function is to oxidize the offgas from the primary fluidized bed in the presence of air and catalyst to form carbon dioxide and water vapor. Particulate and gases departing the secondary fluidized bed enter the air pollution control system where a cyclone separator removes the coarsest particles. These particulates will be collected for repackaging. Sintered metal and HEPA filters will remove smaller particulates. A catalytic converter will convert any remaining hydrocarbons in the offgas stream to carbon dioxide and water vapor.

The processed combustible residue collected in the cyclone separators will be cooled to room temperature. The residue will then be batched and placed into 8.2-L (2.2-gal) containers. The cans will be sealed, taped, and bagged-out of the glovebox, and placed into 30.5-cm (12-in) convenience cans. Each can will contain approximately 83.5 g (2.9 oz) of plutonium.

Nondestructive assay will be performed and the assayed and repackaged residue containers will be transported for final drum packaging. Two containers will be loaded into a pipe component staged inside a 55-gallon drum. The sealed drums will be placed into interim site storage awaiting shipment to WIPP.

C.6 Detailed Process Descriptions for Processing Technologies With Plutonium Separation

C.6.1 Purex Process with Plutonium Metal or Oxide Recovery

Purex stabilization processing of residues has been proposed at the Savannah River Site. This technology option requires residue preprocessing at Rocky Flats.

The Purex processing of sand, slag, and crucible, and plutonium fluoride residues, and scrub alloy at the Savannah River Site is considered to be a proven technology, as is any preprocessing, packaging, and transportation which must occur to allow shipping of the materials. The capability for preprocessing and packaging at Rocky Flats is being installed to support the disposition of below-safeguards termination limit materials, and should be available several months after the issuance of the draft of the EIS.

After Rocky Flats preprocessing, the packaged residues will be shipped to the Savannah River Site and processed. Sufficient numbers of 6M shipping containers are available to ship the currently-stored scrub alloy; however, the Type-B shipping containers required for shipping of powdered materials have yet to be certified and procured. This process is on-going and is anticipated to provide approved containers within several months after issuance of the draft EIS. Safe and Secure Trailers are available as required. The Purex process is considered to be a proven technology and an on-going operation, and the processing "canyon" will be

available for scheduled windows of processing consistent with its other on-going missions. The technical and programmatic risks associated with residue shipping and processing at the Purex facility are considered minimal, with the exception of SS&C and Fluoride "Heels," where these previously-extracted materials may not be compatible with canyon operations because of their difficult dissolution characteristics.

❒ Preprocessing at Rocky Flats

Preprocessing options include various technologies depending on the residue type: ash fusion for incinerator ash residues; packaging of ash; grinding and packaging of sand, slag, and crucible; and repackaging of plutonium fluoride residues and scrub alloy. The preprocessing activities are drum unloading/bag-in; feed preparation/bag-out; calcination and fusion with sodium peroxide (for incinerator ash); repackaging (for plutonium fluorides); nondestructive assay of cans for accountability purposes; loading cans into shipping containers; and moving them to interim storage with shipment to the Savannah River Site. Calcination of the incinerator ash will be required to convert reactive metals to unreactive oxides before mixing with sodium peroxide. For plutonium fluorides and scrub alloy, special precautions will need to be taken to minimize operator exposure due to high radiation fields. All glovebox operations for ash residues will be performed in Building 707, while all glovebox operations for plutonium fluoride residues and scrub alloy will be performed in Building 371. The packaging process for shipment to Savannah River Site is shown in **Figure C–19**.

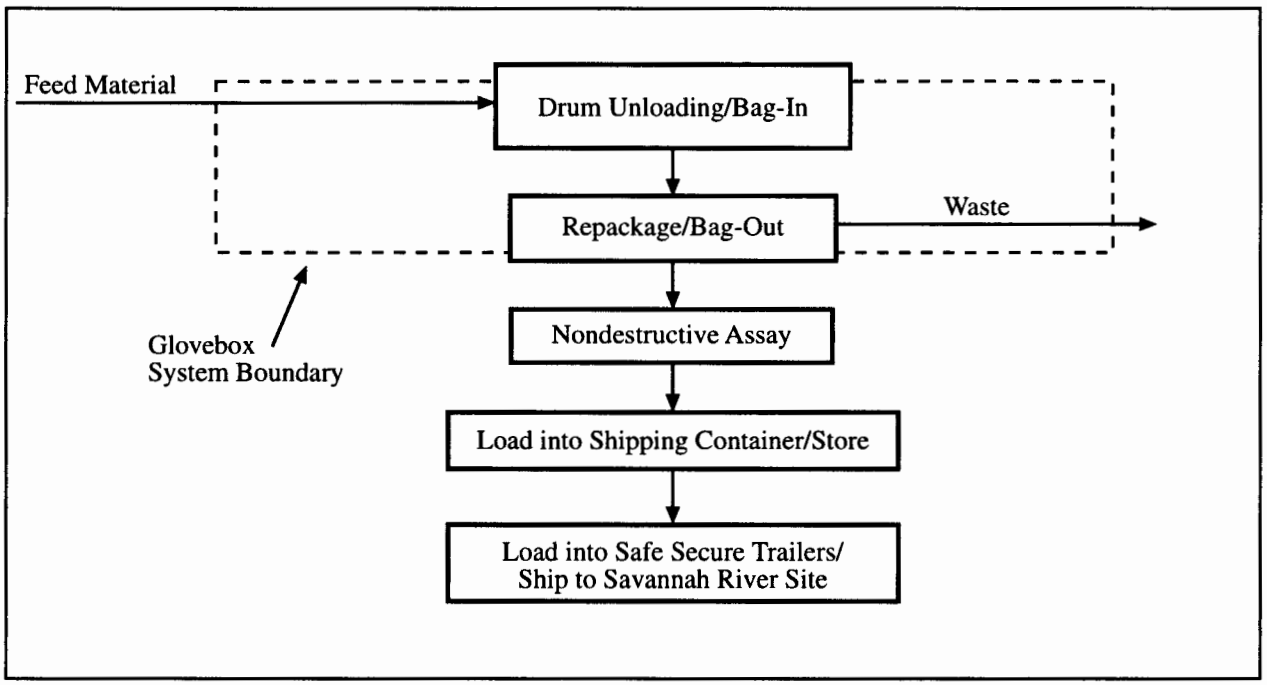


Figure C–19 Packaging Process at Rocky Flats for Shipment to Savannah River Site

◆ Detailed Process Description

For the ash residues, drums will be manually transferred from storage into a contamination control enclosure. The contamination control enclosure is designed to control airflow in the event of a bag failure within a drum. The drum will be opened and the integrity of the packaging will be checked. If the packaging has not been compromised, the containers will be transferred to the glovebox. Any unnecessary packaging materials will be removed to limit the amount of packaging introduced into the feed preparation glovebox. If the integrity of the packaging has been compromised, the packaging will be overpacked with a new plastic bag before transfer to the glovebox.

- *Ash Fusion Preprocessing for Incinerator Ash Residues*—Incinerator ash will be introduced into the glovebox and the IDC verified. The individual packages will be opened and if necessary sieved to remove any tramp metal and other unwanted materials. Following the sieving, the incinerator ash will be crushed, as necessary, to produce a particle size which will facilitate calcination and subsequent fusion. The treated incinerator ash will again be sieved, if necessary, with a finer mesh screen and any large chunks returned to the crusher for reprocessing. The material will then be batched for calcining at nominally 2 kg (4.4 lb) bulk per batch. Combustible packaging materials from the individual packages will be bagged out of the glovebox and sent to a combustible handling process. Other materials will be bagged out and treated appropriately. Each batch will be calcined at 900°C (1,650°F), which will oxidize carbon and organic to carbon dioxide and eliminate water, and increase the bulk density of the residues. Crushing may be required after calcination. After crushing, the batches are available for fusion. The calcined batch, at approximately 1.5 kg (3.3 lb) bulk weight, will be mixed with about 400 g (14 oz) of crushed sodium peroxide reagent materials and placed in a 2-L (0.53-gal) mild steel can. The mixture will be heated in a furnace to 450°C (840°F) for 2 hours and allowed to cool (4-hour cycle time). The dissolvable cans will be sealed and bagged out of the glovebox using dissolvable nylon bags. They will then be placed in larger "tall cans," also of mild steel.

- *Packaging Preprocessing for Sand, Slag, and Crucible Ash Residues*—After bag-in, the IDCs of the residue containers will be verified. As the containers are emptied, they will be transferred to a sorting and loading station. At the loading station, the residue will be removed from the containers and loaded into the crusher. The empty residue containers will be removed from the glovebox as solid waste. From the loading station, the residue will be processed through a crusher for size-reduction. The crushed material will then be screened through a mesh screen, packaged into a dissolvable mild steel can, crimp sealed, and weighed. Each can will contain approximately 2 kg (4.4 lb) bulk material based on estimated weight and volume limitations. If necessary, the contents will be sampled for plutonium assay. The cans will then be bagged out of the glovebox using special dissolvable nylon bags and sent to nondestructive assay. Coarse materials from screening will be re-crushed. The crusher and screening stations will provide local dust control.

- *Preprocessing for Plutonium Fluoride Residues*—Plutonium fluorides are currently stored in containers within an in-line vault in Building 371 and in Building 777. Because of the alpha-neutron reaction between plutonium alpha particles and fluorine nuclei, the unshielded radiation exposure of operators routinely handling this material may approach administrative limits. The principal radiation is neutrons, thus hydrogenous shielding (water walls) is necessary for operator protection. Cans of fluoride will be transferred from the storage area (an in-line vault) to a glovebox in Building 371 containing suitable neutron shielding (such as 5.1- to 10.2-cm [2- to 4-in] water walls). The materials will be transferred into a dissolvable mild steel tared container, crimp sealed, and weighed. The high assay fluorides may be sampled for plutonium analysis. The dissolvable container will be bagged out of the glovebox line. Special bags (nylon) that are readily dissolvable in the Savannah River Site dissolver will be used. The empty containers will be bagged out of the glovebox line, assayed with nondestructive assay, and disposed of as waste.

- *Preprocessing for Scrub Alloy* —Scrub alloy contains a high americium content, therefore, special precautions must be taken to minimize personnel radiation exposure. The alloy currently in stainless-steel containers needs to be repackaged. They will be removed from storage vaults (located in several buildings other than Building 371), transferred to Building 371, and bagged into a glovebox line. Outer packaging materials will be bagged out and managed appropriately. Once in the glovebox line, the scrub alloy will be removed from the stainless steel can and placed into a dissolvable mild-steel 1-L (0.26-gal) can that will be crimp-sealed, weighed, and bagged out of the line using dissolvable nylon bags. Two 1-L (0.26-gal) cans will be placed into a tall mild steel can. The original stainless steel cans and other packaging will be removed from the glovebox and disposed of as waste. The scrub alloy already

packaged in dissolvable containers will be statistically sampled and inspected to verify integrity of the package. Some of the alloy is already stored in Type 6M containers ready to be shipped, and some is currently in dissolvable containers stored in building vaults ready to load into shipping containers. For materials already packaged, the dissolvable container is aluminum. Inspection will require opening the outer container or the shipping container and inspecting the condition of the inner container. If deterioration of the inner container is found, then the entire package will be bagged into the glovebox line and repackaged. Repackaging will use mild steel as the dissolvable container. Dissolvable containers in shipping containers which are not inspected will be transferred directly to interim storage or to Safe Secure Transport or other DOE-approved transport, as appropriate loading. Containers that need to be loaded into shipping containers but do not require nondestructive assay will be transferred directly to shipping container loading. Packages ready for shipment will not be re-assayed using nondestructive assay.

After preprocessing of each residue and scrub alloy, nondestructive assay will be performed to confirm the amount of plutonium being shipped to Savannah River Site. After nondestructive assay, the packages will be loaded into Type 9975 (Type 6M for scrub alloy) shipping containers, and transferred to the shipping facility. There will be two cans (one can for scrub alloy) placed into each shipping container. The shipping containers will be cleaned and surveyed for contamination before transfer to interim storage within the process building or to the Building 707 shipping facility. The loaded Type 9975 (Type 6M for scrub alloy) shipping containers will be picked up at the process building and transferred to the shipping facility, where they will be loaded into a Safe Secure Trailer or other DOE-approved transport, as appropriate and transported to the Savannah River Site. The distance from Rocky Flats to Savannah River is approximately 2,620 km (1,625 mi).

❒ Purex Processing at the Savannah River Site

The Purex process at Savannah River Site following the preprocessing at Rocky Flats is shown in **Figure C–20**. The preprocessed residues or scrub alloy will be dissolved in a Savannah River Site Canyon facility with plutonium being separated from the residue using solvent extraction technology. The plutonium will be converted to metal or oxide, packaged (inner container for DOE-STD-3013-96 [DOE 1996c]), transferred to either the PB-L or 235-F vault until the Savannah River Actinide Packaging and Storage Facility vault is complete, where packaging will be completed (outer container to meet DOE-STD-3013-96 [DOE 1996c]), and stored until decisions are made on fissile material disposition. This process is currently in operation and no changes to the process are required to process residues and scrub alloy.

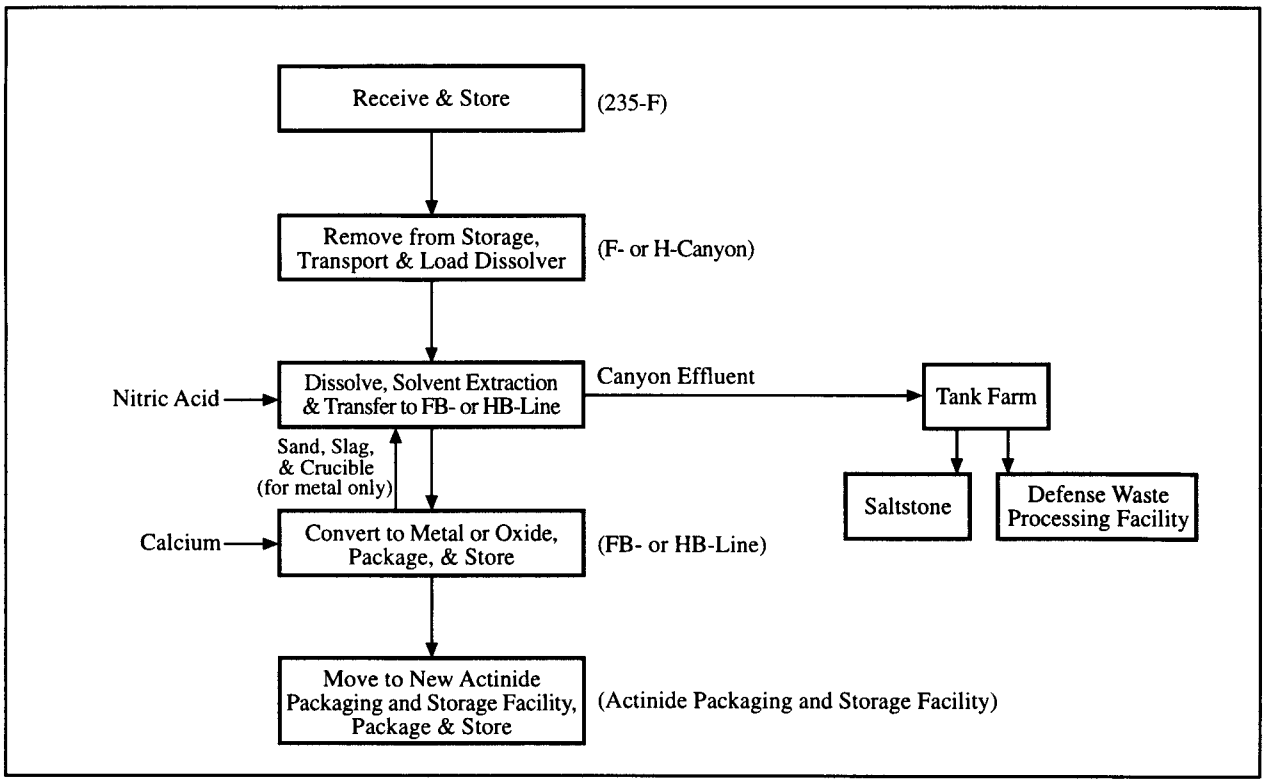


Figure C–20 Purex Process

◆ Detailed Process Description

The shipping containers received from Rocky Flats will be unloaded, confirmatory measurements will be made, and the containers will be placed in a vault-like room in the 235-F facility. Shipping containers will be removed from storage and transported to the F- or H-Canyon crane maintenance area where the shipping containers will be opened and the cans loaded into a dissolver tube. The dissolver tube will then be loaded into a dissolver by remote control. Heated nitric acid in the tank dissolves the residue or scrub alloy, resulting in a solution containing many constituents (dependent on material type). The solution will be purified by removing the impurities in an aqueous stream. The waste liquid will be transferred from the Savannah River F- or H-Canyon to the Savannah River high-level waste system. The plutonium product solution will be transferred to canyon hold tanks for later transfer to the finishing line.

The FB-Line process includes concentration of plutonium by cation exchange, precipitation of plutonium as a trifluoride, recovery of the trifluoride by filtration, drying of trifluoride in an oxygen atmosphere, and reduction with calcium metal to form plutonium metal buttons. The sand, slag, and crucible generated from button reduction will be dissolved in F-Canyon. The HB-Line process includes concentration of plutonium through anion exchange, precipitation of plutonium as plutonium oxalate, recovery of the oxalate by filtration, drying and calcining the oxalate, converting it to plutonium oxide. The metal buttons and oxide will be packaged in 3013-96 bagless inner cans that will be placed in an F area vault for temporary storage. The cans will then be removed from the F area vault, placed into shipping containers, and transported to either the PB-L or 235-F vault until the Actinide Packaging and Storage Facility is complete. At the vault the cans will be removed from the shipping containers, packaged into an outer 3013 container, and placed into the vault for long-term storage pending disposition in accordance with decisions reached under the Surplus Plutonium Disposition Environmental Impact Statement.

C.6.2 Mediated Electrochemical Oxidation

The mediated electrochemical oxidation process is a relatively new dissolution process which has been incorporated into a standard aqueous separation process for the stabilization of plutonium-containing residues. The mediated electrochemical oxidation/aqueous process will be used to remove the majority of the plutonium from the residue matrix material, creating a concentrated plutonium oxide stream and leaving the residual material suitable for disposal at WIPP. It is a dissolution process to separate plutonium from a residue using a highly oxidizing metal cation generated in an acid solution using an electrochemical cell. These metal cations migrate from the anode to the residue surface, and oxidize any reactive substance present on exposed surfaces. The mediated electrochemical oxidation process will be used to dissolve less reactive plutonium materials from residues, along with some of the residue matrix. Depending on the substrate material, the mediated electrochemical oxidation process will oxidize some materials into carbon dioxide and water. Once dissolved, the plutonium species must be removed from the other dissolved solids by precipitation as a plutonium oxalate solid. All separated and residual solids must be treated for storage and shipment, and the liquids solidified as transuranic or low-level waste.

Mediated electrochemical oxidation has been proposed at Rocky Flats (for combustible, filter media, glass, graphite, and inorganic residues) and at Savannah River with preprocessing at Rocky Flats (for incinerator ash and graphite and firebrick fines, and graphite and inorganic residues). Though similar, enough details differ to warrant two discussions.

C.6.2.1 Mediated Electrochemical Oxidation at Rocky Flats

The mediated electrochemical oxidation process will principally be conducted inside gloveboxes located in Room 3701 of Building 371. The mediated electrochemical oxidation process for residues is shown in **Figure C–21**.

The mediated electrochemical oxidation process at Rocky Flats, consisting of dissolving the plutonium and oxidizing "combustible" constituents contained in various residues, filtering the solution, and precipitating and calcining a plutonium oxalate, is considered to be a well-demonstrated technology with radioactive materials, although not yet used in production operations in DOE facilities. The process would be required to be installed in areas of Building 371 adjacent to the neutralize-dry process to take advantage of the liquid treatment facilities. The requirements for using this area for other residue activities (e.g., neutralize dry, cementation) would impact the installation, testing, and operational schedule of new process equipment. Therefore, operations of the mediated electrochemical oxidation process may not be able to start until a minimum of 4 years after issuance of the Record of Decision.

❒ Detailed Process Description

Drums will be manually transferred into a contamination control enclosure and unpacked. This will contain any contamination which could result from an individual package containment damaged by radiolysis or other physical damage to the package during storage. Any unnecessary packaging materials will be removed to limit the amount of packaging introduced into the feed preparation glovebox.

After bag-in, the IDCs of the residue containers will be verified and the original residue containers will be transferred to a residue sorting and loading station which will provide local dust control and a sorting station to separate all oversized residue and tramp material. The residues will either be shredded and batched (combustibles) or just batched (filter media, glass, and inorganic residues) into a dissolver feed container.

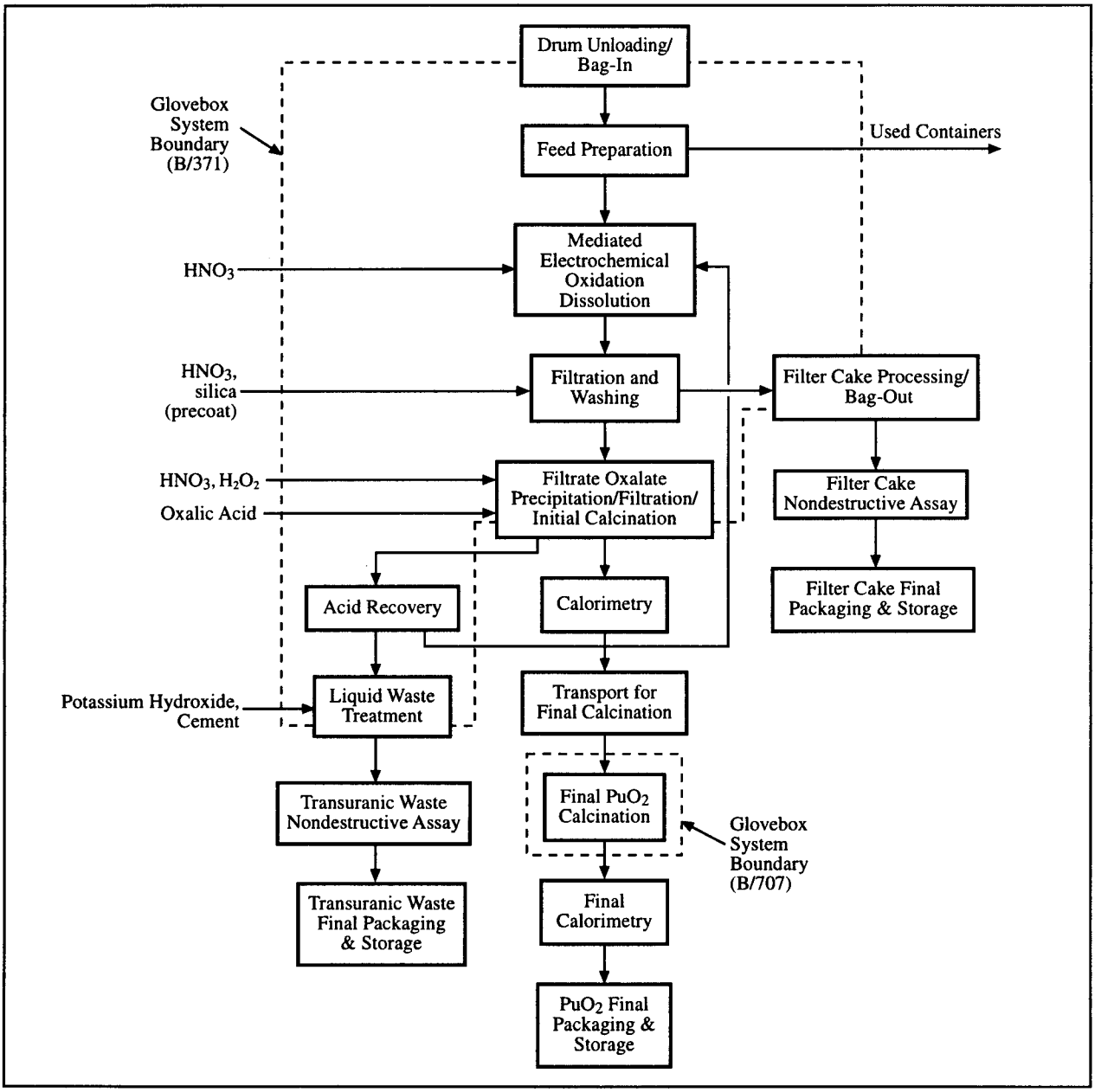


Figure C–21 Mediated Electrochemical Oxidation Process at Rocky Flats

Graphite residues will be crushed and sieved over a 0.32-cm (1/8-in) sieve, with oversized pieces returned to the crusher, and the material passing the sieve will be batched into a dissolver feed container. Each dissolver feed container may be batched to hold either 5 kg (11 lb) of bulk residue or 200 g (7 oz) or less of plutonium. A verification step will take place to ensure that each transfer container will contain less than 200 g (7 oz) of plutonium using a gram estimator. The dissolver feed container will be transferred to the dissolver glovebox as required.

The mediated electrochemical oxidation dissolution step consists of a 40-L (10.6-gal) mediated electrochemical oxidation dissolver, an electrolysis cell where divalent silver ions will be generated, a catholyte regeneration system, a condenser for off-gas treatment, and piping and tankage to support the equipment. The process will be operated on a batch basis.

First, the dissolver tank/anolyte compartment will be filled with concentrated nitric acid and monovalent silver ions. The electrolysis cell will be started and solution will be recirculated between the cell and the tank. The pre-batched residue will be fed into the solution, which will be agitated to maintain the solution in contact with the solid particles. The solution temperature will be maintained at between 80 and 90°C (176 and 194°F). Each dissolution batch will take two hours of active dissolution time, with another 2 hours of tank draining/filtering time and recharging and feed time. Most carbonaceous materials in the residue feed will be oxidized to carbon dioxide and water.

A filtration and washing step filters the dissolver slurry through two vacuum drum filters with 30.5-cm (12-in) diameter drums covered with a precoat of porous silica material. The precoat will be sucked onto the rotating, fabric-covered drum in an initial step to create a filter cake, and then the dissolver slurry will be fed into the pan in which the drum will be rotating. As vacuum is applied, some of the liquid from the slurry will be sucked through the precoat while the slurry solids adhere to the precoat surface. The solids remaining on the cylindrical precoat surface cause the liquid flow through the precoat to diminish and nearly stop in a given area. The rotation of the drum brings these blinded areas out of the pan, where they will be spray-washed with nitric acid to displace some of the entrained solution. Before the blinded/washed area rotates back into contact with the slurry in the pan, the outer layer of solids and precoat will be cut off to expose fresh precoat surface for filtration. The mixture of the residual solids and precoat cut from the filter, and liquids which will be entrained with it, will be collected in pans as the waste from the dissolution process. Liquids collected in a vacuum receiving tank will be transferred as feed for the oxalate precipitation process.

The pans of filter cake solids (residual solids and precoat) will be placed in an oven and heated to 150°C (300°F) for approximately 1 hour, and then placed in a 20-L (5.3-gal) can. When a can is filled, it will be taped and bagged out of the glovebox. After the solids will be dried, packaged, and removed from the glovebox line, nondestructive assay will be performed on the cans. Containers of assayed solids that meet the WIPP/Waste Acceptance Criteria fissile material limits will be transported as necessary for final drum packaging. Approximately two containers will be loaded into a pipe component staged inside a 55-gallon drum. The sealed drums will be placed into interim site storage awaiting shipment to WIPP.

The plutonium-rich solution recovered from filtration will be transferred to the precipitation feed tanks, where it will be prepared for precipitation. The batched material will be placed in glass agitated precipitator columns, and oxalic acid will be added. After a digestion period to allow for the formation and growth of plutonium oxalate crystals, the slurry will be drained into stainless steel filter boats with a sintered metal filter. The liquids will be sucked through the filter, leaving the solid plutonium oxalate material within the filter boat. This filter boat will be placed in a calciner and heated to approximately 400°C (750°F) for an hour to decompose the plutonium oxalate to plutonium oxide and carbon dioxide. The plutonium oxide will then be consolidated into slip-lid cans, weighed, and bagged out of the glovebox. The package will be loaded into a convenience can as necessary prior to being nondestructively assayed and transported to Building 707 for final calcination.

The plutonium oxide package will be assayed for plutonium content based on its rate of thermal generation using calorimeters and gamma-ray isotopic spectrometer equipment. After assay, the containers will be ready for storage. This activity is required to maintain accountability within the mediated electrochemical oxidation material balance area. The cans containing the plutonium oxide will be placed in appropriate outer containers and transferred to the Building 371 loading dock. The containers will then be transported to the Building 707 loading dock by intra-site truck transportation, and moved to appropriate vault storage pending final calcination.

The plutonium oxide cans will be transferred from the Building 707 storage vault to Module J and bagged into the plutonium stabilization and packaging system. The plutonium oxide will be removed from the cans, placed in furnaces, and calcined at 1,000°C (1,800°F) for 4 hours. The material, now suitable for long-term storage or transportation, will be weighed, characterized, and placed in a 3013 inner container. This container will then be removed from the glovebox via the bagless transfer process and sent to calorimetry. The plutonium oxide package will be assayed for plutonium content based on its rate of thermal generation using calorimeters and gamma-ray isotopic spectrometer equipment. After assay, the containers will be placed in vault storage pending disposition in accordance with decisions reached under the Surplus Plutonium Environmental Impact Statement.

The spent solution will be transferred to a batch evaporator where approximately 82 percent of the water and acid in the solution will be evaporated and condensed to be recycled through the dissolution and filtration wash steps as recycled acid. The unevaporated acid solution, containing the remaining dissolved solids, will be transferred to liquid waste treatment. The use of this acid recovery step reduces the amount of low-level waste generated by about 80 percent. The waste acid stream from the recycle evaporator will be combined with potassium hydroxide in a cooled neutralization tank to produce a solution pH between 6.0 and 9.0. The neutralized solution and cement will be mixed together in a 55-gallon drum at a water to cement ratio of 0.2 to 0.4, and a waste loading of 15 percent to 25 percent. After the solidified transuranic waste solids are cured and removed from the glovebox line, nondestructive assay will be performed on the drums. Containers of assayed solids that meet the WIPP/Waste Acceptance Criteria fissile material limits will be transported as necessary for final drum packaging and the sealed drums will be placed into interim site storage awaiting shipment to WIPP.

C.6.2.2 Mediated Electrochemical Oxidation at Savannah River Site with Preprocessing at Rocky Flats

The stabilization of residues with the mediated electrochemical oxidation process at the Savannah River Site requires preprocessing at Rocky Flats, which includes crushing the residues as necessary, calcining (for incinerator ash and graphite and fire brick fines), and repackaging the residue materials in preparation for shipment. The cans will be bagged out of the glovebox using dissolvable nylon bags and nondestructively assayed for accountability purposes, packaged in the final transport/storage container, and stored in interim storage or sent directly to a Safe Secure Trailer or other DOE-approved transport, as appropriate for shipment to the Savannah River Site.

The calcining and packaging process for incinerator ash and graphite and firebrick fines will be conducted inside a glovebox located in Module E of Building 707, while Mediated Electrochemical Oxidation glovebox operations will be performed in Building 371. Calcination of the incinerator ash and graphite and firebrick fines will be required in order to high-fire the material to prevent offgassing during shipment. The packaging process for shipment to Savannah River Site is shown in **Figure C–22**. The mediated electrochemical oxidation process at Savannah River is considered to be a proven technology. The process would be required to be installed in the New Special Recovery facility. Operations of the mediated electrochemical oxidation process may not be able to start until 2 years after issuance of the Record of Decision.

❒ **Preprocessing at Rocky Flats**

◆ Detailed Process Description

Drums will be manually transferred into a contamination control enclosure and unpacked. This will contain any contamination which could result from any individual package containment failure or damage by radiolysis or physical damage to the package during storage. The drum will be opened and the integrity of the packaging will be checked.

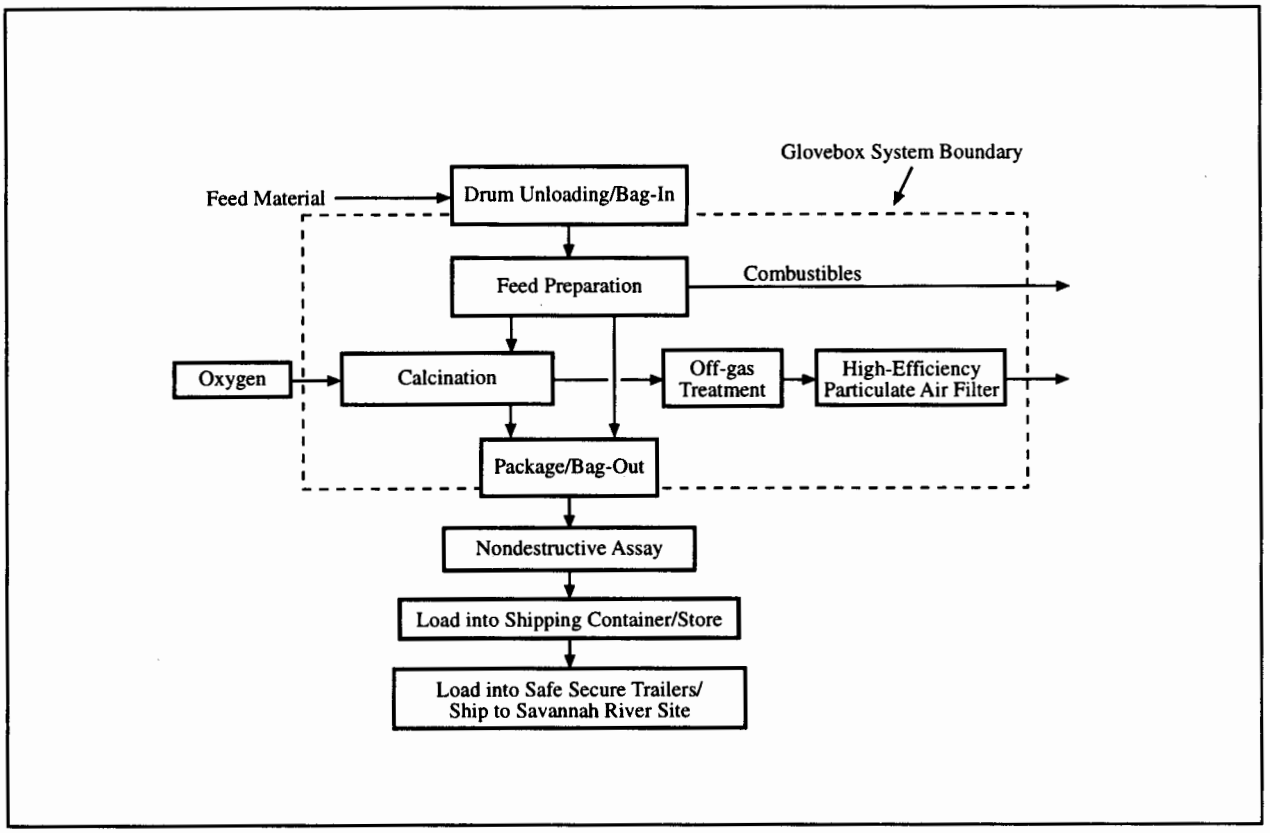


Figure C–22 Packaging Process at Rocky Flats for Shipment to Savannah River Site

If the packaging has not been compromised, the containers will be transferred to the glovebox. Any unnecessary packaging materials will be removed to limit the amount of packaging introduced into the residue preparation glovebox. If the integrity of the packaging has been compromised, the packaging will be overpacked with a new plastic bag prior to transfer to the glovebox. All individual containers will be bagged into the preparation glovebox.

The residue material will be introduced into the glovebox, the IDC verified, and each package will be opened and sorted/sieved to remove any tramp metal and other unwanted materials. Following the sorting/sieving, the residue materials will be crushed, if necessary. For organic and graphite residues, this will provide small enough material to fit inside a 1-L (0.26-gal) dissolvable can.

The materials will then be batched into the dissolvable cans so that the cans will contain an average bulk amount of 2 kg (4.4 lb). For the materials requiring calcining, the residues will again be sieved, if necessary, with a finer mesh screen and any large chunks returned to the crusher for reprocessing. The materials will then be batched for calcining so that, after calcination, the shipping cans will contain an average bulk amount of 2 kg (4.4 lb). The repackaging of all residues is bulk weight dependent, not plutonium weight dependent.

The cans will be bagged out of the glovebox using dissolvable nylon bags. Combustible packaging materials from the individual containers will be bagged out of the glovebox and sent to a combustible handling process. Other unwanted materials will be bagged out of the glovebox and managed appropriately.

For the incinerator ash and graphite and firebrick fines, each batch will be calcined at 900°C (1,650°F), which will oxidize carbon and organic to carbon dioxide and eliminate water, and increase the bulk density

of the residues. Crushing may be required after calcination. After crushing, the batches are available for final packaging.

Nondestructive assay will be performed using a segmented gamma scanner to confirm the amount of plutonium being shipped to the Savannah River Site. After nondestructive assay, the packages will be loaded into Type 9975 shipping containers and transferred to the shipping facility. There will be two cans placed into each shipping container. The shipping containers will be cleaned and surveyed for contamination before transfer to interim storage within the Building 371 or to the shipping facility. The loaded Type 9975 containers will be picked up at the process building and transferred to the shipping facility, where they will be loaded into a Safe Secure Trailer or other DOE-approved transport, as appropriate and transported to the Savannah River Site. The distance from Rocky Flats to the Savannah River is approximately 2,620 km (1,625 mi).

❒ Mediated Electrochemical Oxidation at the Savannah River Site

The mediated electrochemical oxidation process at the Savannah River Site following preprocessing at Rocky Flats is shown in **Figure C–23**. The plutonium within the preprocessed residues will be leached and/or dissolved in the New Special Recovery or HB-Line facility using two newly installed dissolvers that use the silver II ion to dissolve the normally intractable plutonium in the residue. Once the plutonium is in solution, the residue will be separated/filtered out and discarded as transuranic waste.

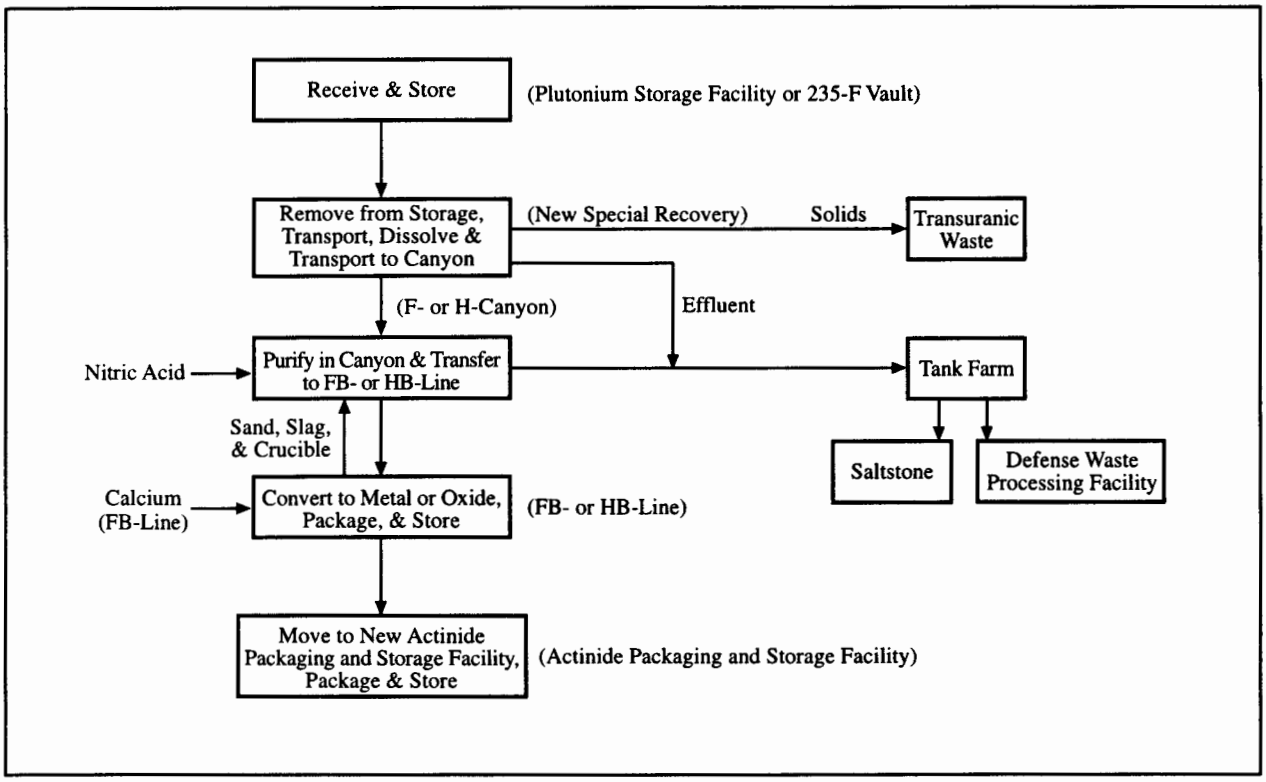


Figure C–23 Mediated Electrochemical Oxidation Process at Savannah River

The plutonium will be converted to metal or oxide and packaged (inner container for DOE-STD-3013-96 [DOE 1996c]) in the FB- or HB-Line. It will be transferred to the Savannah River Actinide Packaging and Storage Facility or another Savannah River vault where packaging will be completed (outer container to meet DOE-STD-3013-96 [DOE 1996c]) and it will be stored until decisions are made on fissile material disposition. The Plutonium Storage Facility and New Special Recovery facility are not currently in operation and would require two silver dissolvers to be installed and the facilities started up; the HB-Line

is operating and would require modification to existing, or installation of new silver dissolvers. All other facilities are currently in operation and no changes to the process are required.

- Detailed Process Description

The shipping containers received from Rocky Flats will be unloaded, confirmatory measurements made, and the containers placed in the Plutonium Storage Facility or other Savannah River Site vault (such as 235-F). One batch of shipping containers will be removed from storage and moved via a conveyor to New Special Recovery or transferred to the HB-Line where each shipping container will be opened up and the two cans removed. The cans will be opened and the contents processed through a leach/dissolve (or wash/filter/dissolve) and filter cycle in a silver dissolver. Any nondissolved material will be discarded as transuranic waste. The silver will be continually reused and the filtered plutonium solution will be transferred to F- or H-Canyon.

Waste liquid containing impurities and residual plutonium will be transferred from the Savannah River Site canyon to the Savannah River Site high-level waste system. The residual plutonium will be vitrified as borosilicate glass in the Savannah River Site Defense Waste Processing Facility. Savannah River Site high-level waste glass is scheduled for disposal in a deep geological repository beginning in 2015. Decontaminated aqueous solutions containing the residue and associated spent processing reagents (the bulk of the secondary waste) will be transferred to the Savannah River Site Z-Area Saltstone Treatment and Disposal Facility. The resultant nonhazardous stabilized waste form will be disposed of in engineered vaults at the Savannah River Site low-level radioactive industrial landfill.

Within the canyon facilities, nitric acid is added to the primary plutonium solution to dissolve the remaining solids (for incinerator ash and fines) and purified (for all proposed residues) by removing the impurities in an aqueous stream. The plutonium product solution is transferred to F- or H-Canyon hold tanks for later transfer to FB- or HB-Line.

The FB-Line process includes concentration of plutonium by cation exchange, precipitation of plutonium as a trifluoride, recovery of the trifluoride by filtration, drying of trifluoride in an oxygen atmosphere, and reduction with calcium metal to form plutonium metal buttons. The sand, slag, and crucible generated from button reduction will be dissolved in F-Canyon. The HB-Line process includes concentration of plutonium through anion exchange, precipitation of plutonium as plutonium oxalate, recovery of the oxalate by filtration, drying and calcining the oxalate, converting it to plutonium oxide. The metal buttons and oxide will be packaged in 3013-96 bagless inner cans which will be placed in an F area vault for temporary storage. The cans will then be removed from the F area vault, placed into shipping containers, and transported to the Actinide Packaging and Storage Facility. At the Actinide Packaging and Storage Facility, the cans will be removed from the shipping containers, packaged into an outer 3013 container, and placed into the vault for long-term storage pending disposition in accordance with decisions reached under the *Surplus Plutonium Disposition Environmental Impact Statement.*

C.6.3 Salt Distillation

Salt distillation technology requires pyro-oxidation of the sodium/potassium chloride pyrochemical salts to convert reactive metals to oxides prior to salt distillation. This technology can be used on electrorefining salts and molten salt extraction salts. Salt distillation has been proposed at Rocky Flats and at Los Alamos National Laboratory with preprocessing at Rocky Flats. Though similar, enough details differ to warrant two discussions.

Salt distillation, consisting of the separation of the higher-vapor pressure alkali halide salts from the transuranic oxides, is considered to be a technology which has been well demonstrated on a pilot scale with actual residue

materials, although optimization studies are ongoing and final designs of the production equipment will be required. Operations of the salt distillation process may not be able to start until 2 years after the issuance of the Record of Decision. The capability for salt distillation at Los Alamos National Laboratory is already installed and operational at Los Alamos National Laboratory on a pilot scale. Additional capabilities could be installed if necessary, however this capability would not be available for between 2-4 years after issuance of the Record of Decision.

An additional uncertainty involved in the salt distillation process is the disposition of the resultant transuranic oxide materials resulting from the processing of the molten salt extraction salts. These materials contain elevated concentrations of americium by comparison to other plutonium oxide materials, resulting in elevated gamma radiation levels which must be addressed in handling. Estimates of radiation levels from these oxides packaged in normal containers which meet DOE-STD-3013-96 indicate that the materials may not be suitable for storage at the new vault being constructed at the Savannah River Site, although special shielding approaches are being evaluated. In the event that shielding is an unacceptable alternative, these materials may have to be processed in another manner or stored separately prior to final disposition.

C.6.3.1 Salt Distillation at Rocky Flats

The vacuum distillation process then reduces the plutonium concentration below the safeguards termination limit for pyrochemical salts. The resulting products are a lean transuranic salt waste to be shipped to WIPP and plutonium oxide to be stored at Rocky Flats. Vacuum distillation has not been shown to be effective on calcium chloride (direct oxide reduction) salts. The entire distillation process will be conducted inside gloveboxes located in Module A and Module B of Building 707 or in Building 371.

The salt distillation process for pyrochemical salts is shown in **Figure C–24**. Electrorefining and molten salt extraction salts will be sorted and batched in preparation for pyro-oxidation. After pyro-oxidation, the salts will be vacuum distilled to separate the plutonium oxide from the salts. The packaged salts will be removed from the glovebox and nondestructively assayed for accountability purposes. The salts will be packaged in the final transport/storage container, and moved into interim storage, pending disposal at WIPP. The plutonium oxide will be transferred to the bagless transfer system for final calcination, removed from the glovebox line, nondestructively assayed for accountability purposes, and then transferred to plutonium storage.

❒ Detailed Process Description

Drums will be manually transferred into a contamination control enclosure and unpacked. This step is to contain any contamination which could result from an individual package containment damaged by radiolysis, or physical damage to the package during storage. Any unnecessary packaging materials will be removed to limit the amount of packaging introduced into the feed preparation glovebox. All of these individual containers will be bagged into the feed preparation glovebox.

The feed materials will be introduced into the glovebox, one stream at a time, and the IDC verified. The individual packages will be opened and loaded into a crucible in preparation for pyro-oxidation. Sodium carbonate or another oxidant will also be added to the crucible at this time. Combustible packaging materials from the individual packages will be bagged out of the glovebox and managed as transuranic waste. Other materials will be bagged out and managed appropriately.

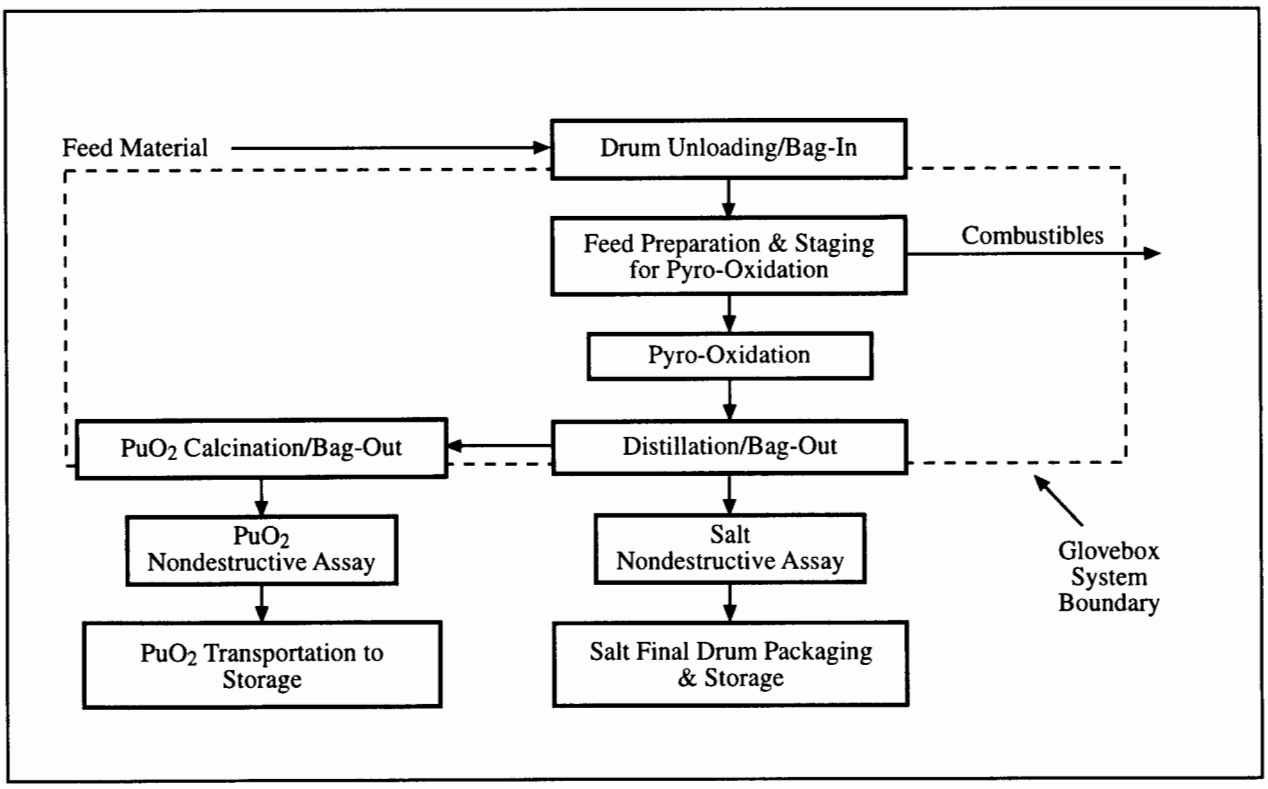


Figure C–24 Salt Distillation Process at Rocky Flats

Once the crucible is loaded with salt feed, it will be placed in a glovebox furnace and heated to approximately 800°C (1,470°F) with sodium carbonate or another oxidant as a reagent for 2 to 3 hours (8-hour cycle time), stirring continuously. The product will be a stabilized plutonium salt matrix. This process converts reactive metals (such as sodium, calcium, or potassium) to oxides. When the furnace has cooled to below 100°C (212°F), the crucible will be removed from the furnace. During the heating, stirring, and cooling phases, argon will flow through the furnace. During the last part of the heating phase, argon will be replaced by a mixture of air and argon. Once the crucible is removed from the furnace, it will be allowed to completely cool. The material will be placed into containers and transferred to the distillation glovebox via the chain conveyer system.

Each batch of pyro-oxidized salts will be placed into a vacuum distillation unit and distilled under vacuum for several hours (12-hour cycle time). The distillation process will remove the salts in gaseous form. The salt gases will be condensed to form a lean transuranic salt waste, leaving behind plutonium oxide. At this point, the salts are assumed to contain only parts per million amounts of plutonium. The salts will be batched into containers, bagged out of the glovebox, and packaged for nondestructive assay. The plutonium oxide will be placed into interim storage or directly transferred to the calcination glovebox for the required final plutonium oxide calcination, if necessary.

Nondestructive assay will be performed to ensure requirement limits are met and to obtain data to ensure that required accountability procedures are followed. Nondestructive assay methods will be selected to ensure that the best accountability data is obtained. Assayed product packages will be selected for final packaging to minimize the number of shipping containers required to be shipped to WIPP. Selected packages will be loaded into an inner container and sealed prior to placing the container into the final outer shipping container.

Plutonium oxide from the distillation process step is removed from the cans and placed in furnaces, and calcined at 1,000°C (1,800°F) for 4 hours, if necessary to meet 3013 criteria. The material, now suitable

for storage or transportation, is weighed, characterized, and placed in a container. This container is then removed from the glovebox using the bagless transfer process and sent to nondestructive assay. The plutonium oxide is assayed for plutonium content based on its rate of thermal generation using calorimeters and Gamma-Ray Isotopic Spectrometer equipment. After assay, the containers are ready for storage. Assayed product packages containing the plutonium oxide will be transported to appropriate plutonium storage areas pending disposition in accordance with decisions reached under the Surplus Plutonium Disposition Environmental Impact Statement.

C.6.3.2 Salt Distillation at Los Alamos National Laboratory with Preprocessing at Rocky Flats

❒ Preprocessing at Rocky Flats

A pyro-oxidation process will be conducted inside gloveboxes located in Module A of Building 707 or in Building 371 at Rocky Flats and the resulting products will be shipped to Los Alamos National Laboratory by Safe Secure Trailer or other DOE-approved transport, as appropriate for final processing. The pyro-oxidation preprocessing process for pyrochemical salts and subsequent shipment to Los Alamos National Laboratory are shown in **Figure C–25**. The residue materials will be sorted and batched in preparation for pyro-oxidation. The salts will be pyro-oxidized to convert reactive metals to oxides. After pyro-oxidation, the oxidized plutonium salts will be packaged for storage and shipment. The packaged material will be removed from the glovebox, nondestructively assayed for accountability purposes, and then packaged in the final transport/storage container and stored, if necessary, until it can be shipped to Los Alamos National Laboratory.

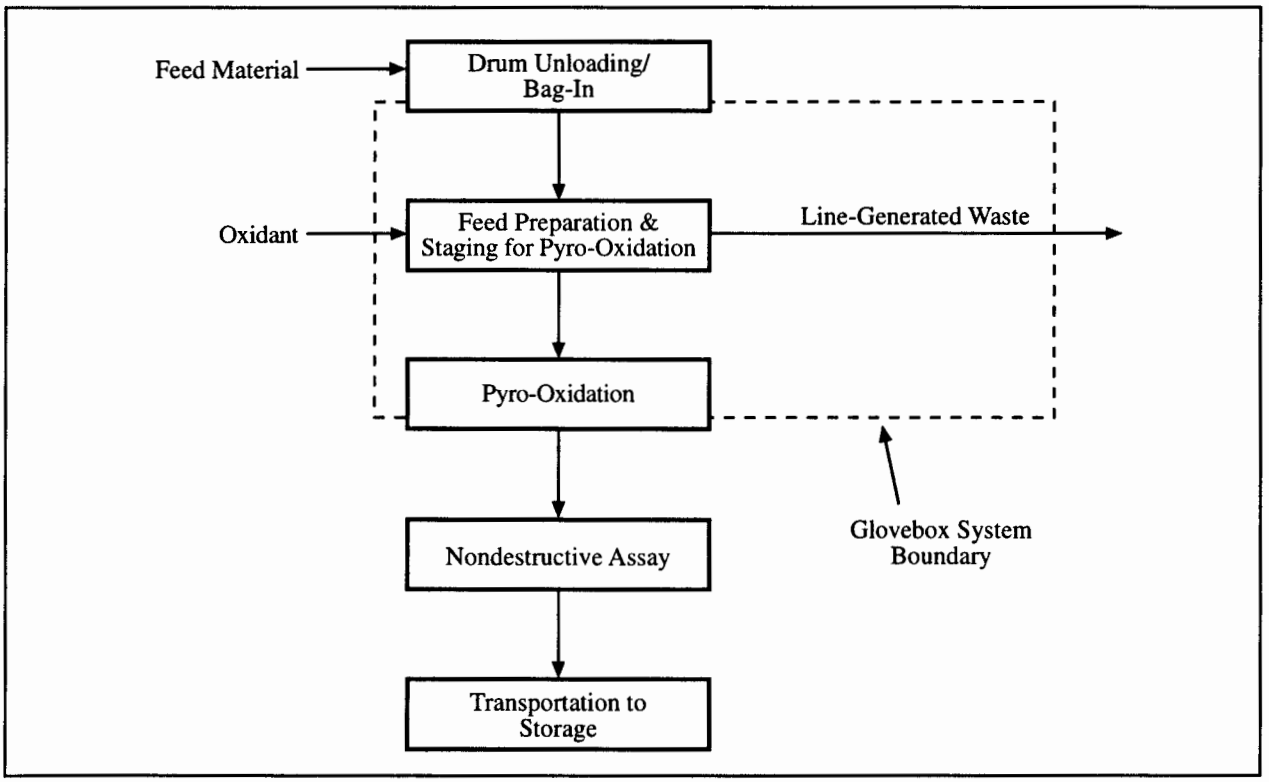


Figure C–25 Pyro-Oxidation Preprocessing Process

◆ Detailed Preprocessing Description

Drums will be manually transferred into a contamination control enclosure and unpacked. This is to contain any contamination which could result from an individual package containment damaged by radiolysis, or physical damage to the package during storage. Any unnecessary packaging materials will be removed to limit the amount of packaging introduced into the feed preparation glovebox. All of these individual containers will be bagged into the feed preparation glovebox.

The salt feed will be introduced into the glovebox, one stream at a time, and the IDC verified. The individual packages will be opened and loaded into a crucible in preparation for pyro-oxidation. Sodium carbonate or another oxidant will also be added to the crucible at this time. Combustible packaging materials from the individual packages will be bagged out of the glovebox and managed as transuranic waste. Other materials will be bagged out and managed appropriately.

Once the crucible is loaded with salt feed, it will be placed in a glovebox furnace and heated to approximately 800°C (1,470°F) with sodium carbonate or another oxidant as a reagent for 2 to 3 hours (8-hour cycle time), stirring continuously. The product will be a stabilized plutonium salt matrix. This process converts reactive metals, such as calcium, sodium, and potassium, to oxides. When the furnace has cooled to below 100°C (212°F), the crucible will be removed from the furnace. During the heating, stirring, and cooling phases, argon will flow through the furnace. During the last part of the heating phase, argon will be replaced by a mixture of air and argon.

Once the crucible is removed from the furnace, it will be allowed to completely cool before breakout. The salt matrix will then be removed from the crucible and the crucible discarded. The salt matrix will be placed into stainless steel containers in nominal 3.5-kg (7.7-lb) bulk (net) batches. The containers will be crimp sealed, weighed, and bagged out of the glovebox line. After bagout, two smaller cans will be placed in one tall can and sealed and nondestructive assay will be performed.

Calorimetry may be used for determining a heat signature for a shipping package. Packages will be loaded into 9975 Type shipping containers and transferred to interim vault storage or the shipping dock. There will be one can in each shipping container. The shipping containers will be cleaned and surveyed for contamination before transfer to either interim vault storage or the shipping dock. All transfers within the process building will be made by forklift. The loaded 9975 Type containers will be picked up at the process building or interim vault storage and transferred to the shipping facility, where they will be loaded into a Safe Secure Trailer or other DOE-approved transport, as appropriate by forklift and transported to Los Alamos National Laboratory. The distance from Rocky Flats to Los Alamos is approximately 730 km (450 mi).

❒ Salt Distillation at Los Alamos National Laboratory

The salt distillation process at Los Alamos National Laboratory separates sodium chloride/potassium chloride pyrochemical salt residues into a slightly contaminated (<100 parts per million [ppm] plutonium) salt fraction, suitable for disposal as transuranic waste, and a chloride-free, plutonium oxide powder suitable for long-term storage. The separation is based on the large difference in vapor pressure between alkali metal chlorides and actinide oxides at elevated temperatures. Calcium chloride has a much lower vapor pressure than the alkali metal chlorides and cannot be processed by present distillation equipment. The distillation of the plutonium salts will be carried out at Technical Area 55, Building PF-4, Room 420. The salt distillation process is shown in **Figure C–26**.

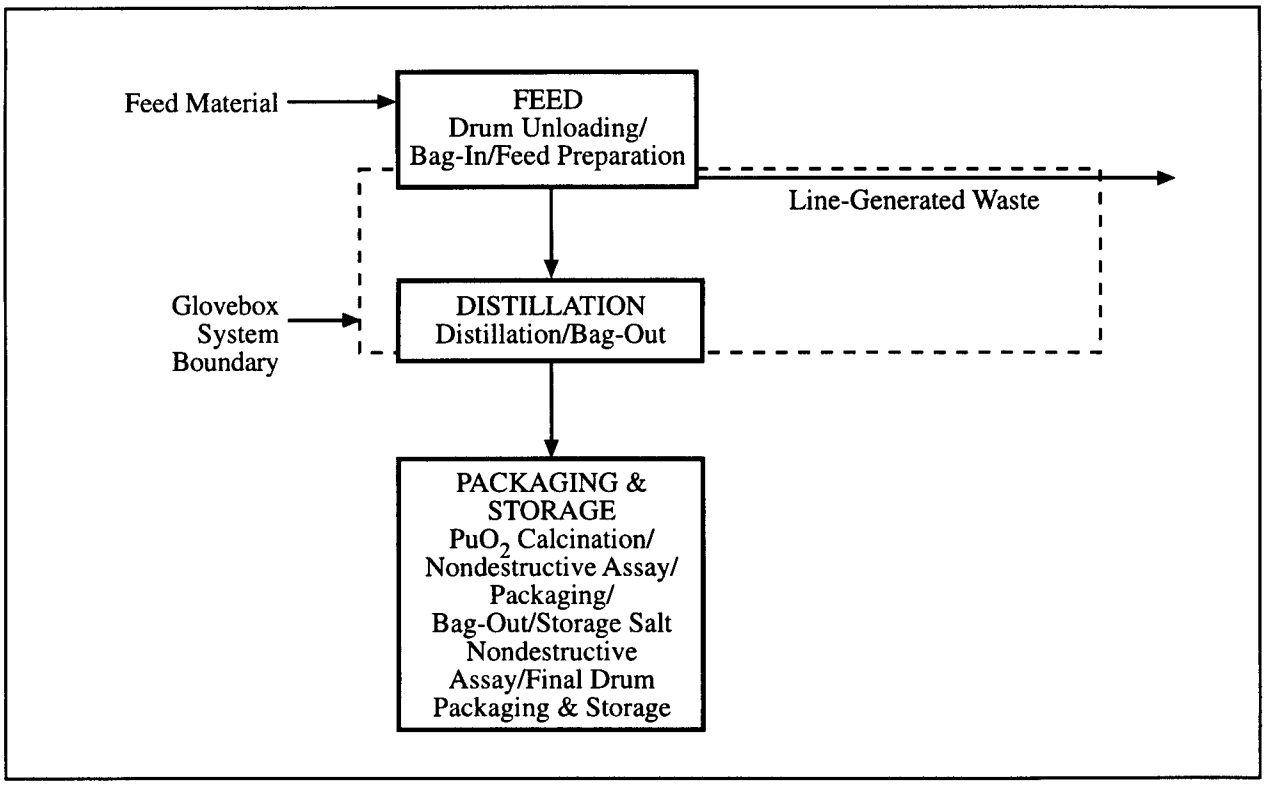


Figure C–26 Salt Distillation Process at Los Alamos

◆ Detailed Process Description

The pretreated feed residues are directly loaded into the Los Alamos National Laboratory salt distillation apparatus. The distillation unit has been designed to handle 3-kg (6.6-lb) salt batches. The distillation unit is sealed and a vacuum applied. The furnaces on the evaporator side are heated to 950°C (1,740°F) so that the salt will begin to evaporate and solidify on cool condenser surfaces. The condensing salt raises the temperature of the condenser. Once all the salt has distilled from the evaporator side, the temperature of the condenser will begin to fall, signaling completion of the evaporation step. Typically, this occurs at 4 to 5 hours after heat is first applied. At this point, the unit is backfilled with argon to atmospheric pressure and the condenser is heated to 850°C (1,560°F) to melt the salt into a receiving mold. This provides a convenient salt monolith for disposal and typically requires one hour. All power is shut off and the unit is allowed to cool to room temperature overnight. If shorter times are required, active cooling can be used to speed the cycle up. It is unlikely a full cycle can be completed in an 8-hour shift; twelve hours is usually required for a complete load/unload cycle.

The waste salt is packaged and removed from the glovebox line for nondestructive assay by neutron counting, and then loaded into a 55-gallon drum destined for WIPP. Because of the small amount of plutonium in the salt (<100 ppm), the drum can be filled to a volume capacity without exceeding the radionuclide or safeguards termination limit on waste for WIPP.

The oxide distillation heel will meet the criteria of DOE-STD-3013-96 (DOE 1996c) without further processing. However, several distillation runs will be required before the 4-kg (8.8-lb) batch size for packaging is accumulated. The oxide will begin to absorb atmospheric moisture once removed from the distillation unit. Unless rigorously dry conditions are maintained for in-line oxide storage, calcination will be required before final packaging. Interim storage will be maintained pending disposition in accordance with decisions reached under the *Surplus Plutonium Disposition Environmental Impact Statement.*

C.6.4 Water Leach with Plutonium Oxide Recovery

The water leach technology for pyrochemical salts includes the pyro-oxidation of calcium chloride pyrochemical salts to oxidize any reactive metals, followed by selective aqueous dissolution of the soluble portion of the salt. The insoluble plutonium-containing material remains undissolved, and is filtered and calcined to plutonium oxide for storage. The filtrate is evaporated to dryness. Water leach has been proposed at Rocky Flats and at Los Alamos National Laboratory with preprocessing at Rocky Flats. Though the proposals are similar, enough details differ to warrant two discussions.

The water leach process at Rocky Flats is considered to be a proven technology. The process would be required to be installed in areas of Building 371 adjacent to the neutralize-dry process to take advantage of the liquid treatment facilities. The requirements for using this area for other residue activities (e.g., neutralize-dry, cementation) would impact the installation, testing, and operational schedule of new process equipment. Therefore, operations of the water leach process may not be able to start until a minimum of 4 years after issuance of the Record of Decision. The capability for water leach at Los Alamos National Laboratory is already installed and operational on a limited scale. Additional capabilities are available using a similar aqueous dissolution process. If any additional capabilities were necessary, they could be installed, however this capability would not be available for between 1–2 years after issuance of the Record of Decision.

Although principally considered for direct oxide reduction salts, if the water leach process is used to process molten salt extraction salts (or those calcium chloride salts used for a molten salt extraction-type process) there is an additional uncertainty involving the disposal of the resulting transuranic oxide materials. These materials contain elevated concentrations of americium by comparison to other plutonium oxide materials, resulting in elevated gamma radiation levels which must be addressed in handling. Estimates of radiation levels from these oxides packaged in normal containers which meet DOE-STD-3013-96 indicate that the materials may not be suitable for storage at the new vault being constructed at the Savannah River Site, although special shielding approaches are being evaluated. In the event that shielding is an unacceptable alternative, these materials may have to be processed in another manner or stored separately prior to final disposition. Although these materials have been identified as being difficult to handle due to their higher than normal radiation levels, they are only one of a number of similar materials which must be accommodated for storage at the Savannah River Site.

C.6.4.1 Water Leach with Plutonium Oxide Recovery at Rocky Flats

The entire water leach process will be conducted inside gloveboxes located in Rooms 3305 and 3701 of Building 371, except for the final calcination step, which will be done in Module J of Building 707. The resulting products are a lean transuranic salt waste to be shipped to WIPP and plutonium oxide to be stored at Rocky Flats.

The water leach process at Rocky Flats is shown in **Figure C–27**. The feed materials will be sorted and batched in preparation for pyro-oxidation. The salts will be pyro-oxidized to convert reactive metals to oxides. After pyro-oxidation, the salts will go through aqueous dissolution to dissolve the salts and soluble oxides. The solution will be filtered to separate the plutonium and americium oxides from the salt solution. The plutonium and americium oxides will be dried, nondestructively assayed for accountability purposes, calcined, and sent to storage pending DOE decisions on eventual disposition of the plutonium. The salt solution will be evaporated and the resulting salts will be dried, cast, packaged, and nondestructively assayed for accountability purposes. The salts will be packaged in the final transport/storage container, and moved into interim storage, pending disposal at WIPP.

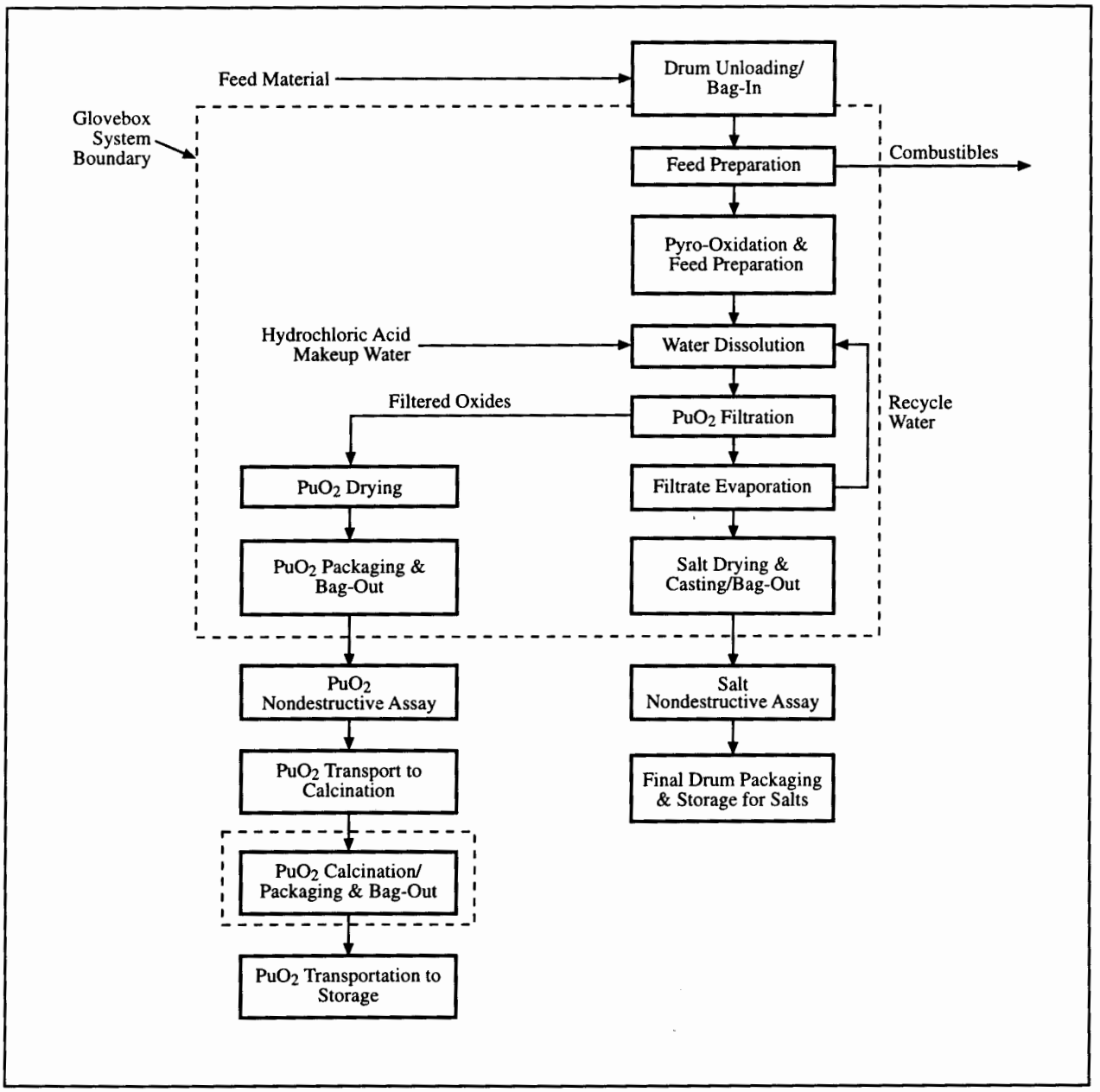


Figure C–27 Water Leach Process at Rocky Flats

During the heating, stirring, and cooling phases, argon will flow through the furnace. During the last part of the heating phase, argon will be replaced by a mixture of air and argon. Once the crucible is removed from the furnace, it will be allowed to completely cool before breakout. The salt matrix will then be removed from the crucible and crushed to be more amenable to dissolution; the crucible will be discarded. The salt matrix will be packaged suitable for dissolution, bagged out, and transferred to Building 371 for the water dissolution step.

After bag-in, the salt is treated using the water dissolution process on a batch basis. Water dissolution consists of placing the pyro-oxidized salts into a vessel approximately 15 L (4.0 gal) in volume, adding approximately two parts slightly acidified (1.7N HCl) water to one part total residue, and stirring for approximately 4 hours until the salts have dissolved. Approximately 90 percent of the water needed will be recycled from the filtrate evaporation step. Thus, a small quantity of 12.4N HCl and makeup water will be added to the recycle water

in order to achieve the desired normality. After the salts have dissolved, the resulting solution will be treated in the filtration step.

❒ Detailed Process Description

Drums will be manually transferred from storage into a contamination control enclosure. The contamination control enclosure is designed to control airflow in the event of a bag failure within a drum. The drum will be opened and the integrity of the packaging will be checked. If the packaging has not been compromised, the containers will be transferred to the glovebox. Any unnecessary packaging materials will be removed to limit the amount of packaging introduced into the feed preparation glovebox. If the integrity of the packaging has been compromised, the packaging will be overpacked with a new plastic bag prior to transfer to the glovebox. All of these individual containers will be bagged into the salt feed preparation glovebox. The salt materials will be introduced into the glovebox and the IDC verified. The individual packages will each be opened, batched to a 200 g (7 oz) maximum of plutonium, and then loaded into a magnesium oxide crucible in preparation for pyro-oxidation. An oxidant, such as sodium carbonate, will also be added to the crucible at this time. Combustible packaging materials from the individual packages will be bagged out of the glovebox and sent to a combustible-handling process. Other materials will be bagged out and managed appropriately.

Once the crucible is loaded with salt feed, it will be placed in a glovebox furnace and heated to approximately 800°C (1,470°F) with an oxidant such as sodium carbonate as a reagent for 2 to 3 hours, stirring continuously. The product will be a stabilized plutonium salt matrix. This process converts reactive metals (such as calcium) to oxides. When the furnace has cooled to below 100°C (212°F), the crucible will be removed from the furnace.

After bag-in, the salt will be treated in the water dissolution process on a batch basis. Water dissolution consists of placing the pyro-oxidized salts into a vessel approximately 15 L in volume, adding approximately two parts slightly acidized water to one part total residue, and stirring for approximately 4 hours until the salts have dissolved. Approximately 90 percent of the water needed will be recycled from the filtrate evaporation step. Thus, a small quantity of high normality hydrochloric acid and makeup water will be added to the recycle water in order to achieve the desired normality. After the salts have dissolved, the resulting solution will be treated in the filtration step.

The salt solution from water dissolution will be decanted and the resultant wet solids vacuum filtered to remove the plutonium oxide and americium oxide solids from the salt solution. The filtered oxides will go to plutonium oxide drying and the lean salt solution will go to evaporation. The wet plutonium and americium oxides will contain about 20 percent water after filtration. They will be placed into a small furnace and dried for about 4 hours at about 400°C (750°F). The resultant material is assumed to be only plutonium and americium oxides.

After drying, the oxides will be batched to 1 kg (2.2 lb) of plutonium batches. The batches will be placed into slip-lid cans and bagged out into convenience cans for nondestructive assay. The plutonium and americium oxides will be assayed for plutonium content based on their rates of thermal generation using calorimeters and gamma-ray isotopic spectrometer equipment. After assay, the containers will be ready for final calcination. The oxides will be transferred by truck from Building 371 to Building 707 to be calcined in Module J.

Plutonium oxide from the nondestructive assay step will be removed from the cans, batched into 3-kg (6.6-lb) batches, placed into furnaces, and calcined at 1,000°C (1,800°F) for 4 hours. The material, now suitable for storage or transportation, will be weighed, characterized, and placed in a 3013 container. This container will then be bagged out and sent to storage. Product packages containing the calcined plutonium

oxide will be transported to appropriate plutonium storage areas pending disposition in accordance with decisions reached under the *Surplus Plutonium Disposition Environmental Impact Statement.*

Two batches of filtered salt solution will be combined, placed into an evaporator unit and evaporated to a damp solid. The process will evaporate the water and cause the nonvolatile salts to remain in the product solids. The distillate water will be condensed and recycled back to the dissolution step, and the salts will be sent to the drying ovens. The batch of damp solids from evaporation will be placed into drying ovens and dried for about 4 hours at about 200°C (390°F) .

After drying, the salts will be placed into salt casting furnaces, heated to approximately 500°C (930°F) (melted) for about 1 hour, and cooled into solid form. The salts will be removed from the furnaces after cooling and packaged for bag-out. After bag-out, the salts will be sent to nondestructive assay.

Nondestructive assay will be performed to ensure requirement limits are met and to obtain data to ensure that required accountability procedures are followed. Nondestructive assay methods will be selected to ensure that the best accountability data is obtained. Assayed product packages will be selected for final packaging to minimize the number of shipping containers required to be shipped to WIPP. Selected packages will be loaded into an inner container and sealed prior to placing of the container into the final outer shipping container.

C.6.4.2 Water Leach with Plutonium Oxide Recovery at Los Alamos National Laboratory with Preprocessing at Rocky Flats

❒ **Preprocessing at Rocky Flats**

The stabilization of salts with the water leach process at Los Alamos National Laboratory requires preprocessing at Rocky Flats which includes pyro-oxidation which converts reactive metals to oxides. The pyro-oxidation process will be conducted inside gloveboxes located in Module A of Building 707. The feed materials will be sorted and batched in preparation for pyro-oxidation. The salts will be pyro-oxidized to convert reactive metals to oxides. After pyro-oxidation, the oxidized plutonium salts will be packaged for storage and shipment. The packaged material will be removed from the glovebox, nondestructively assayed for accountability purposes. It will then be packaged in the final transport/storage container and stored, if necessary, until it can be shipped by Safe Secure Trailer or other DOE-approved transport, as appropriate to Los Alamos National Laboratory. The pyro-oxidation preprocessing process is shown in Figure C–25.

◆ Detailed Process Description

Drums will be manually transferred into a contamination control enclosure and unpacked. This step is to contain any contamination which could result from any individual package containment which was damaged by radiolysis or physical damage. Any unnecessary packaging materials will be removed during this step to limit the amount of packaging introduced into the feed preparation glovebox. All of these individual containers will be bagged into the feed preparation glovebox.

The salt feed will be introduced into the glovebox, the IDC verified, and the individual packages will be opened and loaded into a magnesium oxide crucible in preparation for pyro-oxidation. An oxidant such as sodium carbonate will also be added to the crucible at this time. Combustible packaging materials from the individual packages will be bagged out of the glovebox and sent to a combustibles handling process. Other materials will be bagged out and managed appropriately.

Once the crucible is loaded with salt feed, it will be placed in a glovebox furnace and heated to approximately 800°C (1,470°F) with an oxidant such as sodium carbonate as a reagent for 2 to 3 hours (8-hour cycle time), stirring continuously. The product will be a stabilized plutonium salt matrix. This process converts reactive metals (such as, sodium, calcium, or potassium) to oxides. When the furnace has cooled to below 100°C (212°F), the crucible will be removed from the furnace. During the heating, stirring, and cooling phases, argon will flow through the furnace. During the last part of the heating phase, argon will be replaced by a mixture of air and argon. Once the crucible is removed from the furnace, it will be allowed to completely cool before breakout. The salt matrix will then be removed from the crucible and the crucible discarded. The salt matrix will be placed into stainless steel containers in nominal 3.5-kg (7.7-lb) bulk (net) batches. The salt matrix batches will be weighed and placed in steel containers. The containers will be crimp sealed, weighed, and bagged out of the glovebox line. After bag-out, two smaller cans will be placed in one tall can and sealed, and non-destructive assay will be performed. Calorimetry may be used for determining a heat signature for a shipping package.

Packages will be loaded into 9975 Type shipping containers with one tall can per shipping container, the shipping containers will be cleaned and surveyed for contamination, and then they will be transferred to interim vault storage or the shipping dock. The loaded 9975 Type containers will be picked up at the process building or interim vault storage and transferred to the shipping facility, where they will be loaded into a Safe Secure Trailer or other DOE-approved transport, as appropriate. The pretreated salt shipments will be transported to Los Alamos National Laboratory via Safe Secure Trailer or other DOE-approved transport, as appropriate. The distance from Rocky Flats to Los Alamos National Laboratory is approximately 730 km (450 mi.).

❒ Water Leach with Plutonium Oxide Recovery at Los Alamos National Laboratory

Pyro-oxidized pyrochemical salts will be received from Rocky Flats for final processing. These salts will be dissolved in a water leaching process. The resulting products will be lean calcium chloride salt for shipment to WIPP, and plutonium oxide to be stored at Los Alamos National Laboratory. The water leach of the plutonium salts will be carried out at Technical Area 55, Building PF-4, Room 420. The water leach process is shown schematically in **Figure C–28**. The process steps are Safe Secure Trailer or other DOE-approved transport, as appropriate unloading and receiving at Los Alamos National Laboratory, shipping container unloading and nondestructive assay, aqueous leaching and filtration, calcination of plutonium oxide, casting of calcium chloride salt, and bag-out. Nondestructive assay for plutonium oxide and salts will be performed, followed by final drum packaging and storage for salts, and transfer of the plutonium oxide to storage.

◆ Detailed Process Description

The leach equipment is sized to process a complete salt batch at one time. The salt batch is placed in a leaching vessel sized to dissolve all the calcium chloride salt in the residue. During the leaching operation, the solution will become slightly alkaline from dissolution of excess sodium carbonate and the slight solubility of calcium oxide. Aqueous hydrochloric acid will be added to convert calcium oxide and sodium carbonate into the respective chlorides. This is necessary to maintain the plutonium concentration in the filter cake above 50 percent. The pH of the solution is monitored and is always maintained above 7. The plutonium and americium oxides will remain insoluble. A 3-kg batch of salt can be dissolved in 3 hours. During this time, an operator monitors the operation for parameters such as temperature, mixing rate, leaching time, and dissolver condition. Once leaching is complete, the slurry containing the plutonium and americium insolubles is ready for filtration.

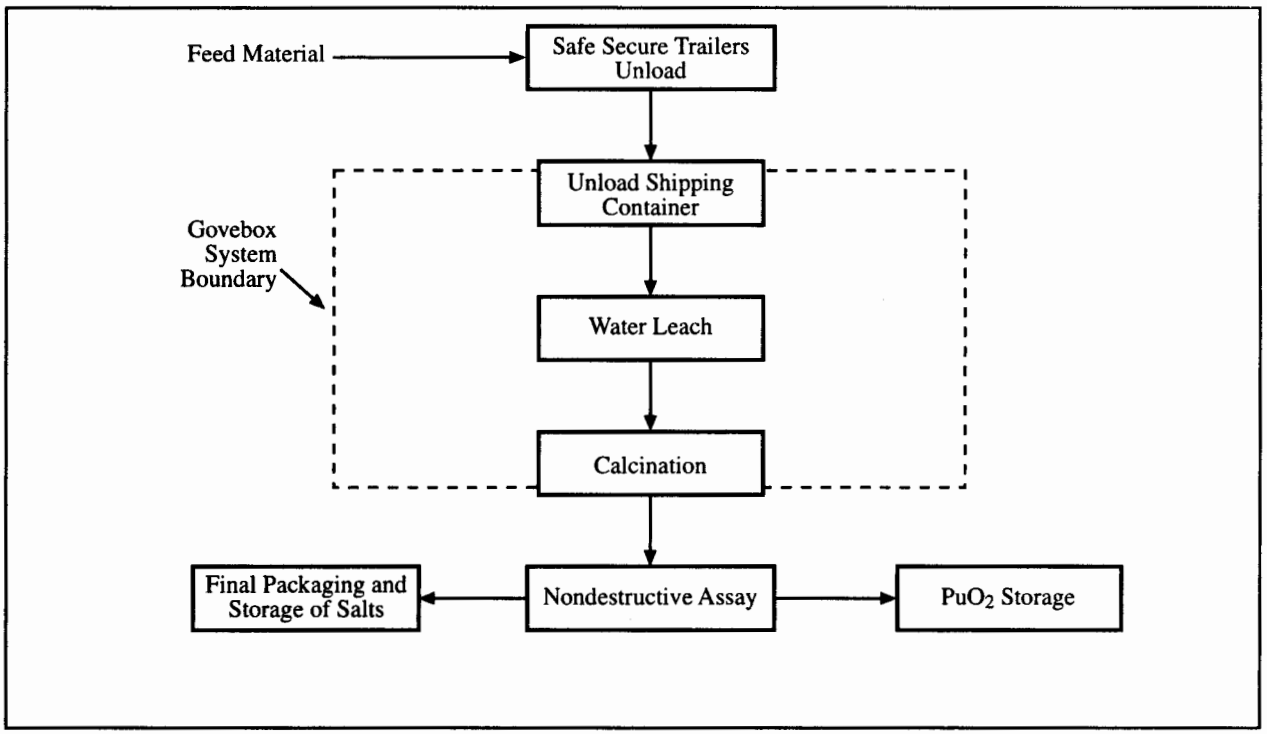


Figure C–28 Water Leach Process at Los Alamos

The slurry is transferred to the filtration system, where the solids containing plutonium and americium oxides are removed. The solids are washed with water to remove salt contaminants. The clarified solution is collected in a geometrically favorable tank and sampled for alkalinity and plutonium/americium concentration. The volume is estimated at 6 L (1.6 gal) per 3-kg (6.6-lb) batch. The solution is then evaporated to dryness and the solid salt transferred to a furnace and heated to 850°C (1,560°F) for melt consolidation. The final plutonium concentration in the salt is expected to be about 100 ppm. The insolubles collected on the filter are removed and transferred to the calcination workstation. The wet cake from filtration is placed in a crucible and calcined at 950°C (1,740°F) to remove water and other volatiles. The calcined product will contain less than 50 percent plutonium and will be stabilized. The stabilized product is weighed and sampled for Pu and Am analysis, Loss on Ignition and transferred to a packaging workstation. The calcined product will be packaged in accordance with DOE-STD-3013-96 (DOE 1996c) and placed in interim storage pending disposition in accordance with decisions reached under the *Surplus Plutonium Disposition Environmental Impact Statement.* Where batches contain small quantities of plutonium, multiple batches may be combined for storage after calcination.

C.6.5 Salt Scrub with Purex Processing of Newly Created Scrub Alloy

❒ Preprocessing at Rocky Flats

The salt scrub process for pyrochemical salts reduces the plutonium level of the salts below the safeguards termination limit for pyrochemical salts and produces a high plutonium yield scrub alloy that would be shipped to Savannah River Site for further processing. The resulting low plutonium-bearing pyrochemical salts will be a lean transuranic waste to be shipped to WIPP. The salt scrub process can be used on electrorefining salts, molten salt extraction salts, and direct oxidation reduction salts. The salt scrub process will be conducted inside gloveboxes located in Modules A and B of Building 707.

The salt scrub process, consisting of the reduction and capture of plutonium and americium from chloride salts into a metal "button" in a pyrochemical process at Rocky Flats, and the subsequent shipment of the button to Savannah River for processing in the Purex process is considered to be a proven process for clean,

recently-packaged salt residues. Technical uncertainties exist for this process as applied to less pure salts and/or salts which have absorbed moisture during storage. Development work would be required prior to or in parallel to the operations to address these uncertainties, with the result possibly being a population of salts not amenable to this technique. Since the scrub alloy process could be performed in the stationary furnaces which have been installed at Rocky Flats as part of the No Action Alternatives, currently-installed capability exists to support the this process, although the scrub alloy processing would have to be coordinated with the current pyro-oxidation commitments. The salt scrubbed by this process may not all meet the safeguards termination limits and could need some subsequent processing prior to disposition.

The salt scrub process for pyrochemical salts and subsequent shipment of resultant scrub alloy to Savannah River Site are shown in **Figure C–29**. Because of differences in salt composition, each of the salt types will be processed separately; however, the process steps are the same for each. The feed materials will be sorted and batched in preparation for salt scrub. The salts will be scrubbed to remove as much plutonium as possible. This description assumes all salts will be scrubbed as a bounding condition; certain lots of material may be unsuitable for this process due to age, condition, or low plutonium content, and will require alternative processing.

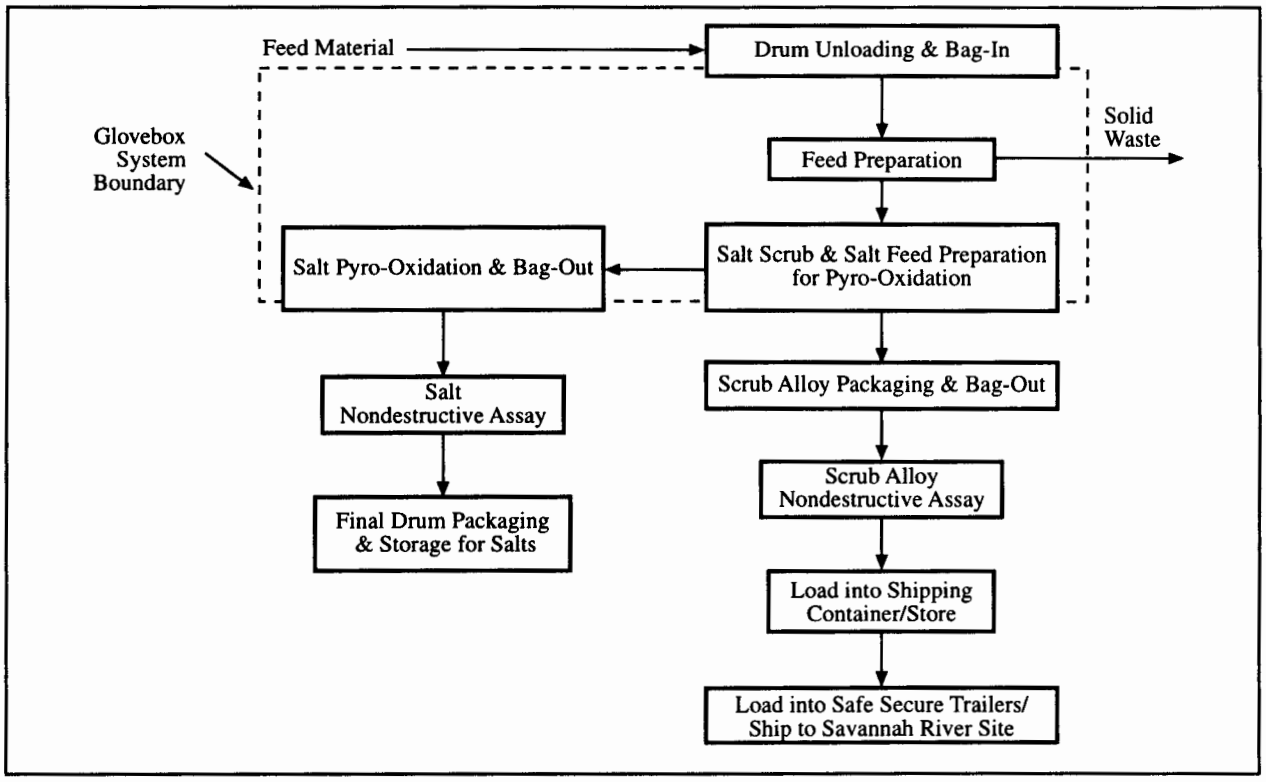


Figure C–29 Salt Scrub Process and Subsequent Shipment of Resultant Scrub Alloy to Savannah River Site

After salt scrub, the salts will be re-batched for pyro-oxidation. The salts will be pyro-oxidized to convert any reactive metals to oxides. After pyro-oxidation, the salts will be removed from the glovebox and nondestructively assayed for accountability purposes, packaged in the final transport/storage container, and placed in interim storage. The scrub alloy will also be removed from the glovebox, nondestructively assayed for accountability purposes, and packaged in the final transport/storage container and stored, if necessary, until it can be shipped to Savannah River Site by Safe Secure Trailer or other DOE-approved transport, as appropriate.

◆ Detailed Process Description

As required, drums will be manually transferred into a contamination control enclosure and unpacked. This step is to contain any contamination on the outside of the inner package which could result from radiolysis or physical damage to the package during storage. Any unnecessary packaging materials will be removed to limit the amount of packaging introduced into the feed preparation glovebox. All of these individual containers, after examination and/or repackaging in the contamination control enclosure, will be bagged into the feed preparation glovebox.

The feed materials will be introduced into the glovebox, one stream at a time, and the IDC verified. The salt will be removed from the original container, weighed, and batched with the appropriate amount of metal reductants and matrix (e.g., gallium and calcium metal). The quantities of gallium and calcium used will be dependent on the plutonium and americium content. The maximum batch size will be 2.5 kg (5.5 lb) of bulk residue, which produces approximately 200 g (7 oz) plutonium metal. Combustible packaging materials from the individual packages will be bagged out of the glovebox and sent to a combustibles handling process. Other materials will be bagged out and managed appropriately.

Although, in the salt scrub process, an aluminum/magnesium alloy has been used in the past and may be used in specific cases, the newer gallium/calcium alloy system will lower the overall radiation levels, since alpha-neutron reactions will be minimized. The charge, containing the salt/metal mixture, will be placed into a furnace and heated at 800°C (1,470°F) for 2 hours (8-hour cycle time). During heating, the molten salt/metal mixture will be mechanically stirred. The furnace will then be allowed to cool, and the crucible will be removed from the furnace and allowed to completely cool before breakout. The scrub alloy button and the plutonium-depleted salts will be removed from the crucible and the crucible will be discarded. The salts will be either stored in-line or batched into magnesium oxide or other crucibles and sent to pyro-oxidation by chain conveyer.

Once the crucible is loaded with salt feed, it will be placed in a glovebox furnace and heated to approximately 800°C (1,470°F) with sodium carbonate as a reagent for 2 to 3 hours, stirring continuously (8-hour cycle time). The product will be a stabilized plutonium salt matrix. Pyro-oxidation can be applied to both sodium chloride-potassium chloride and calcium chloride matrices. This process converts reactive metals (i.e., calcium, sodium, and potassium) to oxides. When the furnace has cooled to below 100°C (212°F), the crucible will be removed from the furnace. During the heating, stirring, and cooling phases, argon will flow through the furnace. During the last part of the heating phase, argon will be replaced by a mixture of air and argon.

Once the crucible is removed from the furnace, it will be allowed to completely cool before breakout. The salt matrix will then be removed from the crucible and the crucible will be discarded. The material will be batched to 9.1 kg (20.0 lb) of total residue (based on an estimated maximum weight to be handled in a glovebox), placed into a container, bagged from the glovebox, and placed in a convenience container for safe handling. If metal crucibles are used, the pyro-oxidized salt will remain in the crucibles and be sealed and bagged out directly in nominal 2.5-kg (5.5-lb) bulk (net) batches.

Nondestructive assay will be performed to ensure requirement limits are met and to obtain data to ensure that required accountability procedures are followed. Nondestructive assay methods will be selected to ensure that the best accountability data are obtained. Assayed product packages will be selected for final packaging to minimize the number of shipping containers required to be shipped to WIPP. Selected packages will be loaded into an inner container and sealed before placing of the container into the final outer shipping container.

The scrub alloy buttons will be weighed and placed in dissolvable (mild steel) container. The containers will be crimp-sealed, weighed, and bagged out of the glovebox line, using special dissolvable, nylon bags. After bag-out, two smaller cans will be placed in one tall dissolvable can and sealed. Although aluminum containers have been used in the past, mild steel cans will be used on all future shipments.

Nondestructive assay will be performed and calorimetry may be used for determining a heat signature for a shipping package. Packages will be loaded into Type 6M shipping containers and transferred to interim vault storage or the shipping dock. There will be one can in each shipping container. The shipping containers will be cleaned and surveyed for contamination before transfer to either interim vault storage or the shipping dock. The loaded Type 6M containers will be picked up at the process building or interim vault storage and transferred to the shipping facility, where they will be loaded into a Safe Secure Trailer by forklift. Safe Secure Trailer transported shipments to Savannah River Site will be required for the newly-created scrub alloy. The distance from Rocky Flats to Savannah River Site is approximately 2,620 km (1,625 mi.).

❒ Purex Processing at Savannah River Site of Newly Created Scrub Alloy

The scrub alloy will be dissolved in the Savannah River Site F- or H-Canyon. The plutonium will be separated from americium and aluminum using the solvent extraction technology. The plutonium will be converted to metal or oxide and packaged (inner container for DOE-STD-3013-96 [DOE 1996c]) in the FB- or HB-Line. That metal or oxide will be transferred to Savannah River Site's PB-L or 235-F vault until the Actinide Packaging and Storage Facility vault is complete, packaging completed (outer container) to meet DOE-STD-3013-96 (DOE 1996c) and stored until decisions are made on fissile material disposition. This process is currently in operation and no changes to the process are required due to salt scrub alloy. The salt scrub alloy Purex processing to metal or oxide at Savannah River Site is shown in **Figure C–30**.

◆ Detailed Process Description

The shipping containers received from Rocky Flats will be unloaded, confirmatory measurements made and placed in a vault-like room in 235-F. Twelve shipping containers at a time will be removed from storage and transported to the F- or H-Canyon crane maintenance area where the shipping containers will be opened up and the cans loaded into a dissolver tube. The dissolver tube will then be loaded into a dissolver by remote control. Twelve cans make up one dissolving batch.

Heated nitric acid in the tank dissolves the salt scrub alloy, resulting in a solution containing americium, chloride, aluminum, magnesium, and plutonium. The plutonium is recovered and purified by solvent extraction; the impurities remain in the aqueous stream. The waste liquid containing americium, aluminum, and residual plutonium will be transferred from the Savannah River Site canyon facility to the Savannah River Site high-level waste system. The plutonium product solution is transferred to canyon hold tanks for later transfer to FB- or HB-Line.

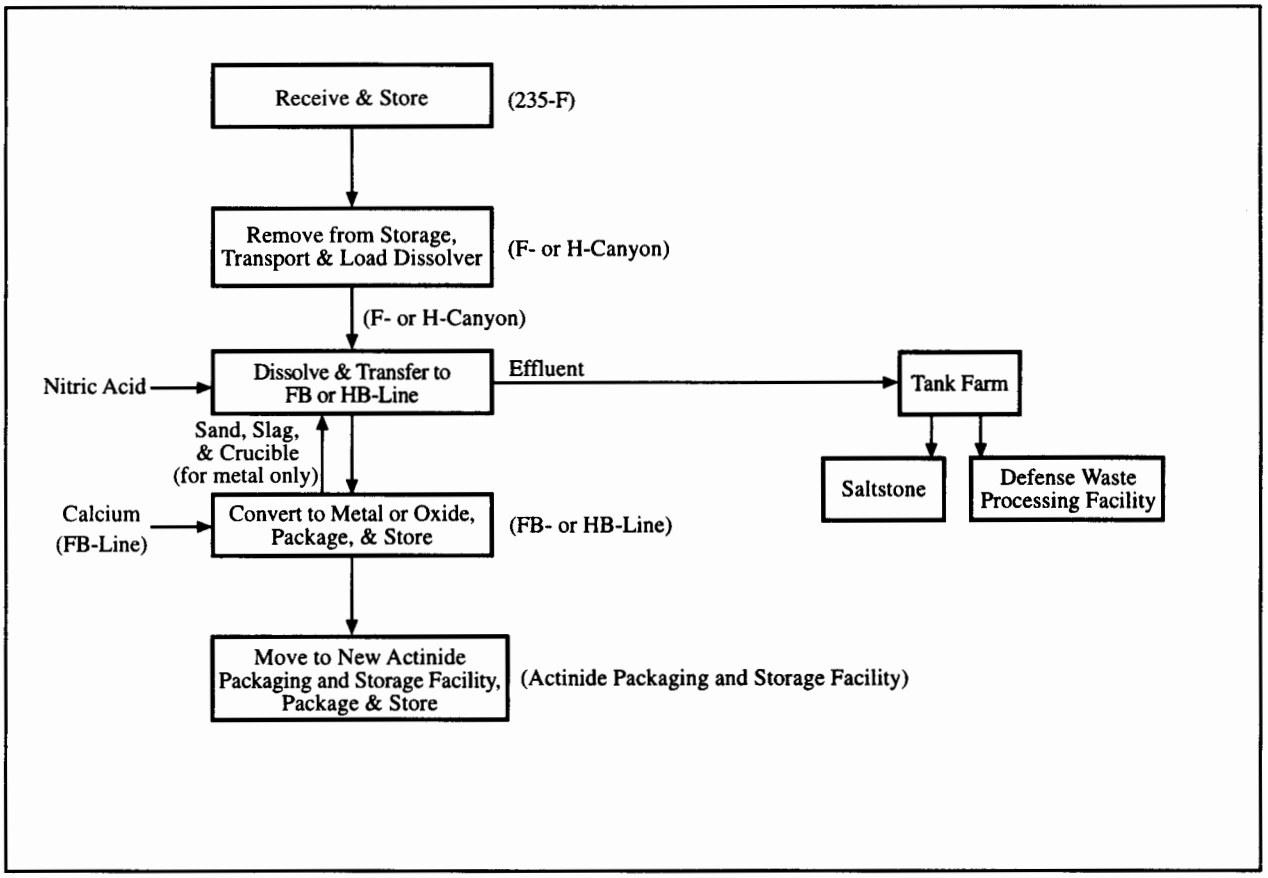


Figure C–30 Salt Scrub Alloy Purex Process at Savannah River Site

The FB-Line process includes concentration of plutonium by cation exchange, precipitation of plutonium as a trifluoride, recovery of the trifluoride by filtration, drying of trifluoride in an oxygen atmosphere, and reduction with calcium metal to form plutonium metal buttons. The sand, slag, and crucible generated from button reduction will be dissolved in F-Canyon. The HB-Line process includes concentration of plutonium through anion exchange, precipitation of plutonium as plutonium oxalate, recovery of the oxalate by filtration, drying and calcining the oxalate, converting it to plutonium oxide. The buttons and oxide will be packaged in 3013-96 bagless inner cans which will be placed in an F area vault for temporary storage. The cans will then be removed from the F area vault, placed into shipping containers, and transported to the Actinide Packaging and Storage Facility. At the Actinide Packaging and Storage Facility, the cans will be removed from the shipping containers, packaged into an outer 3013 container, and placed into the vault for long-term storage pending disposition in accordance with decisions reached under the *Surplus Plutonium Disposition Environmental Impact Statement.*

C.6.6 Acid Dissolution with Plutonium Oxide Recovery of Sludge Residues

The acid dissolution of sludge residues involves dissolution of the sludges, followed by precipitation and filtration of plutonium oxalate, and calcination to plutonium oxide for storage. The filtrate from the oxalate precipitation is treated with magnesium hydroxide to precipitate the plutonium remaining in the solution. That precipitate is then filtered, calcined, repackaged, and placed in interim site storage until a final disposition decision is made. The dissolution process will be conducted inside gloveboxes located in Room 3701 of Building 371.

The acid dissolution/plutonium oxide recovery process consisting of dissolving the plutonium contained in sludges, filtering the solution, and precipitating and calcining a plutonium oxalate, is considered to be a proven technology. The process to be used for the limited quantities of materials identified in these categories will be consistent with equipment and activities that can be performed in the neutralize-dry process area. Thus, the capability for Rocky Flats is currently being installed to support the disposition of below-safeguards termination limit materials, and should be available several months after the issuance of the draft of the EIS. However, the use of this equipment for acid dissolution will generally be preceded by the neutralize-dry processing of the combustible residues required by the Defense Nuclear Facilities Safety Board Recommendation 94-1 stabilization program, and may not be able to start until 4 years after issuance of the Record of Decision.

The plutonium residue acid dissolution process is shown in **Figure C–31**. The feed materials will be unpacked and batched for acid dissolution. The dissolved residues will be sent through precipitation to form plutonium oxalate precipitate in slurry form, which will then be filtered to separate the effluent solution from the precipitate. The oxalate will be calcined, nondestructively assayed, calcined again for long-term storage, again nondestructively assayed, and then packaged for storage. Magnesium hydroxide will be mixed into the oxalate precipitation effluent to precipitate the remaining plutonium, and the effluent filtered to form magnesium hydroxide and effluent. The magnesium hydroxide will be calcined and packaged. The packaged magnesium hydroxide product will be removed from the glovebox and nondestructively assayed for accountability purposes, packaged in the final transport/storage container, and placed in interim storage. The last filtration effluent will be sent for evaporation at the Rocky Flats wastewater treatment facility.

❒ Detailed Process Description

The residue feed will be introduced into the glovebox, and the IDC will be verified. The materials will then be removed from the containers and batched to a maximum of 200 g (7 oz) of plutonium in preparation for nitric acid dissolution. Combustible packaging materials from the individual containers will be bagged out of the glovebox and sent to a combustible handling process. Other unwanted materials will be bagged out of the glovebox and managed appropriately.

The contents of the residue cans will be transferred to one of two heated stirrers. The operator will add 7N nitric acid (HNO_3) and 60 percent aluminum nitrate ($Al(NO_3)_3$) solution to each dissolver before stirring. $Al(NO_3)_3$ is added to complex residue ions during dissolution. The slurry will be heated to approximately 80°C (176°F) and stirred until dissolution is achieved. Vented fumes will be cooled in a condenser, and then piped to the process vent system. The batch will be filtered to remove any undissolved solids and then split into two equal amounts and transferred to the adjacent heated stirrers for precipitation.

For plutonium oxalate precipitation, 3N potassium hydroxide (KOH) will be added to each can to adjust the normality to 0.75N nitric acid. Hydroxylamine nitrate (HAN) will then be added as a 1.9M solution to adjust the plutonium valence to +3. After these adjustments have been made, solid oxalic acid will be added to form plutonium oxalate precipitate. The solution will be heated to approximately 80°C (176°F) and stirred to form a slurry.

The slurry from the two stirrer assemblies will be poured onto an R-4 filter. Filtration of plutonium oxalate will be achieved by pulling a vacuum through the filter and drawing effluent liquids into a filtrate tank. The plutonium oxalate precipitate will be scooped into a filter boat in preparation for calcining.

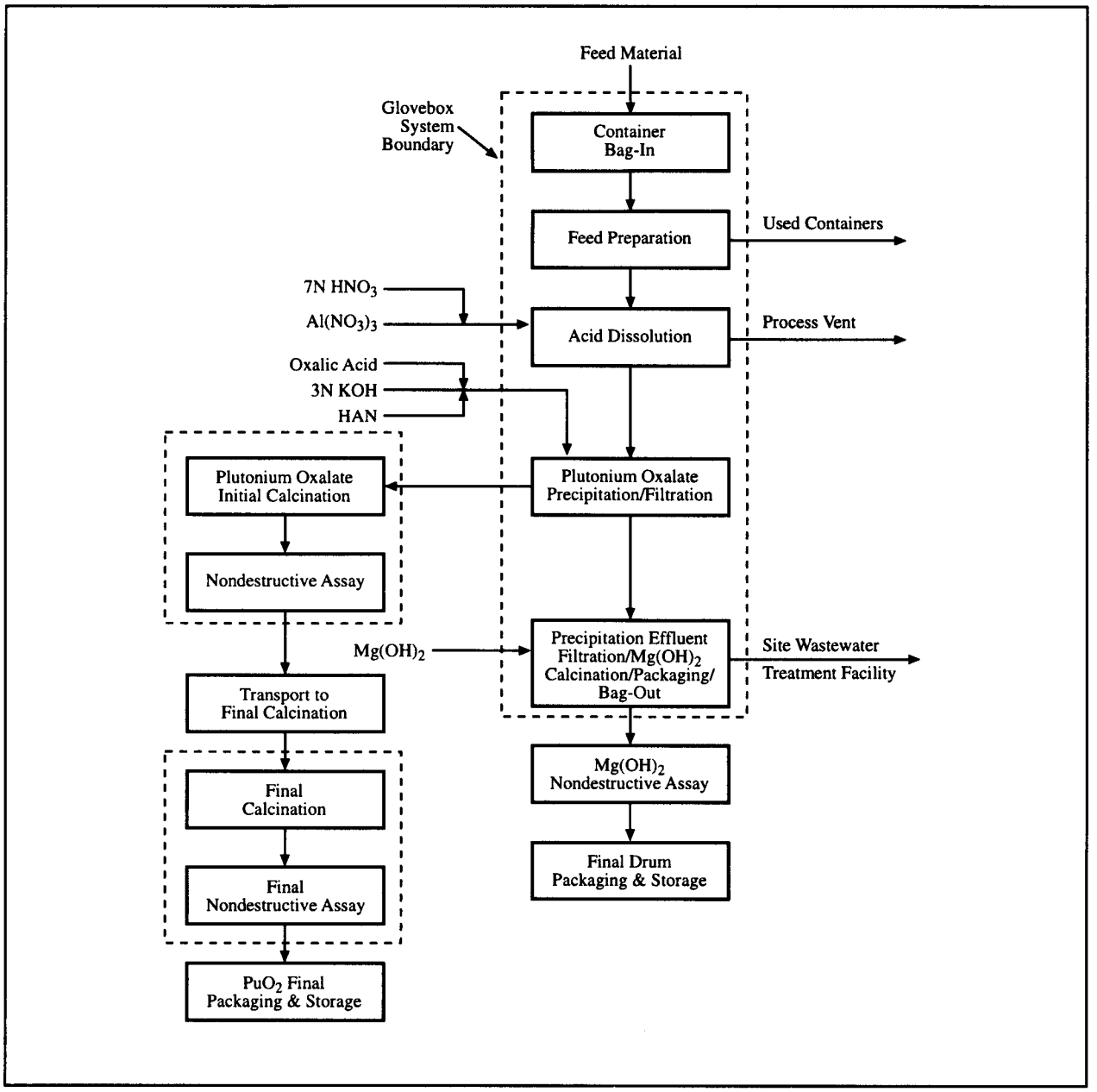


Figure C–31 Acid Dissolution Process for Sludge Residues

The plutonium oxalate will require calcining at 450°C (840°F) to convert the oxalate into the oxide form. In this process, the filter boat will be placed on a pneumatic lift, placed into the calcination furnace, and the precipitate will be heated to 450°C (840°F). Glovebox air will be drawn down through the precipitate at a rate of approximately 0.10 m^3 (3.5 ft^3) per minute during the heating cycle. After a cooling cycle, the calcined oxide will be transferred from the filter boat back into a can, batched to 1,000 g (2.2 lb), sealed, and sent to calorimetry.

The plutonium oxide can will be assayed for plutonium content based on its rate of thermal generation using calorimeters and gamma-ray isotopic spectrometer equipment. This activity is required to maintain accountability within the acid dissolution material balance area. After assay, the containers are ready for final calcination. The cans containing the plutonium oxide will be placed into appropriate outer containers

and transferred to the Building 371 loading dock. The containers will then be transported to the Building 707 loading dock by intra-site truck transportation, and moved to appropriate vault storage pending final calcination.

The plutonium oxide cans will be transferred from the Building 707 storage vault to Module J and bagged into the plutonium stabilization and packaging system. The plutonium oxide will be removed from the cans, placed into furnaces, and calcined at 1,000°C (1,830°F) for 8 hours. The material, now suitable for long-term storage or transportation, will be weighed, characterized, and placed into a 3013 inner container. This container is then removed from the glovebox by the bagless transfer process and sent to calorimetry. The plutonium oxide package is assayed for plutonium content based on its rate of thermal generation using calorimeters and gamma-ray isotopic spectrometer equipment. After assay, the containers will be placed into vault storage, pending a final disposition decision.

Magnesium hydroxide will be added to the effluent liquid in the filtrate tank from the precipitation filtration step, and the tank will be mixed by sparging. The liquid and precipitate will then be drained onto an R-4 filter. Filtration will be achieved by pulling a vacuum through the R-4 filter and drawing effluent liquids into the transfer tank. The magnesium hydroxide precipitate will then be scooped into a filter boat in preparation for calcining. The magnesium hydroxide will be calcined at 450°C (840°F). In this process, the filter boat will be placed on a pneumatic lift, placed into the calcination furnace, and the precipitate will be heated to 450°C (840°F). Glovebox air will be drawn down through the precipitate at a rate of approximately 0.10 m^3 (3.5 ft^3) per minute during the heating cycle. After a cooling cycle, the calcined hydroxide will be transferred from the filter boat back into a can, batched to 9.1 kg (20 lb), sealed, and bagged out into convenience cans.

Nondestructive assay of the magnesium hydroxide will be performed to ensure requirements limit are met and to obtain data to ensure that required accountability procedures are followed. Nondestructive assay methods will be selected to ensure that the best accountability data are obtained. Assayed product packages will be selected for final packaging to minimize the number of shipping containers and placed in interim storage pending a final disposition decision. Selected packages will be loaded into an inner container and sealed before placing the container into the final outer shipping container.

C.7 REFERENCES

DOE (U.S. Department of Energy), 1997a, *Department of Energy Plutonium Sand, Slag, and Crucible Trade Study, Nuclear Materials Stabilization Group, Working Draft Trade Study Notes*, Volumes 1-3, Nuclear Material Stabilization Task Group, January 2.

DOE (U.S. Department of Energy), 1997b, *Residue Rebaselining for Combustibles, Fluorides, Ash, and Miscellaneous Residues*, Rocky Flats Field Office, Golden, CO, January.

DOE (U.S. Department of Energy), 1996a, *Department of Energy Plutonium Combustibles Trade Study, Nuclear Material Stabilization Task Group, Working Draft Trade Study Notes*, Volumes 1-3, Nuclear Materials Stabilization Task Group, December 24.

DOE (U.S. Department of Energy), 1996b, *Ash Residues End-State Trade Study, Nuclear Material Stabilization Task Group,* Nuclear Material Stabilization Task Group, September 25.

DOE (U.S. Department of Energy), 1996c, *DOE Standard Criteria for Preparing and Packaging Plutonium Metals and Oxides for Long-Term Storage*, DOE-STD-3013-96, Washington, DC, September.

DOE (U.S. Department of Energy), 1996d, *Environmental Assessment, Finding of No Significant Impact, and Response to Comments Solid Residue Treatment, Repackaging, and Storage*, DOE/EA-1120, Rocky Flats Office, Golden, CO, April.

DOE (U.S. Department of Energy), 1996e, *Department of Energy Plutonium Scrub Alloy Trade Study, Nuclear Material Stabilization Task Group Data Package*, Nuclear Material Stabilization Task Group, February 28.

DOE (U.S. Department of Energy), 1996f, *Plutonium Salts Trade Study*, Volumes 1 and 2, Nuclear Material Stabilization Task Group, February 21.

DOE (U.S. Department of Energy), 1995, *Rocky Flats Environmental Technology Site: Direct Disposal Trade Study for Plutonium-Bearing Residues*, Rocky Flats Field Office, Golden, CO, November 21.

Appendix C - Attachment 1

Relevant Memos and Letters in the Development of the Safeguards Termination Limits

Los Alamos
NATIONAL LABORATORY

Nuclear Materials Technology Division
NMT-7, Mail Stop E500
Los Alamos, New Mexico 87545
(505) 667-2345 / FAX 667-7066

Date: January 22, 1996
Refer to: NMT-DO:(U)96-020

Mr. David W. Crawford
NN-512
Office of Safeguards and Security
U. S. Department of Energy, Headquarters Germantown
19901 Germantown Road
Germantown, MD 20585

Dear Mr. Crawford:

REFERENCE: **"Safeguards Termination", D.W. Crawford, Department of Energy, Office of Safeguards and Security, August 22, 1995**

SUBJECT: **Recommendations for Safeguards Termination Policy**

The purpose of this correspondence is to formalize Los Alamos National Laboratory (LANL) recommendations for establishing safeguard termination limits for low grade SNM-bearing materials.[1] These recommendations are offered in response to the referenced proposal by the Office of Safeguards and Security (OSS). It is my understanding that these recommendations have been closely coordinated with LANL's internal safeguards and security organization, safeguards and security organizations at several other Department of Energy (DOE) facilities, LANL recovery process personnel who are also familiar with recovery processes at other DOE facilities, DOE Albuquerque Operations Office (DOE/ALO), and your office.

There are two factors that make the issuance of safeguards termination limits at this juncture both timely and important.

First, while there are a number of efforts underway within DOE with the objective of dispositioning SNM inventories,[2] only the DOE/ALO Plutonium Disposition Methodology (PDM)[3] recognizes fundamental operational constraints such as the need to recover and stabilize SNM for safety reasons,[4] and the operational imperative for distinguishing between waste and product on a real-time basis (i.e., SNM-bearing materials are processed and process residuals are generated). The PDM establishes criteria for the disposition of potential excess SNM in inventory and SNM-bearing materials as they are processed. These criteria establish a

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[1] SNM -Special Nuclear Materials
[2] (i.e., the Materials-in-Inventory (MIN) initiative, the Fissile Materials Disposition Programmatic Environmental Impact Statement, secretarial commitments for transfer of SNM to IAEA safeguards, the Residue Elimination Program at Rocky Flats, etc.)
[3] The PDM was developed under guidance from DP-22: reference : "Plutonium Disposition Plans", C.G. Halsted, DP-273, April 18, 1994.
[4] Reference: Defense Nuclear Facilities Safety Board (DNFSB) Recommendation 94-1

framework for insuring that waste management and environmental concerns, processing constraints, proliferation issues, and economics are all considered in the disposition of SNM-bearing materials. Consequently, issuance of quantitative safeguards termination limits at this time supports plutonium disposition in an important and concrete fashion. Also, safeguards termination limits which are derivative of the degree of difficulty of recovery operations not only satisfy the intent of the Atomic Energy Act in preventing SNM diversion, they also confirm the fundamental rationale for disposition of SNM-bearing materials. SNM-bearing materials that can be processed for SNM recovery using extant technologies should be retained and SNM-bearing materials whose recovery is impractical due to technology limitations[5] should be processed for disposal.

The second reason why issuance of safeguards termination limits is important is fundamental. Such limits serve as a reminder to organizations dispositioning SNM that there are national security reasons for retaining fissile materials regardless of whether there is presently an identified use for such materials, and safeguards termination limits present a constraint to facilities considering discard of SNM-bearing materials simply because it's easier than employing a recovery mechanism.

Consequently, LANL strongly endorses issuance of safeguards termination limits by your office. We have prepared a detailed justification for recommendations for modification of the initial OSS proposal (see attachment) with which I understand you are already conversant. In essence, our recommendations are as follows.

- Safeguards termination limits should be a function of the degree of difficulty of the recovery process and the attractiveness of the isotopic composition of the SNM.[6]

- Safeguards termination limits should be viewed as ceilings below which individual facilities may establish discard limits derivative of recovery technologies and other factors associated with specific material matrices.

- Discard limits should be approved by responsible DOE field offices and such limits should be re-evaluated periodically to account for advances in technology and other pertinent factors.

- OSS should be the final authority regarding any requests to discard materials exceeding safeguards termination limits. Proposals to discard materials exceeding safeguards termination limits should be supported by vulnerability and security assessments prepared by the requesting facility or the intended disposal facility (as required by DOE Order 5633.3B.

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[5] Technology limitations include excessive waste generation rates associated with the recovery process, refractory nature of the material matrix, recovery economics, ALARA considerations, etc.

[6] Our premise that, if recovery is too difficult to be warranted suing our advanced technologies and facilities, then it is certainly too difficult for less sophisticated states/groups -particularly if relatively massive volumes must be diverted from waste management facilities before recovery can even be attempted. Also, if an isotope, or the isotopic composition of an alloy is not suitable for proliferation purposes without further refinement/enrichment (i.e., low-enriched uranium or reactor-grade plutonium vs. highly enriched uranium or weapons grade plutonium), then safeguards termination limits should be appropriately higher for such materials.

It is our hope that this correspondence proves helpful in your efforts toward development of an overall DOE safeguards termination policy. LANL recognizes the difficulties associated with oversight of both facilities that no longer have a viable mission and the facilities whose operations remain important to national security. We also recognize the difficulty associated with facilities dealing with low activity SNM-bearing materials and facilities that process (or intending to process) very high activity materials (e.g., spent fuel or high level waste). However, for operational facilities it is necessary that the safeguards termination process be coordinated with, and support, SNM disposition procedures, such as the DOE/ALO Plutonium Disposition Methodology. Our recommendations are intended to facilitate such coordination and support as well as address the issue of safeguards termination of high-activity materials. However, lacking operational experience with such items, it may be that further input from other facilities is warranted, or that safeguards termination policy for such materials should be delayed until facilities are fully prepared to discard such materials (i.e., at Yucca Mountain, or in a Monitored Retrievable Storage facility).

If we can be of further assistance, or if you have any questions in this matter, please call me at 505-665-2345 or Mark Robinson at 505-667-6977.

Regards,

Dana C. Christensen
Deputy Division Director
Nuclear Materials Technology Division

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ATTACHMENT

RECOMMENDATIONS FOR MODIFICATIONS TO THE PROPOSED OSS POLICY FOR SAFEGUARDS TERMINATION

1.0 Introduction

The Department of Energy (HQ) Office of Safeguards and Security (OSS) has issued draft concentration-based criteria for termination of safeguards on low-grade fissile materials (i.e., materials intended for discard as waste).[7] OSS has also circulated a more tentative draft criteria for informal comment.[8] In response to concerns expressed by the LANL Nuclear Materials Technology (NMT) Waste Management and Environmental Compliance group (NMT-7) regarding the initial OSS proposal,[9] NMT Division organized a review by personnel having:

- direct experience in all recovery processes (existing or under development) at the LANL plutonium processing facility (TA-55);
- a broad knowledge of recovery processes at other DOE facilities;
- a broad knowledge of waste stabilization and disposal practices and requirements;
- Material Control and Accountability (MCandA) and Safeguards and Security expertise; and,
- Safeguards and Security and SNM processing expertise at other DOE facilities (e.g., Pacific Northwest Laboratory, the Rocky Flats Environmental Technology Site, the Y-12 Plant, the Savannah River Site, etc.).

This analysis represents the consensus recommendations of that review team. The recommendations herein do not differ significantly from the original NMT-7 discussions, concerns, and recommendations, except that the OSS proposal issued subsequently is also considered.

2.0 Background

OSS has issued two proposals for safeguards termination criteria. The proposed criteria are derived from the following equations:

8/22/95 Formula	Version 1.2 Formula
$C_T = 10^{(r + y - \log a)/2}$	$C_T = 10^{(2y - \log a)/2}$

The variables in these equations are interpreted as follows:

C_T = maximum nuclear concentration (ppm) permitting safeguards to be terminated;

r = 0, 1, 2... as established to represent increasing radioactivity and thus difficulty of handling (8/22/95 formula only);

---

[7] "Safeguards Termination", D.W. Crawford, Department of Energy, Office of Safeguards and Security, August 22, 1995

[8] Version 1.2, "Terminating Safeguard on Discardable Nuclear Materials", D.W. Crawford, Office of Safeguards and Security, not dated

[9] NMT-7-WM/EC-95-262, "Impact of Proposed Criteria for Safeguards Termination on TA-55 Operations, LANL Waste Management Operations, and the DOE/ALO Plutonium Disposition Methodology", M.A. Robinson to D.C. Christensen, November 29, 1995

y = n, n + 1, n + 2... for decreasing recoverability; and

a = nuclear concentration (wt%) of the candidate material.

Under these formulas, safeguards can be terminated if $C_T \geq a$. These formulas, however, are difficult to conceptualize as presented. It is consequently helpful to perform some mathematical simplification and to revisit sensitivity analyses provided by OSS to achieve a better understanding of what is being derived.

Because the upper concentration acceptable for safeguards termination is found where $C_T = a$, the above formulas can be reduced to

8/22/95 Formula	Version 1.2 Formula
$a = 10^{(r + y - 12)/3}$	$a = 10^{(2y - 12)/3}$

where a may be described as the safeguards termination limit.

From this formula, it is readily apparent that the concentration where safeguards can be terminated is a direct function of the assigned values of y (and r where applicable). Under the 8/22/95 proposal, OSS assigned a factor of 0 for items having an unshielded dose rate at 3 meters of < 15 R/hr. As almost all of the accountable materials considered for discard at TA-55 fall into this range, this formula can be further reduced for LANL purposes to $a = 10^{(y - 12)/3}$, where the concentration threshold for safeguards termination is solely a function of y, which -again- represents difficulty of recovery. OSS assigns recovery factors as depicted in the sensitivity analysis below. Using a recovery factor of 4 for Attractiveness Level D materials, safeguards termination limits of 0.22 and 4.5 wt% are obtained using the 8/22/95 and Version 1.2 formulas, respectively.[10]

OSS Sensitivity Analyses (modified)

				8/22/95 Formula		Version 1.2	
Attractiveness Level	Concentration (wt%)	Description	Recovery Difficulty (y)	Safeguards termination Limit (a in wt%)		Safeguards termination Limit (a in wt%)	
B	>50	Pure products Compounds and Alloys	0 / 1	0.01 / 0.02	(safeguards termination not allowed where	0.01 / 0.05	(safeguards termination not allowed where
C	<50 to >10	High Purity Residues and Salts	2 / 3	0.05 / 0.1	a < material concentration wt% range)	0.22 / 1.0	a < material concentration wt% range)
D	<10 to >0.1	Low Grade Materials	4 / 5	0.22 / ~~0.47~~ N/A -rejected by OSS		4.5 / N/A - not calculated by OSS	
E	<0.1	Very Low Grade Materials	4	~~0.22~~ N/A -all Level E materials are below this concentration and acceptable for safeguards termination		~~4.5~~ N/A -all Level E materials are below this concentration and acceptable for safeguards termination	

[10] 8/22/95 formula: $a = 10^{(y - 12)/3}$; $a = 10^{(4 - 12)/3}$; $a = 10^{-8/3}$; $a = 10^{-2.6667}$; a = 0.0022 = 0.22 wt/%.
Version 1.2 formula: $a = 10^{(2y - 12)/3}$; $a = 10^{(8 - 12)/3}$; $a = 10^{-4/3}$; $a = 10^{-1.333}$; a = 0.045 = 4.5 wt/%.

It would appear from these sensitivity analyses that OSS has chosen recovery factors in a manner intended to correlate to DOE 5633.3B Attractiveness Levels. That is, the proposed formulas only allow safeguards termination on some Attractiveness Level D materials and all Attractiveness Level E materials, which is consistent with DOE 5633.3B and its implementation guide. However, while consistency with governing orders may initially seem logical and appropriate, neither of the resultant safeguards termination thresholds are consistent with the realities of recovery technologies at operational facilities or the real needs of facilities without operational recovery processes. In fact, the 0.2 wt% limit approaches (and exceeds in some cases) the limits of recovery technologies for many SNM-bearing matrices, while the 5.0 wt% limit appears unrelated to recovery technologies and intended primarily to accommodate large volumes of residues at facilities no longer maintaining any recovery capabilities (i.e., RFETS).

In reality, what is necessary is that the safeguards termination limits and process (1) fulfill their legislative mandate of preventing proliferation, (2) support the operations of national security facilities, and (3) not unduly impede disposition of SNM-bearing materials at facilities intended for Decontamination and Decommissioning (DandD). Discussions related to the derivation of safeguards termination limits from extant recovery technologies at operable facilities follow. The influence of specific alloys and radioactivity on safeguards termination limits, and safeguards termination at facilities without recovery capabilities are discussed separately.

3.0 Safeguards Termination at Operational Facilities

At operational facilities it becomes apparent that in many cases there are no differences between Attractiveness Level C, D, and E materials in terms of amenability to recovery processes. That is, plutonium in both 20 wt% and 1 wt% residue salts, for example, must be recovered[11] and recovery efficiency is limited by the technologies available, as opposed to being limited strictly by the SNM concentration in candidate materials. Plutonium in some matrices can be virtually completely recovered (e.g., nitrate solutions, glovebox sweepings, etc.), while recovery of plutonium from other matrices is constrained by a number of factors (i.e., refractory matrices, environmental considerations such as waste generation rates associated with the recovery process, costs and ALARA considerations, configuration/location of SNM-bearing items, etc.). All of these factors are germane to the recoverability of SNM from individual matrices and therefore to the Attractiveness of such materials.[12]

Consequently - based primarily on knowledge of extant recovery processes for SNM recovery/purification technologies - it is appropriate to propose modification of OSS's recovery factors in a manner derivative of technical recovery difficulties. One approach to classification of materials is presented in the following table.

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[11] Where possible, plutonium or other SNM is always recovered and utilized or stabilized for long term storage for both nonproliferation and environmental reasons.

[12] It is recognized that given sufficient resources, time, and volumes of SNM-bearing material, sufficient SNM can be recovered from the most refractory matrices to constitute a threat to national security. However, this proposal for derivation of safeguards termination limits is based on the premise that attractiveness of SNM-bearing materials must be directly related to difficulty of recovery and the assumptions that DOE does not have infinite resources to apply to recovery and the resources and technologies possessed by enemy states/groups do not exceed those of DOE.

RECOVERABILITY FACTORS (y) BASED ON PROCESS PARAMETERS			
y	**Category**	**Description**	**Typical Materials**
3	Readily Recoverable	Solutions, contaminated SNM, and SNM metal or oxides mixed with miscellaneous materials	• nitrate, caustic, HCl, or Pu-U solutions • Pu contaminated with Np, Cm, or other radionuclides • metal fines or turnings and/or sweepings from machine tools or gloveboxes
4	Recoverable	Items amenable to dissolution and subsequent SNM separation	pyrochemical salts, chloride melt, MgO crucibles, hydroxide cake, Sand, Slag, and Crucible (SSandC)
5	Difficult to Recover	Items in a hazardous matrix requiring destruction	• organic solutions • oils, PCB's • evaporator bottoms
6	Very Difficult to Recover	Items requiring mechanical separation, size reduction, or disassembly and subsequent multiple recovery operations	HEPA filters, heating mantles, surface contaminated plastics, metal components, graphite molds, combustibles, rubber
7	Extremely Difficult to Recover	SNM bound in the matrix of solid, sintered, or agglomerated refractory materials	• SNM etched or embedded in the matrix of glass or plastic • incinerator ash • previously leached solids • spent resins
8	Practically Non-recoverable	Materials microencapsulated in refractory compounds or in solid-solution with non-fissile alloys	• vitrified, bituminized, cemented, or polymer-encapsulated materials ~~• SNM alloyed with Al, Th, Zr, Pt, Ta, W, or DU~~

To provide a cognitive sense of how recoverability factors relate to current operational practices, the following table compares specific example matrices in terms of current discard limits (established in 1989), safeguards termination limits derived from Nuclear Material Technology (NMT) proposed recoverability factors, and the universal safeguards termination thresholds proposed by OSS. Note that in some cases NMT proposes significantly reducing safeguards termination levels due to improvements in recovery processes since the current discard limits were established (i.e., the majority of the materials designated as "recoverable"). In other cases (primarily those matrices more amenable to stabilization for disposal than to recovery, and those matrices whose recovery generates significant waste) NMT proposes increasing the safeguards termination threshold. If nothing else, these proposed changes should demonstrate that both safeguards termination levels and discard limits should always be a function of extant technology and should be modified accordingly as technology advances. This comparison also clearly demonstrates that the OSS Version 1.2 proposed safeguards termination limit has no relationship to extant recovery capabilities.

Comparison of Current DOE/ALO Discard Limits with OSS and LANL Proposed Safeguards Termination Thresholds[13]

Materials	DOE ALO Discard Limit	LANL Proposed Methodology			OSS 8/22/95 Proposal		OSS Version 1.2 Proposal	
		y	Category	Safeguards Termination Threshold	y	Safeguards Termination Threshold	y	Safeguards Termination Threshold
nitrate solutions caustic solutions HCl solutions Pu-U solutions Pu contaminated with Np	.83 .95 5.24 1.4 1.10	3	Readily Recoverable	1.0	4	2.0	4	50.0 for solids; 2.0 for solutions
Chloride Melt MgO Crucibles SSandC Hydroxide Cake	10.88 8.30 8.96 1.10	4	Recoverable	2.2				
Organics Lapping Oils Evaporator Bottoms	1.73 1.51 3.37	5	Difficult to Recover	4.6				
HEPA filters[14] Heating mantles Surface-contaminated plastics Non-Pu metal components Graphite molds Combustibles Rubber	–4 8.27 4.10 3.31 4.23 4.3 2.62	6	Very Difficult to Recover	10.0				
Pu embedded in plastic Pu etched in glass High-fired incinerator ash Previously leached solids Spent resins	16.0 10.5 18.35 7.24 12.48	7	Extremely Difficult to Recover	21.5				
Pu-Th oxide Pu-AL alloy Pu-U fuel rods Pu-Zr	37.78 14.44 35.72 26.64	8	Practically Irrecoverable	46.4				

[13] r = 0 for LANL and OSS 8/22/95 proposals; concentrations expressed in g/kg
[14] The EDL's for HEPA filters are expressed in g/filter

What may not be immediately evident from the foregoing comparisons is (1) the number of factors that must be considered by an operational facility in establishing Discard Limits, (2) the significant number of SNM-bearing matrices that may fall within each recoverability category (only a relative hand-full of examples were presented), and (3) the number of matrices that may be unique to a facility.

The DOE Albuquerque Operations Office has issued the Plutonium Disposition Methodology (PDM),[15] which requires consideration of 13 waste management, environmental, safety, operational, and economic factors in the dispositioning of potentially-excess SNM; nonproliferation issues are only one of these factors. However, the fundamental rationale for establishing safeguards termination limits is essentially the same as fundamental precepts of environmental and waste management criteria. That is, although these arenas are diverse in their objectives, the technical rationale for achieving these objectives is the same: SNM should always be recovered to the extent technically feasible (to minimize the amount discarded and potentially available for diversion; to minimize the environmental insult of disposal; the minimize the amount of waste generated, etc.). Consequently, the quantitative criteria for terminating safeguards should closely parallel technical recovery capabilities and should support the PDM process overall.

The PDM requires that all facilities under the DOE/ALO purview (LANL, SNL, Pantex, LLNL, NTS, Kansas City, Pinellas, Grand Junction)[16] annually evaluate potentially-excess SNM-bearing materials in inventory. Although LANL is the most prolific generator of SNM and SNM-bearing materials within the DOE/ALO facilities, this means that each facility must annually account for process changes and technology advances in the establishment of Discard Limits. This means that individual facilities may re-categorize matrices within the recoverability categories proposed herein due to technology evolution and that the genesis of new matrices due to process changes may have to be accounted for in terms of Discard Limits. What this means to the establishment of safeguards termination criteria is that the criteria should closely parallel extant technology, but that they should be established as *ceilings below which* individual facilities may establish Discard Limits based on current recovery capabilities and the other relevant criteria of the PDM. It should be noted that where individual facilities establish Discard Limits below the safeguards termination criteria, these Discard Limits *become*, in effect, the facility-specific safeguards termination criteria.

4.0 Attractiveness of the Isotope/Alloy

In addition to recoverability, the value of specific isotopes or alloys for proliferation purposes should also be considered in establishing safeguards termination thresholds. For example, Weapons Grade Plutonium is considered far more attractive to proliferation than reactor grade plutonium (> 6% Pu-240 isotopic composition). This is certainly consistent with historical discard practices at Defense Programs facilities, where the EDLs for Material Types (MT's) 53 - 83 have always been significantly higher that those for MT 51 and 52. Consequently, NMT-7 proposes a modification to the 8/22/95 OSS logarithmic formula to account for less attractive material types, as follows.

$C_T = 10^{(r + y + A - \log a)/2}$, where A is a factor considering attractiveness of the alloy, as defined below.

Attractiveness of the Alloy (A)		
Isotope/Alloy	U-235, U-233, Pu-239,or WG-Pu	> 6% Pu-240 in plutonium alloys (i.e., reactor grade material), low-enriched uranium (<20%), Np-237
A	0	.5

[15] "Plutonium Disposition methodology (PDM) Development, Implementation, and Use", DOE Albuquerque Operations Office, October 1995; as directed by DP-22: "Plutonium disposition Plans", C.G. Halsted, April 18, 1994.

[16] Major DP operations at LLNL and NTS are funded through DOE/ALO but the facilities are under the purview of local DOE Field Offices; whether the PDM will be implemented at these facilities has not yet been determined.

It should be noted that LANL does not propose any modification to the OSS Version 1.2 formula to account for alloy attractiveness because our opinion is that this formula is unsatisfactory for application to operational facilities.

5.0 Influence of Radioactivity on Safeguards Termination

Discussions with OSS, as well as the absence of radioactivity factors in the Version 1.2 proposal, indicate that their is some reluctance to consider surface dose rates in the establishment of safeguards termination criteria at this time.

Although LANL has no significant experience in processing High Level Waste or spent fuel, especially to the point where safeguards termination would be necessary, our experience with Molten Salt Extraction (MSE) salts with high Am-241 concentrations, Pu-238, and various neutron sources, does indicate that the increased difficulty in handling and transport of higher activity materials should be germane to establishing safeguards termination criteria, simply because higher activity increases the difficulty of diversion as well as the difficulty of recovery. LANL recommendations in this regard are, however, limited to the minor modifications of the radiation field definitions proposed by OSS, as follows.

LANL recommends that the radioactivity factors proposed by OSS be modified in terms of definitions to account for (1) standard International Atomic Energy Agency (IAEA) quantification of the High Level Waste threshold[17], and (2) an alternate threshold for considering radioactive materials as posing increased handling difficulties due to penetrating radiation. First, addition of IAEA quantitative thresholds (i.e., by decay heat or activity/volume) would simply allow materials to be classified for the purposes of safeguards termination without actual dose rate measurement, thereby potentially reducing personnel exposure. Second, the point at which shielding is mandatory for transport under IAEA guidance[18], and Department of Transportation (DOT) regulations (200 mrem/hr surface dose rate) would seem to be an appropriate threshold for increased handling difficulty due to radioactivity (i.e., the r = 1 threshold). 200 mrem/hr is also more reflective of the point at which residue salts pose ALARA concerns due to Am-241 ingrowth or intentional concentration, so such a threshold is more consistent with our SNM processing than 15 R/hr at 3 meters. Never-the-less, LANL recommends allowing either level as a threshold for increased handling difficulties to accommodate differing conditions at individual SNM processing facilities.

Radiation Factors (r) Considering IAEA Standard Parameters		
0	1	2
< 200 mrem/hr surface dose rate[19]	>200 mrem/hr surface dose rate, or, >15 R/hr at 3m	> 2 Kw/m³ decay heat, or > 5E+4 Tbq/m³, or > 100 R/hr at 3m

[17] Safety Series No. 111-G-1.1, *Classification of Radioactive Waste*, International Atomic Energy Agency, Vienna, Austria, 1994

[18] Safety Series No. 6, Regulations for the Safe Transport of Nuclear Material, International Atomic Energy agency, Vienna, Austria, 1985 Edition, as amended 1990.

[19] all dose rates are unshielded; 100 mrem = 1mSv

6.0 Quantitative Summary of LANL Proposals

The following table details the safeguards termination limits derived when LANL proposed recoverability factors (y), radioactivity factors (r), and isotopic attractiveness factors (A), are all considered. The safeguards termination thresholds thus derived for typical materials processed by Los Alamos National Laboratory (r = 0 and A = 0 and .5) are consistent with current technical capabilities.

Safeguards Termination Thresholds (a) for Low Grade SNM-bearing Materials, Considering Recoverability (y), Radioactivity (r), and Attractiveness (A) Factors

		Safeguards Termination Thresholds					
		A = 0, U-235, U-233, Pu-239, WG-Pu			A = .5, Reactor Grade Pu (>6% Pu-240), Low-enriched Uranium, Np-237		
		r = 0	r = 1	r = 2	r = 0	r = 1	r = 2
Recoverability	y	a (wt %)[20]			a (wt %)		
Readily Recoverable	3	0.1	0.22	0.46	0.15	0.32	0.68
Recoverable	4	0.22	0.46	1.0	0.32	0.68	1.5
Difficult to Recover	5	0.46	1.0	2.2	0.68	1.5	3.2
Very Difficult to Recover	6	1.0	2.2	4.6	1.5	3.2	6.8
Extremely Difficult to Recover	7	2.2	4.6	10.0	3.2	6.8	14.7
Practically Irrecoverable	8	4.6	10.0	21.5	6.8	14.7	31.6

While LANL does not have specific experience with processing high activity materials (r = 2) for disposal, the safeguards termination thresholds derived for such materials do not appear unreasonable, although they are high in comparison to our recovery experience. West Valley, for example, has demonstrated vitrification of very high activity actinides and fission products in a 6 wt% mixture. The West Valley glassified product is very "hot" (>8000 rem/hr surface dose rate). It would seem, therefore, that vitrification of spent fuel or SNM recovered from spent fuel (which would not be as radioactive as concentrated short-lived radionuclides) could be performed at concentrations in the range derived above for safeguards termination. Further investigation by OSS as to what concentrations of high activity SNM will be obtained when such materials are actually processed for disposal would seem appropriate. Such information will be necessary before any proposed concentration-based safeguards termination criteria for high activity SNM can be validated. Although safeguards termination policy that only addresses low activity materials could be issued as an interim measure, the number of DOE facilities working on vitrification to be applied to HLW or other mechanisms for disposal of spent fuel would indicate that policy "accounting" for such waste forms will be necessary in the relatively near future.

[20] $a = 10^{(r + y + A) - 12/3} \times 100$

7.0 Safeguards Termination at Facilities Without Viable Recovery Processes

The OSS Version 1.2 proposed safeguards termination limit appears to be a "strawman" informally circulated in response to an RFETS request for safeguards termination at 5 wt%. The RFETS request is based solely on the fact that a significant portion of the RFETS residue inventory is in the <5 wt% range. While RFETS circumstances are difficult (RFETS has 3000 kg SNM in their residue inventory and only minor recovery capabilities at best), establishing an across-the-board safeguards termination limit at 50 g/kg in order to accommodate RFETS plans to dispose of this material without SNM recovery is not consistent with the DOE 5630.11 requirement to protect SNM from diversion and so prevent risks to national security. A number of the SNM-bearing materials at RFETS (e.g., residue salts, hydroxide cake, etc.) could be considered very attractive for proliferation purposes at 5 wt% concentrations, as even rudimentary recovery technologies can achieve relatively high recovery efficiencies on some of these materials at such "rich" concentrations.[21]

Also, as time progresses more DOE facilities whose operations have been terminated will face similar problems in trying to disposition SNM-bearing materials remaining in inventory or arising from DandD operations. An artificially-elevated safeguards termination limit is not an appropriate answer for such difficulties. There are both operational and safeguards solutions to such problems. From an operational standpoint, such materials may either be sent to facilities having existing recovery capabilities, or such capacity can be developed on site or via portable treatment units (such portable units have been successfully deployed by LANL previously). From a safeguards perspective, the path forward is already established. Paragraph 1.l(1) of DOE Order 5633.3B clearly states that facilities wishing to discard significant quantities of Attractiveness Level D materials can do so only if a Vulnerability Assessment demonstrates this discard does not present an unacceptable risk to national security. Such vulnerability assessments could be performed by the requesting facility or the intended disposal facility (i.e., WIPP, or Yucca Mountain in the future) could perform a vulnerability assessment that would accommodate the needs of multiple DOE facilities anticipated to encounter disposition problems similar to RFETS.

8.0 Summary/Recommendations

The across-the-board safeguards termination thresholds proposed by OSS are not feasible for implementation at the Los Alamos National Laboratory or other operable Defense Programs facilities. To be practicable and to have a valid derivation from nonproliferation concerns, safeguards termination limits should be based on the degree of difficulty of SNM recovery and the value of specific isotopic compositions for proliferation purposes. The degree of difficulty of SNM recovery from processing residues is not as strongly influenced by SNM concentration in candidate materials as it is by properties of the candidate matrices and available technologies.

LANL proposes a mechanism for deriving safeguards termination thresholds which is strongly tied to degree of difficulty of recovery and attractiveness of specific isotopes. The proposed methodology provides safeguards termination limits which are consistent with extant recovery technologies and discard limits anticipated to be developed through implementation of the DOE/ALO Plutonium Disposition Methodology [although the derived thresholds are not strictly consistent with the existing Economic discard Limits (EDL's) due to advances in technology].

LANL's recommendations for a path forward to issuance of OSS policy for safeguards termination include:

- Adoption of LANL proposed modifications to the 8/22/95 OSS formula for derivation of safeguards termination criteria, i.e., $C_T = 10^{(r + y + A - \log a)/2}$. If OSS is not ready to include radioactivity as a consideration at this time, the proposed formula becomes $C_T = 10^{(y + A - \log a)/2}$

[21] ORNL, 1977

- Structuring policy such that safeguards termination limits are issued as ceilings, below which individual facilities may establish Discard Limits for specific matrices or groups of matrices.

- Requiring facilities establishing Discard Limits to obtain approval for said limits from the responsible DOE Field Office.

- Requiring periodic re-evaluation of Discard Limits to insure that advances in technology and changes in recovery processes are accounted for (i.e., insuring that the safeguards termination process remains a function of the degree of difficulty of recovery.

- Reinforcing the DOE 5633.3B requirement to perform a vulnerability assessment where facilities without recovery technologies identify a need to discard Attractiveness Level D materials exceeding safeguards termination limits; this requirement could be issued in conjunction with a provision for disposal facilities to perform broad vulnerability assessments that accommodate anticipated discards by facilities without recovery capabilities or facilities slated for DandD.

- Seeking additional input from facilities processing high activity SNM-bearing materials as a technical basis for considering the impact of handling/transportation/diversion on the overall degree of difficulty of recovery, and thus the appropriate derivation of safeguards termination limits for such materials.

Department of Energy
Germantown, MD 20874-1290

JUL 22 1998

MEMORANDUM FOR DISTRIBUTION

FROM: EDWARD J. MCCALLUM, DIRECTOR
OFFICE OF SAFEGUARDS AND SECURITY, NN-51

SUBJECT: ADDITIONAL ATTRACTIVENESS LEVEL E CRITERIA FOR SPECIAL NUCLEAR MATERIAL (SNM)

The table in Attachment 1 contains additional and more descriptive information on lower-grade forms of SNM which can be classified as attractiveness level E for purposes of determining levels of safeguards protection. This additional guidance has evolved from Department of Energy (DOE)/Headquarters review of technical recommendations provided by nuclear material processing experts at the Los Alamos National Laboratory (LANL) Materials Technology and the Nonproliferation and International Security Divisions for safeguards termination (see Attachment 2). This review included input from Lockheed-Martin Y-12 Plant processing and safeguards personnel. The attached table complements existing attractiveness level information contained in DOE Order 5633.3B, CONTROL AND ACCOUNTABILITY OF NUCLEAR MATERIAL, and its implementation guide. Using the information in Attachment 2 is appropriate for defining additional attractiveness level E criteria since this criteria and safeguards termination thresholds are closely correlated (refer to DOE Order 5633.3B, Chapter I, 1, 1). In most cases, materials meeting the criteria contained in Attachment 1 can be exempted from materials accountability requirements such as measurements and physical inventories if all other conditions described in DOE Order 5633.3B, Chapter I, 1, 1, are met. It is noted that certain protection measures required to address non-safeguards risks such as radiological sabotage and information security may still be needed based upon results of a risk assessment.

The Office of Safeguards and Security will periodically review and document recoverability and concentration criteria related to attractiveness level E and greater forms of SNM to reflect advances in SNM recovery technology and to ensure appropriateness of attractiveness level classifications.

Please contact David W. Crawford at (301) 903-2536 if you have any questions concerning this guidance.

Attachments:

Attachment 1: Additional Attractiveness Level E Forms and SNM Concentrations

Attachment 2: Letter, Dana C. Christensen, Deputy Division Director, Nuclear Materials Technology Division, LANL, to David W. Crawford, Office of Safeguards and Security, SUBJECT: Recommendation for Safeguards Termination Policy, dated January 22, 1996 (NMT-DO: (U) 96-020) and its attachment

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ATTACHMENT 1

ADDITIONAL ATTRACTIVENESS LEVEL E CRITERIA FOR SPECIAL NUCLEAR MATERIAL

Description/Form	Maximum SNM concentration upon which MC&A and physical protection can be terminated if conditions in DOE Order 5633.3B, I,I,1 are met (wt%)	Maximum SNM concentration upon which only physical protection measures equivalent to Category IV requirements can be applied if conditions in DOE Order 5633.3B, I,I,1 are met* (wt%)
SNM solutions and oxides: nitrate, caustic, chloride solutions contaminated/impure oxides, metal fines and turnings, glovebox sweepings	0.1	N/A
SNM amenable to dissolution and subsequent separation: pyrochemical salts, chloride melt, hydroxide cake, floor sweepings, alumina, condensates, reduction residues, SS&C, MgO crucibles	0.1	0.2
SNM in organic matrices or requiring mechanical separation disassembly and subsequent multiple recovery operations: HEPA filters; organic solutions; oils and sludges; graphite or carbon scrap; surface contaminated plastics; metal components; combustible rubber	0.2	1.0
SNM bound in matrix of solid, sintered, or agglomerated refractory materials: SNM embedded in glass or plastic, high fired incinerator ash, spent resins, salt sludges, raffinates and sulfides	0.5	2.0
SNM microencapsulated in refractory compounds or in solid-dilution: vitrified, bituminized, cemented, or polymer-encapsulated materials, SNM alloyed with refractory elements (W, Pt, Cr, stainless steel), ceramic/glass salvage	1.0	5.0

* concentrations based on LANL recommendations (see Attachment 2)

Department of Energy
Germantown, MD 20874-1290

AUG 22 1996

MEMORANDUM FOR DISTRIBUTION

FROM DAVID W. CRAWFORD, PROGRAM MANAGER
MATERIALS CONTROL AND ACCOUNTABILITY
OFFICE OF SAFEGUARDS AND SECURITY

SUBJECT: DESIGNATION OF MATERIAL FORMS AND CONCENTRATIONS TO THE RETAINED WASTE CATEGORY

Reference 1: Memorandum from E. McCallum to Distribution, Subject: Additional Attractiveness Level E Criteria for Special Nuclear Material (SNM), July 22, 1996.

Reference 2: Department of Energy (DOE) Order 5633.3B, CONTROL AND ACCOUNTABILITY OF NUCLEAR MATERIALS (9-7-94)

This correspondence provides guidance on levels of protection required for special nuclear material (SNM) generated by processing activities or operational accidents which is deemed not worthy of recovery or which is deemed not currently recoverable but does not meet criteria contained in Reference 1. This material, termed "retained waste," can be subjected to reduced protection controls as defined in this memorandum. The criteria for retained waste, based upon material descriptions, are contained in the table below and apply to such materials when they are removed from a processing material balance area (MBA).

Reduced safeguards and security program controls for the materials forms and concentration range in the table below are as follows:

- Physical protection over retained waste should be commensurate with the safeguards category of the material defined in the Graded Safeguards Table (Figure I-2, DOE Order 5633.3B) and determined in accordance to DOE Order 5633.3B, Chapter 1.2. It is noted that the materials description and forms and maximum concentrations in the table represent Attractiveness Level D material. Refer to Reference 1 for physical protection requirements for concentrations below those identified in the table.

- Materials accountability information (material type, quantity, location, etc.) shall remain on the site's inventory records and within the Nuclear Materials Management and Safeguards System.

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- Measurements and physical inventory requirements for the material identified in the table can be deferred to a time when (a) the material is removed from site or (b) the material is reintroduced into a processing MBA. The site must provide requisite physical control over the material to ensure that the contents of items or containers are not altered, e.g., use of tamper-indicating devices, controls commensurate with the safeguards category level of the location, and limited personnel access.

With respect to current and potential SNM-bearing inventory or byproduct material selected for International Atomic Energy Agency (IAEA) safeguards, such materials meeting the criteria contained in the table can be transferred to the retained waste category. This transfer is an approved procedure within the scope of the safeguards agreement between the U.S. and the IAEA. The operational implication of this transfer would be that the IAEA and the U.S. would consult on the adequacy of safeguards measures which should be applied to the retained waste. In principle, the retained waste would be subject to verification by the IAEA, especially if the material is currently part of the inventory that is currently under IAEA inspection.

I can be reached at (301) 903-2536 if you have any questions concerning this technical criteria and guidance.

Technical Criteria for Retained Waste

Description and Form	SNM concentration range (wt %)
SNM solutions and oxides	$>0.1 \leq 0.5$
SNM amenable to dissolution and subsequent separation	$>0.2 \leq 1.0$
SNM alloyed with Al, Th, Zr; spent fuel	≤ 1.0
SNM in organic matrices; SNM requiring mechanical separation/disassembly and multiple recovery operations	$>1.0 \leq 5.0$
SNM bound in matrix of solid, sintered, or agglomerated refractory metals	$>2.0 \leq 7.5$
SNM microencapsulated in refractory compounds or in solid-dilution	$> 5.0 \leq 10.0$

AHLBERG C., CH
BARTELL J., NE-44
BELL D., ID
BOWIE C., SNR
BYERS, K., PNL
DAUGHERTY M., EM-62
GAINES T., EH-21
HENSLEY W., DP-45
HOLMES, F., EM-66
JEWELL D., AL
JORDAN, M., OFO
LEMLEY J., BNL
LUETTERS, F., SNL
MARSH R., OAK
MARTIN R., NBL
MEDLOCK J., OR
NAY W., ER-622
PERRINE E., PNR
PROCO G., NAC INTERNATIONAL
RAMSTEAD R., NV
ROBERTS D., NE-13
RUDOLPH, S., RF
RUTHERFORD D., LANL/N-DIVISION
SMITH G., NN-513.4
√STRAIT S., LLNL
STROHM W., CTA
TODD B., NN-513
WALKER A., RL
WHITE, H.C., YUCCA MOUNTAIN SITE
WHITWORTH A., NN-44
WILLIAMS T., SR
ZACK N., LANL/NIS-7

Appendix D

Evaluation of Human Health Effects from Routine Processing/Storage Operations and Accidents

APPENDIX D
EVALUATION OF HUMAN HEALTH EFFECTS FROM ROUTINE PROCESSING/STORAGE OPERATIONS AND ACCIDENTS

This appendix presents detailed information on the potential impacts and risks to humans associated with releases of radioactivity and hazardous chemicals from the proposed processing and storage technologies during normal operations and from postulated accidents. This information is intended to support the public and occupational health and safety assessments described in Chapter 4 of this Environmental Impact Statement (EIS). Section D.1 provides general background information on radiation and associated health effects, as well as methods and general assumptions used in the assessment of normal and accident radiological impacts; Section D.2 provides information on releases associated with normal operational activities, as well as ranges of potential radiological impacts associated with these normal operational activities at each site; Section D.3 provides indepth information on postulated accidents; and Section D.4 provides information on hazardous chemical impacts. Information regarding potential radiological impacts resulting from intersite transportation is presented in Appendix E of this EIS.

This appendix presents numerical information using engineering and/or scientific notation. For example, the number 100,000 can also be expressed as 1×10^5. The fraction 0.00001 can also be expressed as 1×10^{-5}. The following chart defines the equivalent numerical notations that may be used in this appendix.

FRACTIONS AND MULTIPLES OF UNITS

Multiple	*Decimal Equivalent*	*Prefix*	*Symbol*
1×10^6	1,000,000	mega-	M
1×10^3	1,000	kilo-	k
1×10^2	100	hecto-	h
1×10	10	deka-	da
1×10^{-1}	0.1	deci-	d
1×10^{-2}	0.01	centi-	c
1×10^{-3}	0.001	milli-	m
1×10^{-6}	0.000001	micro-	μ
1×10^{-9}	0.000000001	nano-	n
1×10^{-12}	0.000000000001	pico-	p
1×10^{-15}	0.000000000000001	femto-	f
1×10^{-18}	0.000000000000000001	atto-	a

D.1 RADIOLOGICAL IMPACTS TO HUMAN HEALTH

This section presents supporting information on the potential radiological impacts to humans from normal operations and postulated accidents. It provides the reader with background information on the nature of radiation (Section D.1.1), the methodology used to calculate radiological impacts (Section D.1.2), the input data for the various processing assessments at each site (Section D.1.3), and sample process flow diagrams/ tables that are coordinated with the discussions presented in Appendix C (Section D.1.4).

D.1.1 Background

D.1.1.1 Nature of Radiation and Its Effects on Humans

❒ **What Is Radiation?**—Radiation is energy transferred in the form of particles or waves. Humans are exposed constantly to radiation from the solar system and from the earth's rocks and soil. This radiation contributes to the natural background radiation that has always surrounded us. Manmade sources of radiation also exist, including medical and dental x-rays, household smoke detectors, and materials released from nuclear and coal-fired powerplants.

Radiation comes from the activity of atoms, which form the substance of all matter in the universe. Atoms are composed of even smaller particles (protons, neutrons, electrons), whose number and arrangement distinguish one atom from another. Atoms of different types are known as elements. There are more than 100 natural and manmade elements. Some of these elements, such as uranium, radium, plutonium, and thorium, share a very important quality: they are unstable (i.e., they decay). As they change into more stable forms, invisible waves of energy or particles, known as ionizing radiation, are released. Radioactivity is the emitting of this radiation.

Ionizing radiation refers to the fact that this energy force can ionize, or electrically charge, atoms by stripping off electrons. Ionizing radiation can cause a change in the chemical composition of many things, including living tissue (organs), which can affect the way they function.

- Alpha (α) particles are the heaviest type of ionizing radiation; despite a speed of approximately 16,000 kilometers/second (km/sec) (9,940 miles [mi]/sec), they can travel only several centimeters in air. Alpha particles lose their energy almost as soon as they collide with anything. They can be stopped easily by a sheet of paper or by the skin's surface.

Radiation Type	Typical Speed km/sec	Typical Travel Distance in Air (m)	Barrier
α	16,000	< 1	Sheet of paper or skin's surface
β	160,000	3	Thin sheet of aluminum foil or glass
γ	300,000	Very Large [a]	Thick wall of concrete, lead, or steel
n	39,000	Very Large	Water, Paraffin, Graphite

[a] *Would be infinite in a vacuum*

- Beta particles (β) are much lighter than alpha particles. They can travel at a speed up to 160,000 km/sec (99,400 mi/sec) and can travel in the air for a distance of approximately 3 meters (m) (9.8 feet [ft]). Beta particles can pass through a sheet of paper but may be stopped by a thin sheet of aluminum foil or glass.

- Gamma rays (γ) and x-rays, unlike alpha or beta particles, are waves of pure energy. Gamma rays travel at the speed of light (300,000 km/sec [186,000 mi/sec]). Gamma radiation is very penetrating and requires a thick wall of concrete, lead, or steel to stop it.

- The neutron (n) is another particle that contributes to radiation exposure, both directly and indirectly. The latter is associated with the gamma rays and alpha particles that are emitted following neutron capture in matter. A neutron has about one quarter the weight of an alpha particle and can travel at speeds of up to 39,000 km/sec (24,200 mi/sec). Neutrons are more penetrating than beta particles but less penetrating than gamma rays.

The effects on people of radiation emitted during the disintegration (decay) of a radioactive substance depend on the type of radiation (alpha and beta particles and gamma and x-rays) and the total amount of radiation energy absorbed by the body. The total energy absorbed per unit quantity of tissue is referred to as absorbed dose. The absorbed dose, when multiplied by certain quality factors and factors that take into account different sensitivities of various tissues, is referred to as effective dose equivalent or, where the context is clear, simply dose. The common unit of effective dose equivalent is the roentgen equivalent man (rem); 1 rem equals 1,000 millirem (mrem).

The radioactivity of a material decreases with time. The time it takes a material to lose half of its original radioactivity is designated its half-life. For example, a quantity of iodine-131, a material that has a half-life of 8 days, will lose one-half of its radioactivity in that amount of time. In 8 more days, one-half of the remaining radioactivity will be lost, and so on. Eventually, the radioactivity will essentially disappear. Each radioactive element has a characteristic half-life. The half-lives of various radioactive elements may vary from millionths of a second to millions of years.

When a radioactive element emits a particle or gamma-ray, it often changes to an entirely different element, one that may or may not be radioactive. Eventually, a stable element is formed. This transformation, which may take several steps, is known as a decay chain. Radium, for example, is a naturally occurring radioactive element with a half-life of 1,622 years. It emits an alpha particle and becomes radon, a radioactive gas with a half-life of only 3.8 days. Radon decays first to polonium, then through a series of steps to bismuth, and ultimately to lead.

❒ **Units of Radiation Measure**—Scientists and engineers use a variety of units to measure radiation. These different units can be used to determine the amount, type, and intensity of radiation. Just as heat can be measured in terms of its intensity or effects using units of calories or degrees, amounts of radiation can be measured in curies (Ci), radiation absorbed dose (rad), or rem.

- *Curie*—The curie, named after the French scientists Marie and Pierre Curie, describes the "intensity" of a sample of radioactive material. The rate of decay of 1 gram (g) of radium is the basis of this unit of measure. It is equal to 3.7×10^{10} disintegrations (decays)/sec.

- *Rad*—The total energy absorbed per unit quantity of tissue is referred to as absorbed dose. The rad is the unit of measurement for the physical absorption of radiation. As sunlight heats pavement by giving up an amount of energy to it, so radiation gives up rads of energy to objects in its path. One rad is equal to the amount of radiation that leads to the deposition of 0.01 joule of energy per kilogram of absorbing material.

Radiation Units and Conversions

1 Ci = 3.7×10^{10} sec^{-1} = 3.7×10^{10} Becquerel
1 rad = 100 erg/g = 0.01 Gray
1 erg = 10^{-7} joule
1 Gray = 1 joule/kg = 100 rad
1 rem = 0.01 Sievert

- *Rem*—A rem is a measurement of the dose from radiation based on its biological effects. The rem is used in measuring the effects of radiation on the body as degrees Centigrade are used in measuring the effects of sunlight heating pavement. Thus, 1 rem of one type of radiation is presumed to have the same biological effects as 1 rem of any other kind of radiation. This allows comparison of the biological effects of radionuclides that emit different types of radiation.

An individual may be exposed to ionizing radiation externally (from a radioactive source outside the body) or internally (from ingesting or inhaling radioactive material). The external dose is different from the internal dose because an external dose is delivered only during the actual time of exposure to the external radiation source, but an internal dose continues to be delivered as long as the radioactive source is in the body. For the analyses conducted in this EIS, the dose from internal exposure is calculated over 50 years following the initial exposure; both radioactive decay and elimination of the radionuclide by ordinary metabolic processes decrease the dose rate with the passage of time.

The three types of doses calculated in this EIS are external dose, internal dose, and combined external and internal dose. Each type of dose is discussed separately in the following paragraphs:

- *External Dose*—The external dose can result from several different pathways, all having in common the fact that the radiation causing the exposure is external to the body. In this EIS, these pathways include exposure to a cloud of radiation passing over the receptor, standing on ground that is contaminated with radioactivity, swimming in contaminated water, and boating in contaminated water. The appropriate measure of dose is called the effective dose equivalent. If the receptor departs from the source of radiation exposure, the dose rate will be reduced. It is assumed that external exposure occurs uniformly during the year.

- *Internal Dose*—The internal dose results from a radiation source entering the human body through either ingestion of contaminated food and water or inhalation of contaminated air. In this EIS, pathways for internal exposure include: (1) ingestion of crops contaminated either by airborne radiation deposits or by irrigation using contaminated water sources, (2) ingestion of animal products from animals that ingested contaminated food, (3) ingestion of contaminated water, and (4) inhalation of contaminated air. In contrast to external exposure, once radiation from internal exposure enters the body, it remains there for a period of time that varies depending on decay and biological elimination rates. The unit of measure for internal doses is the committed dose equivalent. It is the internal dose that each body organ receives from 1 "year intake" (ingestion plus inhalation). Normally, a 50- or 70-year dose-commitment period is used (i.e., the 1-year intake period plus 49 or 69 years). The dose rate increases during the 1 year intake. The dose rate after the first year intake declines slowly as the radioactivity in the body continues to produce a dose. The integral of the dose rate over the 50 or 70 years gives the committed dose equivalent. In this EIS, a 50-year dose-commitment period was used.

  The various organs of the body have different susceptibilities to harm from radiation. The quantity that takes these different susceptibilities into account to provide a broad indicator of the risk to the health of an individual from radiation is called the committed effective dose equivalent. It is obtained by multiplying the committed dose equivalent in each major organ or tissue by a weighting factor associated with the risk susceptibility of the tissue or organ, then summing the totals. It is possible for the committed dose equivalent to an organ to be larger than the committed effective dose equivalent if that organ has a small weighting factor. The concept of committed effective dose equivalent applies only to internal pathways.

- *Combined External and Internal Dose*—For convenience, the sum of the committed effective dose equivalent from internal pathways and the effective dose equivalent from external pathways is also called the committed effective dose equivalent in this EIS. The U.S. Department of Energy (DOE), in DOE Order 5400.1, calls this quantity the effective dose equivalent (DOE 1990).

The units used in this EIS for committed dose equivalent, effective dose equivalent, and committed effective dose equivalent to an individual are the rem and mrem (1/1000 of 1 rem). The corresponding unit for the collective dose to a population (the sum of the doses to members of the population, or the product of the number of exposed individuals and their average dose) is the person-rem.

❒ **Sources of Radiation**—The average American receives a total of approximately 350 mrem/year (yr) from all sources of radiation, both natural and manmade. The sources of radiation can be divided into six different categories: (1) cosmic radiation, (2) terrestrial radiation, (3) internal radiation, (4) consumer products, (5) medical diagnosis and therapy, and (6) other sources (NCRP 1987). These categories are discussed in the following paragraphs:

- *Cosmic Radiation*—Cosmic radiation is ionizing radiation resulting from energetic charged particles from space continuously hitting the earth's atmosphere. These particles, and the secondary particles and photons they create, are cosmic radiation. Because the atmosphere provides some shielding against cosmic radiation, the intensity of this radiation increases with altitude above sea level. For the sites considered in this EIS, the cosmic radiation ranges from 29 to 51 mrem/yr. The average dose to the people in the United States is approximately 27 mrem/yr.

- *External Terrestrial Radiation*—External terrestrial radiation is the radiation emitted from the radioactive materials in the earth's rocks and soils. The external terrestrial radiation for the sites in this EIS ranges from 29 to 63 mrem/yr. The average dose from external terrestrial radiation is approximately 28 mrem/yr.

- *Internal Radiation*—Internal radiation results from the human body metabolizing natural radioactive material that has entered the body by inhalation or ingestion. Natural radionuclides in the body include isotopes of uranium, thorium, radium, radon, polonium, bismuth, potassium, rubidium, and carbon. The major contributor to the annual dose equivalent for internal radioactivity are the short-lived decay products of radon, which contribute approximately 200 mrem/yr. The average dose from other internal radionuclides is approximately 39 mrem/yr.

- *Consumer Products*—Consumer products also contain sources of ionizing radiation. In some products, such as smoke detectors and airport x-ray machines, the radiation source is essential to the products' operation. In other products, such as televisions and tobacco, the radiation occurs incidentally to the product function. The average dose from consumer products is approximately 10 mrem/yr.

- *Medical Diagnosis and Therapy*—Radiation is an important diagnostic medical tool and cancer treatment. Diagnostic x-rays result in an average exposure of 39 mrem/yr. Nuclear medical procedures result in an average exposure of 14 mrem/yr.

- *Other Sources*—There are a few additional sources of radiation that contribute minor doses to individuals in the United States. The dose from nuclear fuel-cycle facilities (e.g., uranium mines, mills, and fuel processing plants), nuclear power plants, and transportation routes has been estimated to be less than 1 mrem per year. Radioactive fallout from atmospheric atomic bomb tests, emissions of radioactive material from DOE and Nuclear Regulatory Commission licensed facilities, emissions from certain mineral extraction facilities, and transportation of radioactive materials contribute less than 1 mrem/yr to the average dose to an individual. Air travel contributes approximately 1 mrem/yr to the average dose.

The collective (or population) dose to an exposed population is calculated by summing the estimated doses received by each member of the exposed population. This total dose received by the exposed population is measured in person-rem. For example, if 1,000 people each receive a dose of 1 mrem (0.001 rem), the collective dose is 1,000 persons × 0.001 rem = 1.0 person-rem. Alternatively, the same collective dose (1.0 person-rem) results if 500 people each receive a dose of 2 mrem (500 persons × 2 mrem = 1 person-rem).

❒ **Limits of Radiation Exposure**—The amount of manmade radiation that the public may be exposed to is limited by Federal regulations. Although most scientists believe that radiation absorbed in small doses over several years is not harmful, U.S. Government regulations assume that the effects of all radiation exposures are cumulative.

Under the Clean Air Act, the exposure to a member of the general public from DOE facility releases into the atmosphere is limited by the U.S. Environmental Protection Agency (EPA) to a dose of 10 mrem/yr in addition to the natural background and medical radiation normally received (EPA 1995). DOE also limits to 10 mrem the dose annually received from material released to the atmosphere (DOE 1993e). EPA and DOE also limit the annual dose to a member of the general public from radioactive releases to drinking water to 4 mrem, as required under the Safe Drinking Water Act (EPA 1992a; DOE 1993e). The annual dose from all radiation sources from a site is limited by EPA to 25 mrem (EPA 1992b). The DOE annual limit of radiation dose from all pathways to a member of the general public is 100 mrem. (DOE 1993e).

Each of the three sites covered by this EIS operates below all of these limits. The average individual in the United States receives a dose of approximately 0.3 rem (300 mrem) per year from natural sources of radiation. For perspective, a modern chest x-ray results in an approximate dose of 0.006 rem (6 mrem) and a diagnostic pelvis and hip x-ray results in an approximate dose of 0.065 rem (65 mrem) (NCRP 1987). An acute dose of about 450 rem (450,000 mrem) would result in a 50 percent chance of death.

For people working in an occupation that involves radiation, the Nuclear Regulatory Commission and DOE limit doses to 5 rem (5,000 mrem) in any 1 year (NRC 1993; DOE 1993a). DOE also conventionally imposes a 2 rem/yr Administrative Control Limit amongst its sites in the interest of complying with As Low As Reasonably Achievable initiatives (DOE 1996a).

D.1.1.2 Health Effects

Radiation exposure and its consequences are topics of interest to the general public. For this reason, this EIS places much emphasis on the consequences of exposure to radiation, even though the effects of radiation exposure under most circumstances evaluated in this EIS are small. To provide the background for discussions of impacts, this section explains the basic concepts used in the evaluation of radiation effects.

Radiation can cause a variety of ill-health effects in people. The most significant ill-health effect to depict the consequences of environmental and occupational radiation exposure is induction of cancer fatalities. This effect is referred to as "latent" cancer fatalities because the cancer may take many years to develop and for death to occur and may not actually be the cause of death. In the discussions that follow, all fatal cancers are considered latent and the term "latent" is not used.

Health impacts from radiation exposure, whether from sources external or internal to the body, generally are identified as "somatic" (affecting the individual exposed) or "genetic" (affecting descendants of the exposed individual). Radiation is more likely to produce somatic effects than to produce genetic effects. For this EIS, therefore, only the somatic risks are presented. The somatic risks of most importance are the induction of cancers. Except for leukemia, which can have an induction period (time between exposure to carcinogen and cancer diagnosis) of as little as 2 to 7 years, most cancers have an induction period of more than 20 years.

For a uniform irradiation of the body, the incidence of cancer varies among organs and tissues; the thyroid and skin demonstrate a greater sensitivity than other organs. Such cancers, however, also produce relatively low mortality rates because they are relatively amenable to medical treatment. Because of the readily available data for cancer mortality rates and the relative scarcity of prospective epidemiologic studies, somatic effects leading to cancer fatalities rather than cancer incidence are presented in this EIS. The numbers of cancer fatalities can be used to compare the risks among the various alternatives.

The National Research Council's Committee on the Biological Effects of Ionizing Radiation has prepared a series of reports to advise the U.S. Government on the health consequences of radiation exposures. The latest of these reports, *Health Effects of Exposure to Low Levels of Ionizing Radiation BEIR V* (NAS 1990), provides the most current estimates for excess mortality from leukemia and cancers other than leukemia expected to result from exposure to ionizing radiation. This report updates the models and risk estimates provided in an

earlier report of the Committee, *The Effects on Populations of Exposure to Low Levels of Ionizing Radiation.* The BEIR V models were developed for application to the U.S. population.

BEIR V provides estimates that are consistently higher than those in its predecessor BEIR III. This increase is attributed to several factors, including the use of a linear dose response model for cancers other than leukemia, revised dosimetry for the Japanese atomic bomb survivors, and additional follow-up studies of the atomic bomb survivors and other cohorts. BEIR III employs constant relative and absolute risk models, with separate coefficients for each of several sex and age-at-exposure groups; BEIR V develops models in which the excess relative risk is expressed as a function of age at exposure, time after exposure, and sex for each of several cancer categories. The BEIR III models were based on the assumption that absolute risks are comparable between the atomic bomb survivors and the U.S. population; BEIR V models were based on the assumption that the relative risks are comparable. For a disease such as lung cancer, where baseline risks in the United States are much larger than those in Japan, the BEIR V approach leads to larger risk estimates than the BEIR III approach.

The models and risk coefficients in BEIR V were derived through analyses of relevant epidemiologic data that included the Japanese atomic bomb survivors, ankylosis spondylitis patients, Canadian and Massachusetts fluoroscopy patients (breast cancer), New York postpartum mastitis patients (breast cancer), Israel Tinea Capitis patients (thyroid cancer), and Rochester thymus patients (thyroid cancer). Models for leukemia, respiratory cancer, digestive cancer, and other cancers used only the atomic bomb survivor data, although results of analyses of the ankylosis spondylitis patients were considered. Atomic bomb survivor analyses were based on revised dosimetry with an assumed relative biological effectiveness of 20 for neutrons and were restricted to doses less than 400 rads. Estimates of risks of fatal cancers other than leukemia were obtained by totaling the estimates for breast cancer, respiratory cancer, digestive cancer, and other cancers.

- **Risk Estimates for Doses Equal to or Greater than 20 Rem**—BEIR V includes risk estimates for a single exposure to a high level of radiation to all people in a large population group. The estimates are given in terms of lifetime risks per 1.0×10^6 person-rem. Fatality estimates for leukemia, breast cancer, respiratory cancer, digestive cancer, and other cancers are given for both sexes and nine age-at-exposure groups. These estimates, based on the linear model, are summarized in **Table D–1**. The average risk estimate from all ages and both sexes is 885 excess cancer fatalities per million person-rem. This value has been conservatively rounded up to 1,000 excess cancer fatalities per million person-rem.

Table D–1 Lifetime Risks per 1,000,000 Person-Rem for Individual Exposures Greater Than 20 Rem

Gender	*Type of Fatal Cancer*		
	Leukemia [a]	*Cancers Other Than Leukemia*	*Total Cancers*
Male	220	660	880
Female	160	730	890
Average	190	695	885 [b]

[a] These are the linear estimates, which are double the linear-quadratic estimates provided in BEIR V for leukemia at low doses and dose-rates.

[b] This value has been rounded up to 1,000 excess cancer fatalities per million person-rem.

Source: NAS 1990.

Although values for other health effects are not presented in this EIS, the risk estimators for nonfatal cancers and for genetic disorders to future generations are estimated to be approximately 200 and 260 per million person-rem, respectively. These values are based on information presented in the *1990 Recommendations of the International Commission on Radiological Protection* (ICRP 1991) and are seen to be 20 percent and 26 percent, respectively, of the fatal cancer estimator. Thus, if the number of excess fatal cancers is projected to be "X," the number of excess genetic disorders would be 0.26 times "X."

❒ **Risk Estimates for Doses Less than 20 Rem**—For doses lower than 20 rem, a linear-quadratic model provides a significantly better fit to the data for leukemia than a linear model, and leukemia risks were based on a linear-quadratic function, which reduces the effects by a factor of two over estimates that are obtained from a linear model. For other cancers, linear models were found to provide an adequate fit to the data and were used for extrapolation to low doses. The BEIR V Committee, however, recommended reducing these linear estimates by a factor between 2 and 10 for doses received at low dose rates. For this EIS, a risk reduction factor of two was adopted for conservatism.

Based on the preceding discussion, the resulting risk estimator would be equal to half the value observed for high-dose situations or approximately 500 excess fatal cancers per million person-rem (0.0005 excess fatal cancer per person-rem). This is the risk value used in this EIS to calculate fatal cancers to the general public during normal operations and also for accidents in which individual doses are less than 20 rem. For workers, a value of 400 excess fatal cancers per million person-rem (0.0004 excess fatal cancer per person-rem) is used in this EIS. This lower value reflects the absence of children (who are more radiosensitive than adults) in the workforce. Again, based on information provided in the *1990 Recommendations of the International Commission on Radiological Protection* (ICRP 1991), the health risk estimators for nonfatal cancer and genetic disorders among the public are 20 percent and 26 percent, respectively, of the fatal cancer risk estimator. For workers, the health risk estimators are both 20 percent of the fatal cancer risk estimator. For this EIS, only fatal cancers are presented.

The risk estimates may be applied to calculate the effects of exposing a population to radiation. For example, in a population of 100,000 people exposed only to natural background radiation (0.3 rem/yr), 15 latent cancer fatalities per year would result from this radiation (100,000 persons × 0.3 rem/yr × 0.0005 latent cancer fatalities per person-rem = 15 latent cancer fatalities/yr).

Calculations of the number of excess cancer fatalities associated with radiation exposure do not always yield whole numbers; calculations may yield numbers less than 1.0, especially in environmental applications. For example, if a population of 100,000 were exposed as described in the previous paragraph but to a total dose of only 0.001 rem, the collective dose would be 100 person-rem, and the corresponding estimated number of latent cancer fatalities would be 0.05 (100,000 persons × 0.001 rem × 0.0005 latent cancer fatalities/person-rem = 0.05 latent cancer fatalities).

For latent cancer fatalities less than 1.0, the estimated 0.05 latent cancer fatalities is a statistical estimate—0.05 is the *average* number of deaths that would result if the same exposure situation were applied to many different groups of 100,000 people. In most groups, no person (0 people) would incur a latent cancer fatality from the 0.001 rem dose each member would have received. In a small fraction of the groups, 1 latent cancer fatality would result; in exceptionally few groups, 2 or more latent cancer fatalities would occur. The *average* number of deaths over all the groups would be 0.05 latent cancer fatalities (just as the average of 0, 0, 0, and 1 is 1/4, or 0.25). The most likely outcome is 0 latent cancer fatalities.

These same concepts apply to estimating the effects of radiation exposure on a single individual. Consider the effects, for example, of exposure to background radiation over a lifetime. The "number of latent cancer fatalities" corresponding to a single individual's exposure over a (presumed) 72-year lifetime to 0.3 rem/yr is the following:

1 person × 0.3 rem/yr × 72 yr × 0.0005 latent cancer fatalities/person-rem = 0.011 latent cancer fatalities.

Again, this is a statistical estimate; that is, the estimated effect of background radiation exposure on the exposed individual would produce a 1.1 percent chance that the individual might incur a latent cancer fatality caused by the exposure over his full lifetime. Presented another way, this method estimates that approximately 1.1 percent of the population might die of cancers induced by background radiation (DOE 1996a).

D.1.2 Methodology for Estimating Radiological Impacts

The radiological impacts of normal operation and postulated accidents of processing/storage facilities were calculated using Version 1.485 of the GENII computer code, which will remain the latest version of the code available until the 1998–1999 timeframe (Napier 1997). Site-specific and technology-specific input data were used, including location, meteorology, population, food production and consumption, and source terms. Section D.1.2.1 briefly describes GENII and outlines the approach used for normal operations. The approach used for design basis accidents is discussed later in Section D.3.

D.1.2.1 GENII Computer Code

The GENII computer model, developed by Pacific Northwest Laboratory, is an integrated system of various computer modules that analyze environmental contamination resulting from acute or chronic releases to, or initial contamination in, air, water, or soil. The model calculates radiation doses to individuals and populations. The GENII computer model is well documented for assumptions, technical approach, methodology, and quality assurance issues (PNL 1988). The GENII computer model has gone through extensive quality assurance and quality control steps, including comparing results from model computations with those from hand calculations and performing internal and external peer reviews. Recommendations given in these reports were incorporated into the final GENII computer model, as deemed appropriate.

For this EIS, only the ENVIN, ENV, and DOSE computer modules were used. The codes are connected through data transfer files. The output of one code is stored in a file that can be used by the next code in the system.

- **ENVIN**—The ENVIN module of the GENII code controls the reading of input files and organizes the input for optimal use in the environmental transport and exposure module, ENV. The ENVIN code interprets the basic input, reads the basic GENII data libraries and other optional input files, and organizes the input into sequential segments based on radionuclide decay chains.

  A standardized file that contains scenario, control, and inventory parameters is used as input to ENVIN. Radionuclide inventories can be entered as functions of releases to air or water, concentrations in basic environmental media (air, soil, or water), or concentrations in foods. If certain atmospheric dispersion options have been selected, this module can generate tables of atmospheric dispersion parameters that will be used in later calculations. If the finite plume air submersion option is requested in addition to the atmospheric dispersion calculations, preliminary energy-dependent finite plume dose factors are prepared as well. The ENVIN module prepares the data transfer files that are used as input by the ENV module; ENVIN generates the first portion of the calculation documentation—the run input parameters report.

- **ENV**—The ENV module calculates the environmental transfer, uptake, and human exposure to radionuclides that result from the chosen scenario for the user-specified source term. The code reads the input files from ENVIN and then, for each radionuclide chain, sequentially performs the precalculations to establish the conditions at the start of the exposure scenario. Environmental concentrations of radionuclides are established at the beginning of the scenario by assuming decay of preexisting sources, considering biotic transport of existing subsurface contamination, and defining soil contamination from continuing atmospheric or irrigation depositions. For each year of postulated exposure, the code then estimates the air, surface soil, deep soil, groundwater, and surface water concentrations of each radionuclide in the chain. Human exposures and intakes of each radionuclide are calculated for (1) pathways of external exposure from finite atmospheric plumes; (2) inhalation; (3) external exposure from contaminated soil, sediments, and water; (4) external exposure from special geometries; and (5) internal exposures from consumption of terrestrial foods, aquatic foods, drinking water, animal products, and inadvertent intake of soil. The intermediate information on annual media concentrations and intake rates are written to data

The annual external exposure time to the plume and

transfer files. Although these may be accessed directly, they are usually used as input to the DOSE module of GENII.

- **DOSE**—The DOSE module reads the intake and exposure rates defined by the ENV module and converts the data to radiation dose.

D.1.2.2 Data and General Assumptions for Normal Operations and Postulated Accidents

To perform the dose assessments for this EIS, different types of data were collected and/or generated. In addition, calculational assumptions were made. This section discusses both the data collected and/or generated for use in performing the dose assessments and the assumptions made for this EIS.

- **Meteorological Data**—The meteorological data used for all sites discussed in this EIS were in the form of joint frequency data files. A joint frequency data file is a table listing the fractions of time the wind blows in a certain direction, at a certain speed, and within a certain stability class. The joint frequency data files were based on measurements taken over a period of several years at different locations and heights on each of the sites. Average annual meteorological conditions (averaged over the measurement period) were used for normal operation.

- **Population Data**—Population distributions were based on site-provided information and on the *1990 Census of Population and Housing* data (DOC 1992). Projections were determined for the year 2000 (approximate midlife of operations) for areas within 80 km (50 mi) of the proposed facilities at each candidate site. The site population in 2000, assumed to be representative of the population over the operational period evaluated, was used in the impact assessments. The population was spatially distributed on a circular grid with 16 directions and 10 radial distances up to 80 km (50 mi). The grid was centered on the facility from which the radionuclides were assumed to be released.

- **Source Term Data**—The source terms (quantities of radionuclides released to the environment over a given period) for each alternative were estimated based on experience with similar facility operations and safety analysis assessments. The source terms used to generate the estimated impacts of normal operations are provided in Section D.2 for the processing/storage processes examined in this EIS.

- **Food Production and Consumption Data**—Data from the *1987* and *1992 Censuses of Agriculture* (DOC 1988; DOC 1993) were used to generate site-specific data for food production. Food production was spatially distributed on the same circular grid used for the population distributions. The consumption rates used in GENII were those for the maximum individual and average individual. People living within the 80-km (50-mi) assessment area were assumed to consume only food grown in that area.

- **Calculational Assumptions**—Dose assessments were performed for both members of the general public and workers for each site examined in this EIS. These assessments were made to determine the *incremental* doses that would be associated with the alternatives addressed in this EIS. Doses for members of the public were calculated for two different types of receptors: the maximally exposed offsite individual and the general population living within 80 km (50 mi) of the facility. The maximally exposed individual associated with the alternatives addressed in this EIS was assumed to be located at a position on the [illegible] boundary that would [illegible]

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The exposure, uptake, and usage parameters used in the GENII model for normal operations are provided in **Table D–2** through **Table D–4**. The parameters used for postulated accidents are presented in **Table D–5** through **Table D–7**.

Table D–2 GENII Exposure Parameters to Plumes and Soil Contamination (Normal Operations)

Maximum Individual				*General Population*			
External Exposure		*Inhalation of Plume*		*External Exposure*		*Inhalation of Plume*	
	Soil	*Exposure*	*Breathing*		*Soil*	*Exposure Time*	*Breathing Rate*

Table D–5 GENII Exposure Parameters to Plumes and Soil Contamination (Postulated Accidents)

Maximum Individual				*General Population*			
External Exposure		*Inhalation of Plume*		*External Exposure*		*Inhalation of Plume*	
Plume (hours)	*Soil Contamination (hours)*	*Exposure Time (hours)*	*Breathing Rate (cm^3/sec)*	*Plume (hours)*	*Soil Contamination (hours)*	*Exposure Time (hours)*	*Breathing Rate (cm^3/sec)*
0.00	6,136	100% of Release Time	330	0.00	6,136	100% of Release Time	330

cm^3/sec = cubic centimeter per second
Source: PNL 1988, NRC 1977.

Table D–6 GENII Usage Parameters for Consumption of Terrestrial Food (Postulated Accidents)

	Maximum Individual				*General Population*			
Food Type	*Growing Time (days)*	*Yield (kg/m^2)*	*Holdup Time (days)*	*Consumption Rate (kg/yr)*	*Growing Time (days)*	*Yield (kg/m^2)*	*Holdup Time (days)*	*Consumption Rate (kg/yr)*
Leafy Vegetables	90.0	1.5	1.0	30.0	90.0	1.5	14.0	15.0
Root Vegetables	90.0	4.0	5.0	220.0	90.0	4.0	14.0	140.0
Fruit	90.0	2.0	5.0	330.0	90.0	2.0	14.0	64.0
Grains/Cereals	90.0	0.8	180.0	80.0	90.0	0.8	180.0	72.0

kg/m^2 = kilogram per square meter kg/yr = kilogram per year
Source: PNL 1988.

Table D–7 GENII Usage Parameters for Consumption of Animal Products (Postulated Accidents)

			Stored Feed				*Fresh Forage*			
Food Type	*Consumption Rate (kg/yr)*	*Holdup Time (days)*	*Diet Fraction*	*Growing Time (days)*	*Yield (kg/m^2)*	*Storage Time (days)*	*Diet Fraction*	*Growing Time (days)*	*Yield (kg/m^2)*	*Storage Time (days)*
Maximum Individual										
Beef	80.0	15.0	0.25	90.0	0.80	180.0	0.75	45.0	2.00	100.0
Poultry	18.0	1.0	1.00	90.0	0.80	180.0	--	--	--	--
Milk	270.0	1.0	0.25	45.0	2.00	100.0	0.75	30.0	1.50	0.00
Eggs	30.0	1.0	1.00	90.0	0.80	180.0	--	--	--	--
General Population										
Beef	70.0	34.0	0.25	90.0	0.80	180.0	0.75	45.0	2.00	100.0
Poultry	8.5	34.0	1.0	90.0	0.80	180.0	--	--	--	--
Milk	230.0	3.0	0.25	45.0	2.00	100.0	0.75	30.0	1.50	0.00
Eggs	20.0	18.0	1.0	90.0	0.80	180.0	--	--	--	--

kg/yr = kilogram per year kg/m^2 = kilogram per square meter
Source: PNL 1988.

Workforce doses (on a weekly basis) directly associated with processing/storage normal operations were taken from reports prepared by Rocky Flats, the Savannah River Site, and Los Alamos National Laboratory. To obtain the total workforce dose associated with a particular processing/storage process over its operational interim, the reported weekly dose is multiplied by the estimated number of weeks the particular process is to be in effect.

Radiological impacts to workers from postulated accident scenarios were evaluated at onsite locations where a given incident would cause the highest dose. For conservatism, the maximally exposed onsite worker was assumed to have an inhalation exposure time of 5 minutes and an external exposure time to soil contamination of 20 minutes. For a ground-level release accident, a maximally exposed onsite worker was assumed to be 100 meters from a given release point; for an elevated release, the worker was situated between 200 and 500 meters, depending on the given site's atmospheric dispersion characteristics. All doses to workers include a component associated with the intake of radioactivity into the body and another component resulting from external exposure to direct radiation.

D.1.2.3 Health Effects Calculations

In this EIS, the collective combined effective dose equivalent is the sum of the collective committed effective dose equivalent (internal dose) and the collective effective dose equivalent (external dose), as explained in Section D.1.1.1. Doses calculated by GENII were used to estimate health effects using the risk estimators presented in Section D.1.1.2. The incremental cancer fatalities in the general population and in groups of workers caused by radiation exposure were, therefore, estimated by multiplying the collective combined effective dose equivalent by 0.0005 and 0.0004 fatal cancers/person-rem, respectively, for normal operations and also for accidents in which doses to members of the population were less than 20 rem. For situations in which the dose was greater than 20 rem, these factors were doubled. Although health risk factors are statistical factors and not strictly applicable to individuals, they have been used in the past to estimate the incremental risk to an individual from exposure to radiation. Therefore, the factor of 0.0005 and 0.0004 per rem of individual committed effective dose equivalent for a member of the public and for a worker, respectively (or double these values for individual doses greater than 20 rem), have also been used in this EIS to calculate the individual's incremental fatal cancer risk from exposure to radiation.

For the public, the health effects expressed in this EIS are the risk of fatal cancers to the maximally exposed individual and the number of fatal cancers to the 80-km (50-mi) population from exposure to radioactivity released from any site over the full operational period. For workers, the health effects expressed are the risk to the average worker at a site and the number of fatal cancers to all workers at that site over the full period of site operations.

D.1.2.4 Uncertainties

The sequence of analyses performed to generate the radiological impact estimates from normal operation include: (1) selection of normal operational modes, (2) estimation of source terms, (3) estimation of environmental transport and uptake of radionuclides, (4) calculation of radiation doses to exposed individuals, and (5) estimation of health effects. There are uncertainties associated with each of these steps. Uncertainties exist in the way the physical systems being analyzed are represented by the computational models and in the data required to exercise the models (due to measurement errors, sampling errors, or natural variability).

In principle, one can estimate the uncertainty associated with each source and predict the remaining uncertainty in the results of each set of calculations. Thus, one can propagate the uncertainties from one set of calculations to the next and estimate the uncertainty in the final results. However, conducting such a full-scale quantitative uncertainty analysis is neither practical nor a standard practice for a study of this type. Instead, the analysis is designed to ensure—through judicious selection of release scenarios, models, and parameters—that the results represent the potential risks. This is accomplished by making conservative assumptions in the calculations at each step. The models, parameters, and release scenarios used in the calculations are selected in such a way that most intermediate results and, consequently, the final estimates of impacts are greater than what would be expected. As a result, even though the range of uncertainty in a quantity might be large, the value calculated for the quantity is close to one of the extremes in the range of possible values, so that the chance of the actual quantity being greater than the calculated value is low (or the chance of the quantity being less than the calculated value if the criteria are such that the quantity has to be maximized). This has been the

goal of the radiological assessment for normal operation in this study (i.e., to produce results that are conservative).

The degree of conservatism in the calculated results is closely related to the range of possible values the quantity can have. This range is determined by what can be expected to realistically occur. Thus, the only processes considered are those credible for the conditions under which the physical system being modeled operates. This consideration has been employed for normal operation analyses.

Uncertainties are also derived from the lack of engineering design data for facilities that are only conceptual. Although the radionuclide composition of source terms are reasonable estimates, there are uncertainties in the radionuclide inventory and release reactions that affect estimated impacts.

D.1.3 Radiological Impact Assessment Data

This section presents the various site-dependent GENII input data required for quantifying the potential radiological impacts associated with the processing/storage alternatives discussed in this EIS. Agricultural data, population data, meteorological data, and atmospheric dispersion characteristics are presented for Rocky Flats, the Savannah River Site, and Los Alamos National Laboratory.

- **Agricultural Data**—Agricultural food production data (wheels) were generated based on the results of the 1987 and 1992 U.S. Censuses of Agriculture (DOC 1988; DOC 1993). The wheel was generated by combining the fraction of a county in each segment (e.g., south, southwest, north-northeast) and the county production of the eight food categories analyzed by GENII (leafy vegetables, root vegetables, fruits, grains, beef, poultry, milk, and eggs). Each county's food production (in kilograms) was assumed to be distributed uniformly over the given county's land area. These categorized food wheels are fed into GENII as an input file and are used in the assessment of doses to a given general population from the ingestion pathway. For further discussion, see Section D.1.2.2.

- **Population Data**—Population data (wheels) were generated based on the 1990 U.S. Census of Population and Housing (DOC 1992). For each block in the 1990 census, the population was assigned a distance and direction from the release point; then the block's population was projected based on state estimates of county growth rates through the year 2000. The population in each segment (e.g., south, southwest, north-northeast) was cumulated over all the blocks in the census. These population wheels are fed into GENII as an input file and are used in the assessment of a total dose incurred to a given general population. For further discussion, see Section D.1.2.2.

- **Meteorological Data**—Meteorological data (i.e., Joint Frequency Distributions) were based on measurements of the fractions of time (given as percentages) the wind blows in a certain direction, at a certain speed, and within a certain stability class for each site examined within this EIS. These data are fed into GENII as an input file and are used in the evaluation of χ/Q or E/Q values (these values represent radioisotope concentrations divided by the rates at which they are emitted to the environment), which are used to determine the total dose incurred to a given general population, an offsite maximally exposed individual, or an onsite worker.

D.1.3.1 Radiological Impact Assessments at Rocky Flats

This section presents the radiological impact input data used in the assessment of the various processing/storage alternatives at Rocky Flats. For purposes of radiological impact modeling, the Rocky Flats analyses assumed that Buildings 707 and 371 would be the locations from which radioactive effluents would be released. **Table D–8** presents the characteristics of both these release points, including location, release height, minimum distance, and annual average dispersion to the site boundary in each of 16 directions.

Table D–8 Release Point Characteristics, Direction, Distance, and Atmospheric Dispersion at the Rocky Flats Site Boundary

Release Location	*Building 707*		*Building 371*	
Latitude [a]	39.89°		39.89°	
Longitude [a]	-105.20°		-105.20°	
Release Height	12.4 m		44.2 m	
Distance and Atmospheric Dispersion at Site Boundary				
	Building 707		*Building 371*	
Direction	*Distance (m)*	*χ/Q (sec/m³)*	*Distance (m)*	*χ/Q (sec/m³)*
N	2,350	1.0×10^{-7}	2,310	2.5×10^{-7}
NNE	2,540	7.6×10^{-8}	2,340	2.0×10^{-7}
NE	2,730	5.3×10^{-8}	2,720	1.1×10^{-7}
ENE	3,120	3.9×10^{-8}	3,270	8.1×10^{-8}
E	3,060	3.0×10^{-8}	3,620	5.6×10^{-8}
ESE	3,120	3.2×10^{-8}	3,720	6.0×10^{-8}
SE	2,880	5.0×10^{-8}	3,220	1.0×10^{-7}
SSE	2,440	7.5×10^{-8}	2,670	1.7×10^{-7}
S	2,380	8.9×10^{-8}	2,610	2.2×10^{-7}
SSW	2,440	1.0×10^{-7}	2,460	2.5×10^{-7}
SW	2,140	1.3×10^{-7}	1,610	6.0×10^{-7}
WSW	1,940	2.1×10^{-7}	1,740	7.1×10^{-7}
W	2,980	1.3×10^{-7}	2,560	3.8×10^{-7}
WNW	3,030	1.3×10^{-7}	2,620	3.6×10^{-7}
NW	2,930	8.9×10^{-8}	2,360	3.1×10^{-7}
NNW	2,410	1.1×10^{-7}	2,360	2.7×10^{-7}

χ/Q = Radioisotope concentrations divided by the rates at which they are emitted to the environment
sec/m³ = seconds per cubic meter
[a] The distance between Buildings 707 and 371 is approximately 500 meters.
Source: DOE 1995b, DOE 1996e, PNL 1988.

Descriptions of population and foodstuff distributions centered on Rocky Flats are provided in **Table D–9** and **Table D–10**, respectively. The joint frequency distribution used for the dose assessment (presented in **Table D–11**) was based on the meteorological measurements for 1994 and 1996 taken from the meteorological tower at Rocky Flats at the 10-m (33-ft) height.

Table D–9 Rocky Flats Population Data Out to 80 km (50 mi) for Year 2000

	Distance (miles)										
Direction	*0-1*	*1-2*	*2-3*	*3-4*	*4-5*	*5-10*	*10-20*	*20-30*	*30-40*	*40-50*	*TOTAL*
S	0	0	164	466	519	10,777	41,364	18,942	4,306	3,544	**80,082**
SSW	0	0	164	308	229	438	12,822	8,927	2,551	1,945	**27,384**
SW	0	0	90	56	61	499	3,682	1,227	1,054	1,281	**7,950**
WSW	0	0	21	55	58	500	1,623	2,765	1,890	8,392	**15,304**
W	0	0	53	68	58	496	3,898	1,343	1,112	893	**7,921**
WNW	0	0	21	53	66	418	1,497	1,604	388	1,833	**5,880**
NW	0	0	38	35	144	970	1,490	3,322	5	2,599	**8,603**
NNW	0	0	73	81	211	58,878	29,949	4,208	7,627	5,545	**106,572**
N	0	0	46	94	493	8,207	21,684	17,222	50,176	115,674	**213,596**
NNE	0	0	77	143	595	21,060	22,519	34,494	8,747	11,876	**99,511**
NE	0	0	107	410	200	15,797	3,852	3,772	2,631	85,090	**111,859**
ENE	0	0	5	100	11	28,481	21,467	25,953	3,255	2,106	**81,378**
E	0	0	6	1,315	5,954	41,207	98,629	4,323	3,253	3,031	**157,718**
ESE	0	0	21	223	192	65,014	103,130	137,283	4,034	1,124	**311,021**

Direction	Distance (miles) 0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50	TOTAL
SE	0	0	10	500	3,675	58,471	308,362	316,464	53,246	7,366	**748,094**
SSE	0	0	171	857	1,742	25,320	211,024	179,144	17,158	16,678	**452,094**
TOTAL	**0**	**0**	**1,067**	**4,764**	**14,208**	**336,533**	**886,992**	**760,993**	**161,433**	**268,977**	**2,434,967**

Source: Nesta 1997b.

Table D–10 Rocky Flats Agricultural Data (kg/yr)

Food Type	Distance (miles) 0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50	Wind Direction
Leafy Veg.	0	0	0	0	0	0	0	0	0	0	S
	0	0	0	0	0	0	0	0	0	0	SSW
	0	0	0	0	0	0	0	0	0	0	SW
	0	0	0	0	0	0	0	0	0	0	WSW
	0	0	0	0	0	0	0	0	0	0	W
	0	0	0	0	0	0	0	0	0	0	WNW
	0	0	0	0	0	0	0	0	0	0	NW
	0	0	0	0	0	0	0	0	0	0	NNW
	0	0	0	0	0	0	0	0	0	0	N
	0	0	0	0	0	0	0	0	0	0	NNE
	0	0	0	0	0	0	0	0	0	0	NE
	0	0	0	0	0	0	0	0	0	0	ENE
	0	0	0	0	0	0	0	0	0	0	E
	0	0	0	0	0	0	0	0	0	0	ESE
	0	0	0	0	0	0	0	0	0	0	SE
	0	0	0	0	0	0	0	0	0	0	SSE
Root Veg.	0	0	0	0	0	0	0	0	0	0	S
	0	0	0	0	0	0	0	0	0	0	SSW
	0	0	0	0	0	0	0	0	0	0	SW
	0	0	0	0	0	0	0	0	0	0	WSW
	0	0	0	0	0	0	0	0	0	0	W
	0	0	4,900	19,000	32,000	360,000	1.30×10^{6}	1.50×10^{6}	0	0	WNW
	0	0	34,000	38,000	48,000	400,000	1.60×10^{6}	2.40×10^{6}	980,000	400,000	NW
	0	14,000	27,000	38,000	48,000	400,000	160×10^{6}	2.60×10^{6}	3.00×10^{6}	3.80×10^{6}	NNW
	0	16,000	27,000	38,000	48,000	400,000	1.60×10^{6}	2.40×10^{6}	3.00×10^{6}	3.80×10^{6}	N
	0	15,000	27,000	38,000	48,000	400,000	1.90×10^{6}	7.10×10^{6}	8.60×10^{6}	1.30×10^{7}	NNE
	0	11,000	27,000	38,000	48,000	400,000	6.30×10^{6}	1.30×10^{7}	1.80×10^{7}	2.30×10^{7}	NE
	0	0	19,000	36,000	48,000	380,000	4.30×10^{6}	1.20×10^{7}	1.80×10^{7}	2.30×10^{7}	ENE
	0	0	0	680	7,400	190,000	990,000	2.10×10^{6}	5.60×10^{6}	9.50×10^{6}	E
	0	0	0	0	0	86,000	890,000	1.40×10^{6}	1.30×10^{6}	1.10×10^{6}	ESE
	0	0	0	0	0	7,600	120,000	45,000	0	0	SE
	0	0	0	0	0	0	0	0	0	0	SSE
Fruits	0	0	0	0	0	0	0	0	0	0	S
	0	0	0	0	0	0	0	0	0	0	SSW
	0	0	0	0	0	0	0	0	0	0	SW
	0	0	0	0	0	0	0	0	0	0	WSW
	0	0	0	0	0	0	0	0	0	0	W
	0	0	0.360	1.40	2.40	27.0	99.0	110	0	0	WNW
	0	0	2.50	2.80	3.60	30.0	120	180	50.0	0	NW
	0	1.00	2.00	2.80	3.60	30.0	120	160	8.40	0	NNW
	0	1.20	2.00	2.80	3.60	30.0	120	110	0	0	N

Food Type	Distance (miles) 0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50	Wind Direction
Fruits (continued)	0	1.10	2.00	2.80	3.60	30.0	110	85.0	18.0	28.0	NNE
	0	0.850	2.00	2.80	3.60	30.0	42.0	33.0	46.0	60.0	NE
	0	0	1.40	2.70	3.60	25.0	10.0	32.0	46.0	60.0	ENE
	0	0	0	0	0	6.20	0	1.30	10.0	20.0	E
	0	0	0	0	0	0	0	0	0	0	ESE
	0	0	0	0	0	0	0	0	0	0	SE
	0	0	0	0	0	0	0	0	0	0	SSE
Grains	0	390	480	680	870	7,300	29,000	66,000	220,000	390,000	S
	0	390	480	680	870	7,300	29,000	39,000	33,000	28,000	SSW
	0	390	480	680	870	7,300	16,000	260	0	0	SW
	0	390	480	680	870	7,300	3,200	0	0	0	WSW
	0	0	870	680	870	7,100	210	0	0	0	W
	0	0	11,000	40,000	68,000	760,000	2.80×10^{6}	3.10×10^{6}	0	0	WNW
	0	0	70,000	79,000	100,000	850,000	3.40×10^{6}	5.00×10^{6}	1.90×10^{6}	670,000	NW
	0	29.000	57,000	79,000	100,000	850,000	3.40×10^{6}	5.30×10^{6}	5.10×10^{6}	6.40×10^{6}	NNW
	0	33,000	57,000	79,000	100,000	850,000	3.40×10^{6}	4.70×10^{6}	5.00×10^{6}	6.40×10^{6}	N
	0	32,000	57,000	79,000	100,000	850,000	3.80×10^{6}	1.10×10^{7}	1.30×10^{7}	1.90×10^{7}	NNE
	0	24,000	57,000	79,000	100,000	850,000	9.70×10^{6}	1.90×10^{7}	2.70×10^{7}	3.40×10^{7}	NE
	0	0	40,000	76,000	100,000	1.20×10^{6}	1.10×10^{7}	1.90×10^{7}	2.70×10^{7}	3.40×10^{7}	ENE
	0	0	870	2,100	16.000	1.40×10^{6}	1.10×10^{7}	1.80×10^{7}	2.60×10^{7}	3.40×10^{7}	E
	0	0	870	680	870	960,000	9.90×10^{6}	1.60×10^{7}	1.80×10^{7}	1.80×10^{7}	ESE
	0	0	870	680	870	92,000	1.40×10^{6}	4.20×10^{6}	4.60×10^{6}	3.80×10^{6}	SE
	0	390	480	680	870	7,300	62,000	2.60×10^{6}	360,000	550,000	SSE
Meats	0	0	0	0	0	0	0	75,000	660,000	1.30×10^{6}	S
	0	0	0	0	0	0	0	63,000	320,000	550,000	SSW
	0	0	0	0	0	0	12,000	59,000	540,000	800,000	SW
	0	0	0	0	0	0	130,000	16,000	54,000	170,000	WSW
	0	0	0	0	0	1,100	180,000	440,000	1.10×10^{6}	1.30×10^{6}	W
	0	0	3,200	12,000	21,000	230,000	900,000	1.30×10^{6}	1.30×10^{6}	1.60×10^{6}	WNW
	0	0	21,000	24,000	31,000	260,000	1.00×10^{6}	1.60×10^{6}	1.50×10^{6}	1.60×10^{6}	NW
	0	0	26,000	24,000	31,000	260,000	1.00×10^{6}	1.60×10^{6}	1.30×10^{6}	1.60×10^{6}	NNW
	0	10,000	17,000	24,000	31,000	260,000	1.00×10^{6}	1.40×10^{6}	1.30×10^{6}	1.60×10^{6}	N
	0	9,800	17,000	24,000	31,000	260,000	1.10×10^{6}	1.70×10^{6}	1.90×10^{6}	2.60×10^{6}	NNE
	0	7,500	17,000	24,000	31,000	260,000	1.20×10^{6}	2.10×10^{6}	2.90×10^{6}	3.80×10^{6}	NE
	0	0	11,000	24,000	31,000	240,000	860,000	2.10×10^{6}	2.90×10^{6}	3.80×10^{6}	ENE
	0	0	0	440	4,800	100,000	470,000	840,000	1.50×10^{6}	2.20×10^{6}	E
	0	0	0	0	0	41,000	420,000	650,000	620,000	530,000	ESE
	0	0	0	0	0	3,600	58,000	21,000	540,000	3.00×10^{6}	SE
	0	0	0	0	0	0	0.000190	320,000	1.30×10^{6}	1.70×10^{6}	SSE
Poultry	0	0	0	0	0	0	0	0	0	0	S
	0	0	0	0	0	0	0	0	0	0	SSW
	0	0	0	0	0	0	0	0	0	0	SW
	0	0	0	0	0	0	0	0	0	0	WSW
	0	0	0	0	0	0	0	0	0	0	W
	0	0	0	0	0	0	0	0	0	0	WNW
	0	0	0	0	0	0	0	0	36.0	46.0	NW
	0	0	0	0	0	0	0	44.0	330	440	NNW
	0	0	0	0	0	0	0	110	340	440	N
	0	0	0	0	0	0	3.80	100	270	330	NNE

Food Type	Distance (miles)										Wind Direction
	0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50	
Poultry (continued)	0	0	0	0	0	0	54.0	110	160	210	NE
	0	0	0	0	0	1.10	47.0	110	160	210	ENE
	0	0	0	0	0	2.70	25.0	45.0	81.0	120	E
	0	0	0	0	0	2.20	23.0	49.0	110	180	ESE
	0	0	0	0	0	0.190	3.10	100	120	34.0	SE
	0	0	0	0	0	0	1.10	68.0	0.0750	0	SSE
Milk	0	0	0	0	0	0	0	820	7,200	15,000	S
	0	0	0	0	0	0	0	190	980	1,700	SSW
	0	0	0	0	0	0	0	140	1,700	2,500	SW
	0	0	0	0	0	0	0	0	150	740	WSW
	0	0	0	0	0	0	0	1,600	5,300	6,700	W
	0	0	9,600	37,000	64,000	710,000	2.70×10^{6}	2.90×10^{6}	6,300	8,100	WNW
	0	0	66,000	75,000	96,000	800,000	3.20×10^{6}	4.70×10^{6}	1.70×10^{6}	490,000	NW
	0	28,000	53,000	75,000	96,000	800,000	3.20×10^{6}	4.80×10^{6}	3.70×10^{6}	4.60×10^{6}	NNW
	0	31,000	53,000	75,000	96,000	800,000	3.20×10^{6}	4.00×10^{6}	3.60×10^{6}	4.60×10^{6}	N
	0	30,000	53,000	75,000	96,000	800,000	3.20×10^{6}	5.30×10^{6}	5.70×10^{6}	8.00×10^{6}	NNE
	0	23,000	53,000	75,000	96,000	800,000	3.80×10^{6}	6.60×10^{6}	9.20×10^{6}	1.20×10^{7}	NE
	0	0	38,000	72,000	96,000	710,000	2.50×10^{6}	6.40×10^{6}	9.20×10^{6}	1.20×10^{7}	ENE
	0	0	0	1,400	15,000	280,000	1.10×10^{6}	2.10×10^{6}	4.00×10^{6}	6.10×10^{6}	E
	0	0	0	0	0	97,000	1.00×10^{6}	1.60×10^{6}	1.50×10^{6}	1.30×10^{6}	ESE
	0	0	0	0	0	8,600	140,000	51,000	21,000	380,000	SE
	0	0	0	0	0	0	0	3,500	14,000	33,000	SSE
Eggs	0	25	31	44	56	470	1,900	3,000	2,800	2,500	S
	0	25	31	44	56	470	1,900	2,500	2,200	1,900	SSW
	0	25	31	44	56	470	1,100	26.0	110	170	SW
	0	25	31	44	56	470	200	0	12.0	65.0	WSW
	0	0	56.0	44	56	460	13.0	130	430	540	W
	0	0	51.0	22.0	19.0	44.0	0	160	510	650	WNW
	0	0	19.0	0	0	0	0	44.0	580	870	NW
	0	8.80	0	0	0	0	0	270	2,000	2,700	NNW
	0	6.90	0	0	0	0	0	700	2,100	2,700	N
	0	7.50	0	0	0	0	0	300	1,300	1,400	NNE
	0	12.0	0	0	0	0	0	0	0	0	NE
	0	0	34.0	1.70	0	0	0	0	0	0	ENE
	0	0	56.0	43.0	48.0	170	0	0	0	0	E
	0	0	56.0	44.0	56.0	310	0	0	0	0	ESE
	0	0	56.0	44.0	56.0	450	110	0	450	170	SE
	0	25.0	31.0	44.0	56.0	470	1,200	680	1,400	1,700	SSE

kg/yr = kilogram per year
Source: DOC 1993.

Table D–11 Rocky Flats 1994-1996 Joint Frequency Distributions at 10-m (33-ft) Height

Wind Speed (m/sec)	Stability Class	Wind Blows Toward															
		S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
1.4	A	0.11	0.15	0.13	0.09	0.07	0.11	0.08	0.1	0.15	0.17	0.14	0.24	0.17	0.16	0.22	0.15
	B	0.03	0.01	0.02	0.02	0.06	0.02	0	0.01	0.01	0.02	0.02	0.01	0.01	0.01	0.02	0.02
	C	0.02	0.02	0.02	0.03	0.02	0.02	0.02	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.03	0.03
	D	0.02	0.07	0.11	0.22	0.11	0.07	0.02	0.02	0.02	0.03	0.05	0.09	0	0.01	0.02	0.03
	E	0.05	0.09	0.09	0.2	0.07	0.07	0.02	0.06	0.05	0.06	0.05	0.02	0.02	0.03	0.03	0.01
	F	0.24	0.24	0.34	0.38	0.38	0.28	0.23	0.16	0.16	0.13	0.06	0.1	0.11	0.1	0.16	0.17
2.6	A	0.25	0.17	0.2	0.15	0.14	0.16	0.14	0.28	0.55	0.69	0.72	0.9	1.06	1.05	0.87	0.43
	B	0.11	0.06	0.1	0.07	0.05	0.05	0.06	0.08	0.36	0.36	0.22	0.2	0.22	0.31	0.36	0.18
	C	0.17	0.06	0.06	0.05	0.06	0.07	0.13	0.16	0.18	0.24	0.11	0.07	0.08	0.11	0.23	0.25
	D	0.44	0.67	0.71	0.87	0.92	0.56	0.31	0.33	0.33	0.34	0.31	0.3	0.18	0.11	0.31	0.37
	E	0.31	0.45	0.54	0.94	0.54	0.38	0.26	0.22	0.2	0.13	0.18	0.08	0.08	0.08	0.15	0.15
	F	0.43	0.51	0.45	0.47	0.55	0.64	0.59	0.51	0.47	0.33	0.24	0.26	0.22	0.34	0.33	0.45
4.4	A	0.01	0	0.01	0.01	0	0.02	0.01	0.03	0.01	0.01	0	0	0	0	0.01	0
	B	0.13	0.13	0.07	0.09	0.11	0.11	0.21	0.25	0.43	0.67	0.56	0.41	0.47	0.64	0.64	0.33
	C	0.17	0.09	0.14	0.09	0.17	0.17	0.29	0.41	0.91	0.52	0.39	0.29	0.24	0.45	0.6	0.57
	D	0.93	0.94	0.93	1.22	1.14	1.18	1.46	1.72	1.06	0.83	0.59	0.4	0.32	0.28	0.37	0.78
	E	0.43	0.49	0.56	0.74	0.37	0.51	0.65	0.37	0.15	0.17	0.14	0.13	0.08	0.02	0.05	0.13
	F	0.02	0.01	0.02	0.02	0.01	0.01	0.02	0.03	0.01	0	0.01	0	0	0	0	0
7	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0
	C	0.09	0.07	0.07	0.11	0.21	0.21	0.2	0.24	0.39	0.15	0.1	0.07	0.03	0.05	0.07	0.1
	D	0.67	0.55	0.84	1.34	1.84	2.7	1.41	1.18	1.02	0.6	0.23	0.11	0.08	0.08	0.11	0.53
	E	0.08	0.05	0.05	0.05	0.02	0.07	0.06	0.09	0	0.01	0.01	0	0	0	0	0.01
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9.8	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	0.13	0.15	0.18	0.62	1.26	2.22	0.44	0.17	0.16	0.14	0.02	0.01	0	0.01	0	0.11
	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	0.02	0.05	0.07	0.49	2.4	2.24	0.2	0.02	0.02	0.01	0	0	0	0	0	0.06
	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: Nesta 1997a.

D.1.3.2 Radiological Impact Assessments at the Savannah River Site

This section presents the radiological impact input data used in the assessment of the various processing/ storage alternatives at the Savannah River Site. For purposes of radiological impact modeling, the Savannah River Site analyses used the assumption that either F-Area or H-Area could be the locations from which radioactive effluents would be released. **Table D–12** presents the characteristics of the release point, including location, release height, minimum distance, and annual average dispersion to the site boundary in each of 16 directions.

Table D–12 F-Area and H-Area Release Point Characteristics, Direction, Distance, and Atmospheric Dispersion at the Savannah River Site Boundary

Release Point	*F-Area*		*H-Area*	
Latitude	33.286°		33.286°	
Longitude	-81.676°		-81.640°	
Release Height	61 m		61 m	
Distance and Atmospheric Dispersion at Site Boundary				
Direction	*F-Area Distance (m)*	*χ/Q (sec/m³)*	*H-Area Distance (m)*	*χ/Q (sec/m³)*
N	10,898	1.6×10^{-8}	12,288	1.4×10^{-8}
NNE	12,665	1.1×10^{-8}	12,852	1.1×10^{-8}
NE	14,770	9.6×10^{-9}	14,883	9.5×10^{-9}
ENE	18,525	6.9×10^{-9}	15,959	8.4×10^{-9}
E	17,118	6.2×10^{-9}	14,047	8.0×10^{-9}
ESE	16,943	5.4×10^{-9}	13,688	7.1×10^{-9}
SE	19,771	3.0×10^{-9}	17,629	3.5×10^{-9}
SSE	18,933	2.6×10^{-9}	17,662	2.9×10^{-9}
S	18,516	1.7×10^{-9}	18,109	1.7×10^{-9}
SSW	15,467	5.9×10^{-9}	18,481	4.8×10^{-9}
SW	11,525	1.5×10^{-8}	14,355	1.1×10^{-8}
WSW	9,645	1.5×10^{-8}	14,212	8.8×10^{-9}
W	9,416	1.1×10^{-8}	12,763	7.2×10^{-9}
WNW	9,847	9.6×10^{-9}	12,643	7.1×10^{-9}
NW	9,448	1.3×10^{-8}	11,889	9.4×10^{-9}
NNW	9,972	1.6×10^{-8}	11,749	1.3×10^{-8}

χ/Q = Radioisotope concentrations divided by the rates at which they are emitted to the environment
sec/m^3 = second per cubic meter
Source: HNUS 1996, WSRC 1996a, PNL 1988.

Descriptions of population and foodstuff distributions centered on the F-Area are provided in **Table D–13** and **Table D–14**, respectively. Descriptions of population and foodstuff distributions centered on the H-Area are provided in **Table D-15** and **D-16**, respectively. The joint frequency distribution used for the dose assessment (presented in **Table D–17**) was based on the meteorological measurements for 1987 through 1991 from the meteorological tower at the Savannah River Site at the 61-m (201-ft) height.

Table D–13 Savannah River Site (F-Area) Population Data Out to 80 km (50 mi) for Year 2000

Direction	Distance (miles) 0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50	TOTAL
S	0	0	0	0	0	0	570	1,980	3,289	5,995	**11,834**
SSW	0	0	0	0	0	36	864	1,742	4,721	3,726	**11,089**
SW	0	0	0	0	0	80	1,170	7,477	1,818	6,516	**17,061**
WSW	0	0	0	0	0	183	3,242	3,465	3,510	8,317	**18,717**
W	0	0	0	0	0	297	7,168	39,152	18,993	22,459	**88,069**
WNW	0	0	0	0	0	2,020	9,675	186,036	47,704	7,923	**253,358**
NW	0	0	0	0	0	1,216	15,680	35,012	2,627	4,589	**59,124**
NNW	0	0	0	0	0	2,668	32,691	19,807	8,828	9,247	**73,241**
N	0	0	0	0	0	945	6,680	5,442	5,159	22,630	**40,856**
NNE	0	0	0	0	0	103	1,653	2,487	5,712	25,161	**35,116**
NE	0	0	0	0	0	0	2,922	3,516	5,486	12,551	**24,475**
ENE	0	0	0	0	0	0	2,811	5,675	7,700	38,820	**55,006**
E	0	0	0	0	0	0	5,776	5,167	7,094	6,563	**24,600**
ESE	0	0	0	0	0	0	917	3,896	4,870	8,845	**18,528**
SE	0	0	0	0	0	0	544	1,896	3,798	8,461	**14,699**
SSE	0	0	0	0	0	0	369	667	4,352	4,215	**9,603**
TOTAL	**0**	**0**	**0**	**0**	**0**	**7,548**	**92,732**	**323,417**	**135,661**	**196,018**	**755,376**

Source: DOC 1992.

Table D–14 Savannah River Site (F-Area) Agricultural Data (kg/yr)

Food Type	Distance (miles) 0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50	Wind Direction
Leafy Veg.	0	0	0	0	0	0	0	0	0	0	S
	0	0	0	0	0	0	0	0	0	0	SSW
	0	0	0	0	0	340,000	0	0	0	1,100	SW
	0	0	0	0	0	370	33.0	0	1,600	8,800	WSW
	0	0	0	0	0	1,300	130	0	2,800	4,100	W
	0	0	0	0	0	1,400	3,400	0	0	0	WNW
	0	0	0	0	0	1,400	6,300	4,700	0	0	NW
	0	0	0	0	0	1,300	6,900	8,700	8.60	2,400	NNW
	0	0	0	0	0	1,100	6,900	12,000	11,000	48,000	N
	0	0	0	0	0	590	6,900	12,000	310,000	960,000	NNE
	0	0	0	0	0	46.0	6,000	31,000	250,000	770,000	NE
	0	0	0	0	0	0	7.60	32,000	160,000	210,000	ENE
	0	0	0	0	0	0	0	0	23,000	130,000	E
	0	0	0	0	0	0	0	0	0	0	ESE
	0	0	0	0	0	0	0	0	0	0	SE
	0	0	0	0	0	0	0	0	0	0	SSE
Root Veg.	0	0	0	0	0	0	1.80×10^{6}	3.10×10^{6}	4.10×10^{6}	6.30×10^{6}	S
	0	0	0	0	0	3,100	2.10×10^{6}	3.40×10^{6}	4.30×10^{6}	6.70×10^{6}	SSW
	0	0	0	0	0	9.70×10^{7}	2.20×10^{6}	3.60×10^{6}	4.80×10^{6}	5.80×10^{6}	SW
	0	0	0	0	0	110,000	2.10×10^{6}	3.60×10^{6}	5.30×10^{6}	8.00×10^{6}	WSW
	0	0	0	0	0	180,000	230,000	1.30×10^{6}	3.40×10^{6}	4.40×10^{6}	W
	0	0	0	0	0	190,000	500,000	110,000	54,000	320,000	WNW
	0	0	0	0	0	200,000	880,000	820,000	400,000	140,000	NW
	0	0	0	0	0	190,000	960,000	1.30×10^{6}	730,000	1.20×10^{6}	NNW
	0	0	0	0	0	150,000	960,000	1.60×10^{6}	1.70×10^{6}	2.40×10^{6}	N

Food Type	Distance (miles) 0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50	Wind Direction
Root Veg. (continued)	0	0	0	0	0	81,000	960,000	1.60×10^{6}	2.50×10^{6}	3.80×10^{6}	NNE
	0	0	0	0	0	6,300	1.20×10^{6}	2.60×10^{6}	4.20×10^{6}	5.10×10^{6}	NE
	0	0	0	0	0	0	3.40×10^{6}	6.30×10^{6}	7.80×10^{6}	9.90×10^{6}	ENE
	0	0	0	0	0	0	3.60×10^{6}	6.30×10^{6}	7.90×10^{6}	1.00×10^{7}	E
	0	0	0	0	0	0	3.30×10^{6}	6.60×10^{6}	8.40×10^{6}	5.30×10^{6}	ESE
	0	0	0	0	0	0	6.40×10^{7}	6.80×10^{6}	8.80×10^{6}	9.20×10^{6}	SE
	0	0	0	0	0	0	3.80×10^{7}	3.00×10^{7}	6.70×10^{6}	7.80×10^{6}	SSE
Fruits	0	0	0	0	0	0	390,000	1.10×10^{6}	1.70×10^{6}	2.50×10^{6}	S
	0	0	0	0	0	690	450,000	870,000	1.40×10^{6}	2.30×10^{6}	SSW
	0	0	0	0	0	3.30×10^{7}	480,000	790,000	1.20×10^{6}	1.20×10^{6}	SW
	0	0	0	0	0	44,000	470,000	790,000	1.00×10^{6}	880,000	WSW
	0	0	0	0	0	110,000	45,000	270,000	440,000	390,000	W
	0	0	0	0	0	120,000	280,000	1,100	230	1,300	WNW
	0	0	0	0	0	120,000	530,000	2.80×10^{6}	6.60×10^{6}	2.20×10^{6}	NW
	0	0	0	0	0	110,000	580,000	2.80×10^{6}	1.20×10^{7}	1.40×10^{7}	NNW
	0	0	0	0	0	90,000	580,000	970,000	5.10×10^{6}	4.80×10^{6}	N
	0	0	0	0	0	49,000	580,000	970,000	1.00×10^{6}	740,000	NNE
	0	0	0	0	0	3,900	530,000	890,000	1.00×10^{6}	750,000	NE
	0	0	0	0	0	0	250,000	490,000	850,000	1.10×10^{6}	ENE
	0	0	0	0	0	0	260,000	340,000	160,000	700,000	E
	0	0	0	0	0	0	240,000	400,000	180,000	56,000	ESE
	0	0	0	0	0	0	4.30×10^{6}	310,000	370,000	310,000	SE
	0	0	0	0	0	0	2.60×10^{6}	2.00×10^{6}	1.10×10^{6}	1.00×10^{6}	SSE
Grains	0	0	0	0	0	0	2.60×10^{6}	7.40×10^{6}	1.10×10^{7}	1.50×10^{7}	S
	0	0	0	0	0	4,500	2.90×10^{6}	6.00×10^{6}	1.10×10^{7}	1.40×10^{7}	SSW
	0	0	0	0	0	1.10×10^{8}	3.10×10^{6}	5.10×10^{6}	8.20×10^{6}	1.00×10^{7}	SW
	0	0	0	0	0	140,000	3.00×10^{6}	5.10×10^{6}	8.10×10^{6}	1.50×10^{7}	WSW
	0	0	0	0	0	210,000	640,000	2.20×10^{6}	6.10×10^{6}	7.90×10^{6}	W
	0	0	0	0	0	220,000	760,000	720,000	260,000	650,000	WNW
	0	0	0	0	0	220,000	1.00×10^{6}	1.20×10^{6}	750,000	330,000	NW
	0	0	0	0	0	210,000	1.10×10^{6}	1.60×10^{6}	1.30×10^{6}	2.00×10^{6}	NNW
	0	0	0	0	0	170,000	1.10×10^{6}	1.80×10^{6}	2.30×10^{6}	4.10×10^{6}	N
	0	0	0	0	0	93,000	1.10×10^{6}	1.80×10^{6}	2.70×10^{6}	3.60×10^{6}	NNE
	0	0	0	0	0	7,300	1.30×10^{6}	3.60×10^{6}	6.10×10^{6}	6.90×10^{6}	NE
	0	0	0	0	0	0	4.00×10^{6}	8.70×10^{6}	1.40×10^{7}	1.80×10^{7}	ENE
	0	0	0	0	0	0	4.20×10^{6}	9.00×10^{6}	1.60×10^{7}	1.90×10^{7}	E
	0	0	0	0	0	0	3.90×10^{6}	8.90×10^{6}	1.60×10^{7}	1.20×10^{7}	ESE
	0	0	0	0	0	0	8.20×10^{7}	1.10×10^{7}	1.50×10^{7}	1.70×10^{7}	SE
	0	0	0	0	0	0	5.20×10^{7}	5.20×10^{7}	1.30×10^{7}	1.60×10^{7}	SSE
Beef	0	0	0	0	0	0	120,000	460,000	730,000	990,000	S
	0	0	0	0	0	220	150,000	340,000	690,000	930,000	SSW
	0	0	0	0	0	6.00×10^{6}	150,000	250,000	460,000	610,000	SW
	0	0	0	0	0	10,000	150,000	250,000	410,000	790,000	WSW
	0	0	0	0	0	21,000	40,000	120,000	340,000	510,000	W
	0	0	0	0	0	22,000	70,000	50,000	95,000	180,000	WNW
	0	0	0	0	0	23,000	110,000	140,000	160,000	210,000	NW
	0	0	0	0	0	22,000	110,000	180,000	230,000	350,000	NNW
	0	0	0	0	0	17,000	110,000	190,000	310,000	650,000	N
	0	0	0	0	0	9,600	110,000	190,000	250,000	290,000	NNE

Food Type	Distance (miles) 0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50	Wind Direction
Beef (continued)	0	0	0	0	0	750	100,000	260,000	430,000	500,000	NE
	0	0	0	0	0	0	24,000	220,000	820,000	1.10×10^{6}	ENE
	0	0	0	0	0	0	26,000	140,000	520,000	880,000	E
	0	0	0	0	0	0	24,000	82,000	340,000	450,000	ESE
	0	0	0	0	0	0	480,000	64,000	200,000	520,000	SE
	0	0	0	0	0	0	360,000	580,000	430,000	670,000	SSE
Poultry	0	0	0	0	0	0	0	0	0	54,000	S
	0	0	0	0	0	0	0	0	0	67,000	SSW
	0	0	0	0	0	4.70×10^{7}	0	0	0	45.0	SW
	0	0	0	0	0	51,000	4,500	0	61.0	350	WSW
	0	0	0	0	0	170,000	18,000	0	110	160	W
	0	0	0	0	0	190,000	460,000	0	0	5,100	WNW
	0	0	0	0	0	190,000	860,000	640,000	0	300,000	NW
	0	0	0	0	0	180,000	940,000	1.20×10^{6}	1,200	540,000	NNW
	0	0	0	0	0	150,000	940,000	1.60×10^{6}	1.70×10^{6}	3.60×10^{6}	N
	0	0	0	0	0	80,000	940,000	1.60×10^{6}	1.30×10^{6}	5,400	NNE
	0	0	0	0	0	6,300	820,000	1.20×10^{6}	970,000	0	NE
	0	0	0	0	0	0	1,100	0	0	0	ENE
	0	0	0	0	0	0	0	0	0	0	E
	0	0	0	0	0	0	0	0	0	0	ESE
	0	0	0	0	0	0	0	0	0	0	SE
	0	0	0	0	0	0	0	0	0	0	SSE
Milk	0	0	0	0	0	0	550,000	620,000	650,000	760,000	S
	0	0	0	0	0	970	640,000	2.90×10^{6}	7.90×10^{6}	8.10×10^{6}	SSW
	0	0	0	0	0	3.20×10^{6}	670,000	1.10×10^{6}	3.80×10^{6}	2.90×10^{6}	SW
	0	0	0	0	0	22,000	660,000	1.10×10^{6}	2.00×10^{6}	4.40×10^{6}	WSW
	0	0	0	0	0	12,000	49,000	380,000	1.80×10^{6}	3.50×10^{6}	W
	0	0	0	0	0	13,000	31,000	0	47,000	1.20×10^{6}	WNW
	0	0	0	0	0	13,000	58,000	440,000	1.10×10^{6}	790,000	NW
	0	0	0	0	0	12,000	64,000	430,000	2.00×10^{6}	3.30×10^{6}	NNW
	0	0	0	0	0	9,900	64,000	110,000	1.90×10^{6}	7.40×10^{6}	N
	0	0	0	0	0	5,400	64,000	110,000	390,000	970,000	NNE
	0	0	0	0	0	420	55,000	690,000	1.70×10^{6}	1.80×10^{6}	NE
	0	0	0	0	0	0	70.0	1.10×10^{6}	4.60×10^{6}	5.60×10^{6}	ENE
	0	0	0	0	0	0	0	960,000	4.20×10^{6}	5.70×10^{6}	E
	0	0	0	0	0	0	0	320,000	2.60×10^{6}	1.60×10^{6}	ESE
	0	0	0	0	0	0	24,000	12,000	42,000	120,000	SE
	0	0	0	0	0	0	200,000	320,000	350,000	390,000	SSE
Eggs	0	0	0	0	0	0	630	0	0	83,000	S
	0	0	0	0	0	0	0	0	0	100,000	SSW
	0	0	0	0	0	620,000	0	0	0	91.0	SW
	0	0	0	0	0	0	0	0	120	700	WSW
	0	0	0	0	0	0	0	0	220	330	W
	0	0	0	0	0	0	0	0	0	0	WNW
	0	0	0	0	0	0	0	120,000	320,000	110,000	NW
	0	0	0	0	0	0	0	100,000	590,000	640,000	NNW
	0	0	0	0	0	0	0	0	170,000	29.0	N
	0	0	0	0	0	0	0	0	0	0	NNE
	0	0	0	0	0	0	4,100	4,000	160	120	NE

Food Type	Distance (miles) 0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50	Wind Direction
Eggs (continued)	0	0	0	0	0	0	43,000	55,000	500	630	ENE
	0	0	0	0	0	0	45,000	56,000	71.0	400	E
	0	0	0	0	0	0	42,000	58,000	120	0	ESE
	0	0	0	0	0	0	630,000	1,200	0	0	SE
	0	0	0	0	0	0	310,000	0	0	0	SSE

kg/yr = kilogram per year
Source: HNUS 1996.

Table D–15 Savannah River Site (H-Area) Population Data Out to 80 km (50 mi) for Year 2000

Direction	Distance (miles) 0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50	TOTAL
S	0	0	0	0	0	0	480	1,800	5,200	3,500	**10,980**
SSW	0	0	0	0	0	0	620	1,900	5,100	2,400	**10,020**
SW	0	0	0	0	0	25	880	7,500	1,900	2,900	**13,205**
WSW	0	0	0	0	0	66	2,300	4,400	3,300	8,200	**18,266**
W	0	0	0	0	0	630	4,300	52,000	21,000	13,000	**90,930**
WNW	0	0	0	0	0	1,300	7,300	160,000	72,000	6,500	**247,100**
NW	0	0	0	0	0	950	13,000	32,000	3,900	3,500	**53,350**
NNW	0	0	0	0	0	2,500	28,000	22,000	8,000	6,100	**66,600**
N	0	0	0	0	0	330	3,700	3,500	4,500	19,000	**31,030**
NNE	0	0	0	0	0	82	1,600	2,800	6,000	20,000	**30,482**
NE	0	0	0	0	0	14	3,600	3,500	6,000	9,400	**22,514**
ENE	0	0	0	0	0	9	3,600	6,100	6,900	42,000	**58,609**
E	0	0	0	0	0	110	7,400	3,800	6,800	4,000	**22,110**
ESE	0	0	0	0	0	3	1,300	2,500	3,500	5,700	**13,003**
SE	0	0	0	0	0	0	540	4,800	4,800	8,100	**18,240**
SSE	0	0	0	0	0	0	370	590	1,900	2,700	**5,560**
TOTAL	**0**	**0**	**0**	**0**	**0**	**6,019**	**78,990**	**309,190**	**160,800**	**157,000**	**711,999**

Source: DOC 1992.

Table D–16 Savannah River Site (H-Area) Agricultural Data (kg/yr)

Food Type	Distance (miles) 0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50	Wind Direction
Leafy Veg.	0	0	0	0	0	0	0	0	0	0	S
	0	0	0	0	0	0	0	0	0	0	SSW
	0	0	0	0	0	120,000	0	0	0	430	SW
	0	0	0	0	0	110,000	110,000	0	560	7,900	WSW
	0	0	0	0	0	750	1,100	0	1,800	4,800	W
	0	0	0	0	0	730	5,200	0	0	0	WNW
	0	0	0	0	0	990	6,800	7,100	0	0	NW
	0	0	0	0	0	1,000	6,900	10,000	450	4,000	NNW
	0	0	0	0	0	850	6,900	12,000	30,000	150,000	N
	0	0	0	0	0	610	6,900	12,000	410,000	960,000	NNE
	0	0	0	0	0	110	4,700	47,000	290,000	700,000	NE
	0	0	0	0	0	0	0	44,000	170,000	200,000	ENE
	0	0	0	0	0	0	0	0	35,000	150,000	E

	Distance (miles)										
Food Type	**0-1**	**1-2**	**2-3**	**3-4**	**4-5**	**5-10**	**10-20**	**20-30**	**30-40**	**40-50**	**Wind Direction**
Leafy Veg. (continued)	0	0	0	0	0	0	0	0	0	0	ESE
	0	0	0	0	0	0	0	0	0	0	SE
	0	0	0	0	0	0	0	0	0	0	SSE
Root Veg.	0	0	0	0	0	0	1.4×10^{7}	3.0×10^{6}	4.1×10^{6}	5.8×10^{6}	S
	0	0	0	0	0	0	1.8×10^{6}	3.4×10^{6}	4.3×10^{6}	6.9×10^{6}	SSW
	0	0	0	0	0	4.2×10^{7}	2.7×10^{7}	3.6×10^{6}	4.8×10^{6}	5.8×10^{6}	SW
	0	0	0	0	0	1.5×10^{7}	1.8×10^{7}	3.6×10^{6}	5.1×10^{6}	7.9×10^{6}	WSW
	0	0	0	0	0	100,000	420,000	950,000	3.1×10^{6}	4.8×10^{6}	W
	0	0	0	0	0	100,000	740,000	110,000	58,000	220,000	WNW
	0	0	0	0	0	140,000	950,000	1.1×10^{6}	490,000	280,000	NW
	0	0	0	0	0	140,000	960,000	1.5×10^{6}	770,000	1.3×10^{6}	NNW
	0	0	0	0	0	120,000	960,000	1.6×10^{6}	1.9×10^{6}	2.6×10^{6}	N
	0	0	0	0	0	85,000	960,000	1.6×10^{6}	2.6×10^{6}	3.8×10^{6}	NNE
	0	0	0	0	0	16,000	1.9×10^{6}	3.2×10^{6}	4.8×10^{6}	5.3×10^{6}	NE
	0	0	0	0	0	3,300	4.0×10^{6}	6.1×10^{6}	7.8×10^{6}	9.8×10^{6}	ENE
	0	0	0	0	0	170,000	4.0×10^{6}	6.1×10^{6}	7.9×10^{6}	1.0×10^{7}	E
	0	0	0	0	0	130,000	3.9×10^{6}	6.5×10^{6}	7.9×10^{6}	4.1×10^{6}	ESE
	0	0	0	0	0	0	3.4×10^{7}	6.8×10^{6}	8.3×10^{6}	9.0×10^{6}	SE
	0	0	0	0	0	0	8.3×10^{7}	5.4×10^{6}	7.4×10^{6}	8.2×10^{6}	SSE
Fruits	0	0	0	0	0	0	1.3×10^{6}	1.1×10^{6}	1.7×10^{6}	2.3×10^{6}	S
	0	0	0	0	0	0	410,000	880,000	1.4×10^{6}	2.4×10^{6}	SSW
	0	0	0	0	0	1.2×10^{7}	2.3×10^{6}	790,000	1.2×10^{6}	1.3×10^{6}	SW
	0	0	0	0	0	8.9×10^{6}	1.0×10^{7}	790,000	1.1×10^{6}	930,000	WSW
	0	0	0	0	0	63,000	140,000	190,000	480,000	460,000	W
	0	0	0	0	0	62,000	440,000	1,100	360	840	WNW
	0	0	0	0	0	83,000	580,000	2.4×10^{6}	8.2×10^{6}	4.6×10^{6}	NW
	0	0	0	0	0	84,000	580,000	1.8×10^{6}	1.2×10^{7}	1.3×10^{7}	NNW
	0	0	0	0	0	71,000	580,000	970,000	3.6×10^{6}	4.4×10^{6}	N
	0	0	0	0	0	52,000	580,000	970,000	930,000	730,000	NNE
	0	0	0	0	0	9,100	490,000	830,000	940,000	690,000	NE
	0	0	0	0	0	240	290,000	470,000	880,000	1.0×10^{6}	ENE
	0	0	0	0	0	13,000	290,000	240,000	220,000	810,000	E
	0	0	0	0	0	9,800	290,000	340,000	130,000	28,000	ESE
	0	0	0	0	0	0	2.3×10^{6}	310,000	330,000	300,000	SE
	0	0	0	0	0	0	4.9×10^{6}	640,000	890,000	790,000	SSE
Grains	0	0	0	0	0	0	1.7×10^{7}	7.7×10^{6}	1.1×10^{7}	1.5×10^{7}	S
	0	0	0	0	0	0	2.6×10^{6}	6.0×10^{6}	1.1×10^{7}	1.5×10^{7}	SSW
	0	0	0	0	0	4.9×10^{7}	3.2×10^{7}	5.1×10^{6}	8.4×10^{6}	1.0×10^{7}	SW
	0	0	0	0	0	1.7×10^{7}	2.1×10^{7}	5.1×10^{6}	7.5×10^{6}	1.4×10^{7}	WSW
	0	0	0	0	0	120,000	820,000	1.8×10^{6}	5.4×10^{6}	8.7×10^{6}	W
	0	0	0	0	0	120,000	930,000	740,000	350,000	490,000	WNW
	0	0	0	0	0	160,000	1.1×10^{6}	1.5×10^{6}	910,000	560,000	NW
	0	0	0	0	0	160,000	1.1×10^{6}	1.7×10^{6}	1.4×10^{6}	2.3×10^{6}	NNW
	0	0	0	0	0	130,000	1.1×10^{6}	1.8×10^{6}	2.5×10^{6}	4.1×10^{6}	N
	0	0	0	0	0	98,000	1.1×10^{6}	1.8×10^{6}	2.7×10^{6}	3.6×10^{6}	NNE

Food Type	Distance (miles) 0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50	Wind Direction
Grains (continued)	0	0	0	0	0	18,000	2.2×10^{6}	4.8×10^{6}	7.2×10^{6}	7.8×10^{6}	NE
	0	0	0	0	0	3,900	4.7×10^{6}	9.1×10^{6}	1.4×10^{7}	1.8×10^{7}	ENE
	0	0	0	0	0	200,000	4.7×10^{6}	9.8×10^{6}	1.6×10^{7}	1.8×10^{7}	E
	0	0	0	0	0	160,000	4.6×10^{6}	9.5×10^{6}	1.5×10^{7}	1.0×10^{7}	ESE
	0	0	0	0	0	0	4.4×10^{7}	1.1×10^{7}	1.4×10^{7}	1.7×10^{7}	SE
	0	0	0	0	0	0	1.2×10^{8}	1.0×10^{7}	1.4×10^{7}	1.6×10^{7}	SSE
Beef	0	0	0	0	0	0	210,000	490,000	730,000	960,000	S
	0	0	0	0	0	0	130,000	340,000	700,000	960,000	SSW
	0	0	0	0	0	2.2×10^{7}	320,000	250,000	480,000	620,000	SW
	0	0	0	0	0	1.7×10^{7}	2.0×10^{6}	250,000	380,000	760,000	WSW
	0	0	0	0	0	100,000	55,000	98,000	290,000	540,000	W
	0	0	0	0	0	100,000	92,000	49,000	90,000	160,000	WNW
	0	0	0	0	0	140,000	110,000	160,000	180,000	210,000	NW
	0	0	0	0	0	140,000	110,000	190,000	230,000	390,000	NNW
	0	0	0	0	0	120,000	110,000	190,000	300,000	610,000	N
	0	0	0	0	0	84,000	110,000	190,000	240,000	290,000	NNE
	0	0	0	0	0	1,800	86,000	310,000	490,000	570,000	NE
	0	0	0	0	0	23	28,000	290,000	830,000	1.1×10^{6}	ENE
	0	0	0	0	0	1,200	28,000	210,000	540,000	920,000	E
	0	0	0	0	0	950	28,000	120,000	380,000	410,000	ESE
	0	0	0	0	0	0	260,000	64,000	260,000	510,000	SE
	0	0	0	0	0	0	730,000	240,000	350,000	630,000	SSE
Poultry	0	0	0	0	0	0	0	0	0	26,000	S
	0	0	0	0	0	0	0	0	0	76,000	SSW
	0	0	0	0	0	1.7×10^{7}	0	0	0	17	SW
	0	0	0	0	0	1.4×10^{7}	1.6×10^{7}	0	22	310	WSW
	0	0	0	0	0	100,000	150,000	0	71	190	W
	0	0	0	0	0	100,000	710,000	0	0	300	WNW
	0	0	0	0	0	140,000	940,000	980,000	0	180,000	NW
	0	0	0	0	0	140,000	940,000	1.4×10^{6}	66,000	890,000	NNW
	0	0	0	0	0	120,000	940,000	1.6×10^{6}	1.9×10^{6}	3.1×10^{6}	N
	0	0	0	0	0	84,000	940,000	1.6×10^{6}	1.0×10^{6}	0	NNE
	0	0	0	0	0	15,000	640,000	970,000	660,000	0	NE
	0	0	0	0	0	0	0	0	0	0	ENE
	0	0	0	0	0	0	0	0	0	0	E
	0	0	0	0	0	0	0	0	0	0	ESE
	0	0	0	0	0	0	0	0	0	0	SE
	0	0	0	0	0	0	0	0	0	0	SSE
Milk	0	0	0	0	0	0	480,000	540,000	650,000	800,000	S
	0	0	0	0	0	0	580,000	2.5×10^{6}	6.7×10^{6}	7.7×10^{6}	SSW
	0	0	0	0	0	1.1×10^{6}	640,000	1.1×10^{6}	4.3×10^{6}	4.0×10^{6}	SW
	0	0	0	0	0	980,000	1.7×10^{6}	1.1×10^{6}	1.7×10^{6}	4.2×10^{6}	WSW
	0	0	0	0	0	6,900	80,000	270,000	1.4×10^{6}	3.7×10^{6}	W
	0	0	0	0	0	6,700	48,000	0	0	810,000	WNW
	0	0	0	0	0	9,100	63,000	370,000	1.4×10^{6}	1.0×10^{6}	NW

	Distance (miles)										Wind
Food Type	**0-1**	**1-2**	**2-3**	**3-4**	**4-5**	**5-10**	**10-20**	**20-30**	**30-40**	**40-50**	**Direction**
Milk (continued)	0	0	0	0	0	9,200	64,000	250,000	2.0×10^6	3.8×10^6	NNW
	0	0	0	0	0	7,800	64,000	110,000	1.6×10^6	6.6×10^6	N
	0	0	0	0	0	5,700	64,000	110,000	470,000	960,000	NNE
	0	0	0	0	0	990	43,000	1.2×10^6	2.2×10^6	1.7×10^6	NE
	0	0	0	0	0	0	0	1.6×10^6	4.7×10^6	5.4×10^6	ENE
	0	0	0	0	0	0	0	1.6×10^6	4.2×10^6	5.7×10^6	E
	0	0	0	0	0	0	0	740,000	2.8×10^6	1.1×10^6	ESE
	0	0	0	0	0	0	14,000	12,000	56,000	110,000	SE
	0	0	0	0	0	0	150,000	180,000	260,000	310,000	SSE
Eggs	0	0	0	0	0	0	150,000	0	0	40,000	S
	0	0	0	0	0	0	0	0	0	120,000	SSW
	0	0	0	0	0	310,000	310,000	0	0	35	SW
	0	0	0	0	0	0	0	0	45	630	WSW
	0	0	0	0	0	0	0	0	140	380	W
	0	0	0	0	0	0	0	0	0	0	WNW
	0	0	0	0	0	0	0	87,000	390,000	220,000	NW
	0	0	0	0	0	0	0	44,000	570,000	570,000	NNW
	0	0	0	0	0	0	0	0	98,000	0	N
	0	0	0	0	0	0	0	0	0	0	NNE
	0	0	0	0	0	9.4	16,000	4,600	220	110	NE
	0	0	0	0	0	41	50,000	41,000	520	600	ENE
	0	0	0	0	0	2,200	50,000	38,000	110	470	E
	0	0	0	0	0	1,700	49,000	44,000	0	0	ESE
	0	0	0	0	0	0	330,000	1,900	0	0	SE
	0	0	0	0	0	0	480,000	0	0	0	SSE

kg/yr = kilogram per year

Table D–17 Savannah River Site Meteorological Data (Joint Frequency Distributions) 1987-1991 at 61-m (201-ft) Height

Wind Speed (m/sec)	Stability Class	Wind Blows Toward															
		S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
2	A	0.37	0.41	0.37	0.42	0.4	0.37	0.4	0.36	0.36	0.35	0.45	0.39	0.45	0.43	0.37	0.41
	B	0.08	0.08	0.09	0.1	0.05	0.06	0.06	0.05	0.08	0.07	0.05	0.05	0.05	0.08	0.05	0.07
	C	0.03	0.06	0.09	0.07	0.06	0.05	0.06	0.05	0.07	0.05	0.06	0.05	0.08	0.05	0.05	0.05
	D	0.02	0.05	0.06	0.04	0.06	0.03	0.06	0.07	0.06	0.03	0.07	0.05	0.04	0.03	0.05	0.04
	E	0.01	0.02	0.04	0.01	0.01	0.03	0.03	0.03	0.02	0.02	0.01	0.01	0.02	0.01	0.02	0.02
	F	0	0.01	0.01	0.01	0.01	0.01	0	0.01	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01
4	A	0.87	0.74	0.88	1	0.94	0.94	0.65	0.62	0.74	0.72	1	1.28	1.29	0.94	0.53	0.6
	B	0.27	0.41	0.58	0.62	0.43	0.34	0.24	0.22	0.32	0.33	0.48	0.67	0.56	0.37	0.25	0.21
	C	0.17	0.57	1.13	1.03	0.6	0.41	0.41	0.37	0.48	0.52	0.59	0.79	0.53	0.45	0.3	0.24
	D	0.1	0.44	1.07	0.89	0.55	0.5	0.71	0.69	0.92	0.91	0.8	0.81	0.72	0.57	0.43	0.27
	E	0.06	0.27	0.69	0.48	0.3	0.33	0.46	0.7	0.67	0.57	0.54	0.47	0.43	0.43	0.33	0.3
	F	0.02	0.05	0.09	0.04	0.02	0.08	0.09	0.09	0.11	0.08	0.12	0.09	0.03	0.05	0.05	0.07
6	A	0.57	0.26	0.16	0.19	0.15	0.07	0.07	0.09	0.14	0.14	0.21	0.24	0.27	0.24	0.14	0.24
	B	0.14	0.39	0.38	0.31	0.16	0.11	0.07	0.08	0.19	0.21	0.32	0.51	0.51	0.36	0.13	0.09
	C	0.12	0.54	1.3	0.74	0.35	0.19	0.22	0.25	0.47	0.46	0.56	0.69	0.64	0.56	0.21	0.12
	D	0.12	0.43	0.85	0.58	0.4	0.44	0.65	1.16	1.45	0.78	0.9	0.77	0.78	0.65	0.32	0.09
	E	0.07	0.53	0.69	0.71	0.6	0.45	0.65	1.01	1.18	0.94	0.91	0.89	0.48	0.4	0.19	0.14
	F	0.01	0.26	0.21	0.14	0.14	0.19	0.13	0.16	0.22	0.21	0.24	0.23	0.07	0.04	0.02	0.04
8	A	0.09	0.05	0.01	0.01	0.01	0	0.01	0.01	0.02	0.02	0.02	0.04	0.03	0.02	0.01	0.06
	B	0.01	0.08	0.03	0.01	0.01	0.01	0	0.01	0.05	0.04	0.05	0.1	0.17	0.21	0.06	0.01
	C	0.01	0.1	0.2	0.08	0.02	0.03	0.03	0.06	0.16	0.16	0.21	0.26	0.45	0.43	0.1	0.02
	D	0.01	0.05	0.1	0.02	0.01	0.01	0.05	0.18	0.22	0.15	0.1	0.09	0.03	0.05	0.03	0
	E	0	0.05	0.03	0.04	0.01	0.01	0	0.03	0.04	0.02	0.04	0.01	0.01	0	0	0
	F	0	0.03	0.02	0.02	0	0.01	0	0.01	0.02	0.01	0.02	0.01	0	0	0	0
12	A	0.01	0	0	0	0	0	0	0	0	0.01	0.01	0.01	0	0.01	0	0.01
	B	0	0.01	0	0	0	0	0	0	0	0	0.01	0.01	0.06	0.06	0.01	0
	C	0	0.01	0	0	0	0.01	0	0.03	0.04	0.04	0.05	0.06	0.16	0.17	0.02	0.01
	D	0	0.02	0.02	0	0	0	0	0.01	0.02	0.04	0	0	0.01	0	0	0
	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14.1	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: WSRC 1996a.

D.1.3.3 Radiological Impact Assessments at Los Alamos National Laboratory

This section presents the radiological impact input data used in the assessment of the processing/storage alternatives at Los Alamos National Laboratory. For purposes of radiological impact modeling, Los Alamos National Laboratory analyses used the assumption that Technical Area 55 would be the location from which radioactive effluents would be released. **Table D–18** presents the characteristics of the release point, including location, release height, minimum distance, and annual average dispersion to the site boundary in each of 16 directions.

Table D–18 Release Point Characteristics, Direction, Distance, and Atmospheric Dispersion at the Los Alamos National Laboratory Site Boundary

Release Location		***Technical Area 55***
Latitude		35.876°
Longitude		-106.292°
Release Height		11.2 m
Distance and Atmospheric Dispersion at Site Boundary		
Direction	***Distance (m)***	***χ/Q (sec/m^3)***
N	1,000 [a]	2.5×10^{-6}
NNE	1,390	1.9×10^{-6}
NE	1,760	1.2×10^{-6}
ENE	2,800	4.8×10^{-7}
E	2,680	5.3×10^{-7}
ESE	1,680	9.6×10^{-7}
SE	6,420	1.1×10^{-7}
SSE	4,980	1.8×10^{-7}
S	3,350	3.7×10^{-7}
SSW	3,050	3.8×10^{-7}
SW	3,280	2.8×10^{-7}
WSW	3,430	2.0×10^{-7}
W	3,220	2.0×10^{-7}
WNW	2,600	2.1×10^{-7}
NW	2,000	3.4×10^{-7}
NNW	1,460	8.4×10^{-7}

χ/Q = Radioisotope concentrations divided by the rates at which they are emitted to the environment
sec/m^3 = second per cubic meter
[a] Nearest resident is present at this location (trailer court); this location is on private property that is surrounded by the site.
Source: LANL 1994, PNL 1988.

Descriptions of population and foodstuff distributions centered on Technical Area 55 are provided in **Table D–19** and **Table D–20**, respectively. The joint frequency distribution used for the dose assessment (presented in **Table D–21**) was based on the meteorological measurements for 1993 through 1996 from the meteorological tower at Los Alamos National Laboratory at the 11-m (36-ft) height.

Table D–19 Los Alamos National Laboratory Site Population Data Out to 80 km (50 mi) for Year 2000

	Distance (miles)										
Direction	*0-1*	*1-2*	*2-3*	*3-4*	*4-5*	*5-10*	*10-20*	*20-30*	*30-40*	*40-50*	*TOTAL*
S	0	0	26	20	29	143	711	1,940	1,121	2,422	**6,412**
SSW	0	0	26	24	77	41	884	3,681	3,505	50,614	**58,852**
SW	0	0	26	22	76	114	51	1,237	856	10,074	**12,456**
WSW	0	0	26	32	96	317	256	1,065	1,784	43	**3,619**
W	0	0	47	78	117	163	201	682	85	531	**1,904**
WNW	0	507	65	89	116	195	63	123	2,293	393	**3,844**
NW	0	1,485	1,327	79	103	372	95	186	236	241	**4,124**
NNW	0	1,428	102	79	101	175	127	161	166	216	**2,555**
N	500	545	73	96	127	308	388	611	480	250	**3,378**
NNE	0	419	76	106	136	481	684	709	573	138	**3,322**
NE	0	521	76	95	66	419	5,769	3,046	1,348	2,425	**13,765**
ENE	0	717	142	24	20	275	17,189	3,811	3,049	2,436	**27,663**
E	0	543	415	15	20	444	4,970	774	764	1,105	**9,050**
ESE	0	119	31	15	20	171	1,045	3,520	396	659	**5,976**
SE	0	0	0	0	54	5,524	1,028	76,189	4,297	2,125	**89,217**
SSE	0	0	0	45	26	397	594	10,278	2,402	481	**14,223**
TOTAL	**500**	**6,284**	**2,458**	**819**	**1,184**	**9,539**	**34,055**	**108,013**	**23,355**	**74,153**	**260,360**

Source: DOC 1992.

Table D–20 Los Alamos National Laboratory Site Agricultural Data (kg/yr)

	Distance/Miles										
Food Type	*0-1*	*1-2*	*2-3*	*3-4*	*4-5*	*5-10*	*10-20*	*20-30*	*30-40*	*40-50*	*Wind Direction*
Leafy Veg.	0	0	0	0	0	0	0	0	0	0	S
	0	0	0	0	0	0	0	0	0	0	SSW
	0	0	0	0	0	0	0	0	0	0	SW
	0	0	0	0	0	0	0	0	0	0	WSW
	0	0	0	0	0	0	0	0	0	0	W
	0	0	0	0	0	0	0	0	0	0	WNW
	0	0	0	0	0	0	0	0	0	0	NW
	0	0	0	0	0	0	0	0	0	0	NNW
	0	0	0	0	0	0	0	0	0	0	N
	0	0	0	0	0	0	0	0	0	0	NNE
	0	0	0	0	0	0	0	0	0	0	NE
	0	0	0	0	0	0	0	0	0	0	ENE
	0	0	0	0	0	0	0	0	0	0	E
	0	0	0	0	0	0	0	0	0	0	ESE
	0	0	0	0	0	0	0	0	0	0	SE
	0	0	0	0	0	0	0	0	0	0	SSE
Root Veg.	0	0	0	0	0	0	0	0	0	0	S
	0	0	0	0	0	0	0	0	0	0	SSW
	0	0	0	0	0	0	0	0	0	0	SW
	0	0	0	0	0	0	0	0	0	0	WSW
	0	0	0	0	0	0	0	0	0	0	W
	0	0	0	0	0	0	0	0	0	0	WNW
	0	0	0	0	0	0	0	0	0	0	NW
	0	0	0	0	0	0	0	0	0	0	NNW
	0	0	0	0	0	0	0	0	0	0	N
	0	0	0	0	0	0	0	0	0	0	NNE
	0	0	0	0	0	0	0	0	0	0	NE

Food Type	Distance/Miles 0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50	Wind Direction
Root Veg. (continued)	0	0	0	0	0	0	0	0	0	0	ENE
	0	0	0	0	0	0	0	0	0	0	E
	0	0	0	0	0	0	0	0	0	0	ESE
	0	0	0	0	0	0	0	0	0	0	SE
	0	0	0	0	0	0	0	0	0	0	SSE
Fruits	0	0	0	110	290	3,100	9,.600	12,000	15,000	17,000	S
	0	0	55.0	290	380	3,100	13,000	21,000	29,000	35,000	SSW
	0	0	39.0	290	360	3,100	13,000	21,000	29,000	38,000	SW
	0	0	0	50.0	45.0	2,300	13,000	21,000	29,000	38,000	WSW
	0	0	0	0	0	2,700	13,000	21,000	29,000	38,000	W
	0	0	0	0	0	2,600	13,000	22,000	31,000	38,000	WNW
	0	0	0	0	0	1,700	14,000	24,000	34,000	43,000	NW
	0	0	0	0	0	2,000	15,000	24,000	34,000	44,000	NNW
	0	0	0	0	0	2,100	15,000	24,000	34,000	44,000	N
	0	0	0	0	0	2,300	15,000	24,000	33,000	41,000	NNE
	0	0	0	7.70	38.0	3,200	15,000	24,000	15,000	680	NE
	0	0	4.50	42.0	57.0	1,200	9,900	21,000	23,000	1,100	ENE
	0	0	16.0	44.0	57.0	470	1,900	3,200	8,000	5,400	E
	0	0	13.0	44.0	57.0	440	1,900	3,200	2,000	290	ESE
	0	0	0	0	17.0	280	1,900	3,200	4,200	2,000	SE
	0	0	0	0	0	470	1,900	3,200	4,400	5,700	SSE
Grains	0	0	0	84.0	210	2,300	8,700	14,000	19,000	30,000	S
	0	0	40.0	220	280	2,300	9,200	15,000	22,000	35,000	SSW
	0	0	29.0	210	270	2,300	9,200	15,000	22,000	28,000	SW
	0	0	0	37.0	33.0	1,700	9,200	15,000	22,000	28,000	WSW
	0	0	0	0	0	2,000	9,200	15,000	22,000	28,000	W
	0	0	0	0	0	1,900	9,200	13,000	18,000	28,000	WNW
	0	0	0	0	0	1,200	5,900	5,100	8,000	13,000	NW
	0	0	0	0	0	1,500	3,400	5,100	7,100	9,200	NNW
	0	0	0	0	0	1,300	3,100	5,100	7,100	9,200	N
	0	0	0	0	0	880	3,100	5,100	6,900	8,700	NNE
	0	0	0	30.0	150	900	3,100	5,100	4,400	3,000	NE
	0	0	18.0	170	220	1,600	4,700	6,400	5,500	3,100	ENE
	0	0	61.0	170	220	1,900	7,500	12,000	9,400	7,400	E
	0	0	50.0	170	220	1,700	7,500	12,000	17,000	22,000	ESE
	0	0	0	0	69.0	1,100	7,500	12,000	17,000	22,000	SE
	0	0	0	0	0	1,200	7,500	12,000	17,000	22,000	SSE
Beef	0	0	0	0	0	38.0	58,000	170,000	280,000	510,000	S
	0	0	0	0	0	0	0	0	0	190,000	SSW
	0	0	0	0	0	0	0	0	0	0	SW
	0	0	0	0	0	0	0	0	0	0	WSW
	0	0	0	0	0	0	0	0	0	0	W
	0	0	0	0	0	0	0	85,000	110,000	0	WNW
	0	0	0	0	0	0	110,000	330,000	430,000	460,000	NW
	0	0	0	0	0	270	190,000	330,000	460,000	590,000	NNW
	0	0	0	0	0	7,100	200,000	330,000	460,000	590,000	N
	0	0	0	0	0	20,000	200,000	330,000	450,000	570,000	NNE
	0	0	0	850	4,200	49,000	200,000	330,000	360,000	370,000	NE
	0	0	500	4,700	6,300	52,000	200,000	330,000	400,000	370,000	ENE
	0	0	1,700	4,900	6,300	52,000	210,000	350,000	690,000	970,000	E
	0	0	1,400	4,900	6,300	48,000	210,000	350,000	740,000	1.20×10^{6}	ESE
	0	0	0	0	1,900	31,000	210,000	350,000	510,000	1.00×10^{6}	SE
	0	0	0	0	0	30,000	210,000	350,000	490,000	630,000	SSE

Food Type	Distance/Miles 0-1	1-2	2-3	3-4	4-5	5-10	10-20	20-30	30-40	40-50	Wind Direction
Poultry	0	0	0	0	0	0	0	0	0	0	S
	0	0	0	0	0	0	0	0	0	0	SSW
	0	0	0	0	0	0	0	0	0	0	SW
	0	0	0	0	0	0	0	0	0	0	WSW
	0	0	0	0	0	0	0	0	0	0	W
	0	0	0	0	0	0	0	0	0	0	WNW
	0	0	0	0	0	0	0	0	0	0	NW
	0	0	0	0	0	0	0	0	0	0	NNW
	0	0	0	0	0	0	0	0	0	0	N
	0	0	0	0	0	0	0	0	0	0	NNE
	0	0	0	0	0	0	0	0	0	0	NE
	0	0	0	0	0	0	0	0	0	0	ENE
	0	0	0	0	0	0	0	0	0	0	E
	0	0	0	0	0	0	0	0	0	0	ESE
	0	0	0	0	0	0	0	0	0	0	SE
	0	0	0	0	0	0	0	0	0	0	SSE
Milk	0	0	0	0	0	4.1	6,100	18,000	29,000	1.20×10^{6}	S
	0	0	0	0	0	0	0	0	0	1.50×10^{6}	SSW
	0	0	0	0	0	0	0	0	0	0	SW
	0	0	0	0	0	0	0	0	0	0	WSW
	0	0	0	0	0	0	0	0	0	0	W
	0	0	0	0	0	0	0	3,100	4,000	0	WNW
	0	0	0	0	0	0	3,900	12,000	16,000	16,000	NW
	0	0	0	0	0	9.80	6,700	12,000	17,000	21,000	NNW
	0	0	0	0	0	260	7,100	12,000	17,000	21,000	N
	0	0	0	0	0	720	7,100	12,000	16,000	21,000	NNE
	0	0	0	90.0	440	2,300	7,100	12,000	13,000	13,000	NE
	0	0	53.0	490	670	4,700	13,000	16,000	14,000	13,000	ENE
	0	0	180	520	670	5,.600	22,000	37,000	37,000	43,000	E
	0	0	150	520	670	5,100	22,000	37,000	35,000	28,000	ESE
	0	0	0	0	200	3,300	22,000	37,000	50,000	41,000	SE
	0	0	0	0	0	3,200	22,000	37,000	52,000	67,000	SSE
Eggs	0	0	0	0	0	0.0770	120	340	550	750	S
	0	0	0	0	0	0	0	0	0	0	SSW
	0	0	0	0	0	0	0	0	0	0	SW
	0	0	0	0	0	0	0	0	0	0	WSW
	0	0	0	0	0	0	0	0	0	0	W
	0	0	0	0	0	0	0	70.0	91.0	0	WNW
	0	0	0	0	0	0	89.0	270	360	380	NW
	0	0	0	0	0	22.0	150	270	380	490	NNW
	0	0	0	0	0	5.90	160	270	380	490	N
	0	0	0	0	0	17.0	160	270	360	450	NNE
	0	0	0	1.70	8.40	49.0	160	270	160	57.0	NE
	0	0	1.00	9.40	13.0	91.0	260	350	250	5.40	ENE
	0	0	3.50	9.90	13.0	110	420	700	430	240	E
	0	0	2.80	9.90	13.0	97.0	420	700	720	680	ESE
	0	0	0	0	3.80	63.0	420	700	960	860	SE
	0	0	0	0	0	60.0	420	700	990	1,300	SSE

kg/yr = kilogram per year
Source: DOC 1993.

Table D–21 Los Alamos National Laboratory 1993-1996 Joint Frequency Distributions at 11-m (36-ft) Height

Wind Speed (m/sec)	Stability Class	Wind Blows Toward															
		S	SSW	SW	WSW	W	WNW	NW	NNW	N	NNE	NE	ENE	E	ESE	SE	SSE
0.78	A	0.12	0.26	0.5	0.84	0.74	0.54	0.45	0.32	0.18	0.11	0.08	0.05	0.06	0.06	0.07	0.07
	B	0.03	0.05	0.12	0.19	0.16	0.09	0.08	0.07	0.04	0.01	0.02	0.01	0.02	0.02	0.01	0.02
	C	0.05	0.09	0.14	0.2	0.16	0.09	0.09	0.09	0.07	0.04	0.03	0.03	0.02	0.03	0.02	0.03
	D	0.86	0.69	0.57	0.45	0.47	0.34	0.33	0.33	0.38	0.35	0.33	0.31	0.35	0.4	0.57	0.72
	E	0.59	0.45	0.33	0.23	0.22	0.15	0.13	0.13	0.17	0.24	0.32	0.28	0.29	0.4	0.51	0.62
	F	0.26	0.28	0.27	0.19	0.18	0.17	0.2	0.25	0.3	0.32	0.22	0.17	0.15	0.2	0.24	0.25
2.5	A	0.03	0.07	0.17	0.45	0.56	0.43	0.33	0.22	0.18	0.08	0.06	0.05	0.04	0.03	0.03	0.03
	B	0.02	0.05	0.2	0.39	0.42	0.31	0.27	0.22	0.16	0.1	0.06	0.05	0.05	0.04	0.03	0.02
	C	0.05	0.15	0.46	0.68	0.65	0.45	0.46	0.59	0.59	0.26	0.16	0.12	0.16	0.12	0.07	0.05
	D	0.95	1.09	0.94	0.72	0.56	0.34	0.47	1.3	2.12	1.89	1.93	0.95	1.08	0.81	0.56	0.63
	E	0.87	0.59	0.34	0.19	0.11	0.1	0.13	0.24	0.67	1.82	2.41	1.72	1.84	1.41	0.8	0.8
	F	0.09	0.07	0.05	0.03	0.01	0.01	0.05	0.1	0.25	0.33	0.11	0.36	0.39	0.39	0.12	0.07
4.5	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.01	0.02	0.01	0
	C	0.02	0.04	0.07	0.04	0.02	0.01	0.01	0.03	0.15	0.09	0.11	0.19	0.31	0.19	0.09	0.02
	D	0.81	0.8	0.42	0.16	0.07	0.04	0.11	0.99	3.24	3.52	2.59	1.61	1.86	1.05	0.54	0.44
	E	0.21	0.2	0.08	0.01	0	0	0.01	0.07	0.32	1.74	1.08	1.32	1.31	0.32	0.23	0.22
	F	0	0.01	0	0	0	0	0	0	0.02	0.04	0	0.05	0.05	0.01	0.01	0
6.9	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0.01	0.01	0.01	0	0
	D	0.19	0.2	0.05	0	0	0	0.01	0.31	0.96	1.42	0.87	0.93	0.62	0.48	0.31	0.15
	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9.6	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	0.01	0.01	0	0	0	0	0	0.05	0.03	0.08	0.09	0.19	0.08	0.05	0.04	0.02
	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
105	A	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	D	0	0	0	0	0	0	0	0.01	0	0	0.01	0.01	0	0	0	0
	E	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	F	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Source: LANL 1997a.

D.1.4 Sample Batch Flow Diagrams and Supplemental Data

This section contains a sample "process alternative" batch data summary for Rocky Flats (vitrification of ash). Included are a process description, personnel radiation exposure estimates, operations requirements, and input/output diagrams. A separate Technical Report will include all batch data summaries (i.e., technology descriptions) for all processing alternatives at each site examined in this EIS.

Technology Description
Furnace Vitrification for Ash Residues

A. SUMMARY

The proposed Vitrification Immobilization process uses a Furnace Vitrification Technology similar in concept to calcination. This process has been proposed for stabilization treatment to allow safe interim storage at RFETS until shipment to WIPP is approved. The process will be conducted in gloveboxes located in Module D, E, and F, Building 707, using muffle furnaces to heat the residue material to approximately 700 °C - 1300°C for four hours. The end product consists of a vitrified monolith contained inside of an 8-in. dia. x 10-in. high metal can. Various categories of residues are being proposed for treatment by vitrification. This discussion focuses upon the vitrification of Ash Residues consisting of incinerator ash, firebrick, sand, slag, and crucible.

B. PROCESS DESCRIPTION

The Furnace Vitrification process is shown in Figure 1. The principal activities are: 1) drum unloading, 2) feed preparation, 3) vitrification and bag-out, 4) non-destructive assay (NDA), and 5) final drum packaging and storage.

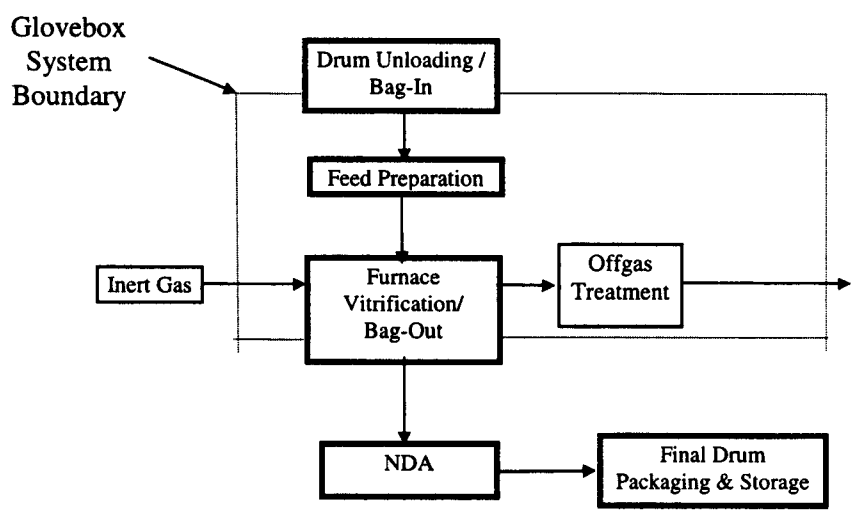


Figure 1 - Furnace Vitrification Process

Furnace Vitrification involves the addition of siliceous material called "frit" to the residues followed by heating at 700° C to 1300° C to produce a glass matrix. It is projected that in addition to the vitrified product stream, there will be two waste streams generated. The first waste stream will be a solid TRU waste stream consisting of size-reduced stainless steel cans, plastic containers, plastic bags and containers. The second waste stream will be a gaseous effluent stream consisting primarily of nitrogen, oxygen, trace acid gases, carbon dioxide and

particulates. The offgas stream will be configured to cool the effluents and remove acids and particulates prior to discharge into the glovebox exhaust HEPA filter system.

A description of the Furnace Vitrification Process follows.

Drum Unloading/ Bag-In

Upon demand, 55-gallon drums will be transferred from storage into a contamination control enclosure in Module D. The contamination control enclosure is designed to control airflow in the event of a bag failure within a drum. The drums will be opened and the integrity of the packaging will be checked. If the packaging has not been compromised, the containers will be transferred into the glovebox in Module E. The containers, including outer bags, clamshells and other packaging materials, will be removed from the drum and bagged into the glovebox. If the integrity of the packaging has been compromised, the package will be overpacked with a new plastic bag, prior to transfer to the glovebox.

There is be approximately five containers in each drum. Although several of the drums contain up to 3000 grams of plutonium, the majority of the drums will contain no more than 1000 grams of plutonium.

Feed Preparation

After bag-in, the IDCs of the ash residue packages will be verified. Then, the original residue packages will be transferred to a residue sorting and loading station. This loading station will provide local dust control and contain a 1/8" sieve to separate all oversized residue and tramp material (uncombusted combustibles, nuts, bolts, etc.) during the transfer process into new containers. The sieved residue fines will be collected in the new containers. Tramp material and large pieces of residue will be collected on the sieve. The tramp material will be separated and transferred for TRU waste size reduction and packaging. Oversized pieces of residue will be sent through a crusher and fed back to the loading station.

Ash residue will be batched so that containers will average 83.5 grams plutonium. Following batching, a blending step will be required wherein the residue material will be blended and diluted with low-melting temperature frit. Each residue stream, to be immobilized by the vitrification process, will be analyzed to determine the appropriate proportions of residue and frit to meet the WIPP Waste Acceptance Criteria (WAC) requirements. The residue containers will then be ready for vitrification.

Furnace Vitrification

Following the residue container being charged and blended, it will be positioned into the heating chamber of the muffle furnace. The furnace will be energized and there will be a gradual ramp-up in temperature within the chamber. The target temperatures for vitrification will be between 700°C to 1300° C. The actual temperature will be determined for each specific type of residue prior to vitrification.

Engineering investigations are underway to identify the most effective method to extract and capture the offgases generated by the heating process. It is anticipated that water vapor, carbon dioxide, nitrous oxide, trace quantities of acid gases, organics, and particulates may be generated during vitrification. This description assumes the use of a dry scrubber using potassium

carbonate for offgas treatment. A concern with residual organic contaminants in the residue feed stream subsequently volatilizing, during the heating process, has necessitated an investigation into the incorporation of a design modification. This will continuously purge the heating chamber with inert gas during the processing of the residues.

The heating process will be approximately 4-hours in duration. The container will be allowed to cool to 100° C prior to removal from the furnace. After final cooling, the container will be sealed with a lid and bagged-out of the glovebox for non-destructive assay (NDA).

Non-Destructive Assay (NDA)

WIPP/WAC requirements limit the amount of packaged Fissile Gram Equivalents per drum. Therefore, post vitrification NDA will be performed on all residue material containers to determine the amount of fissile material present. NDA will be performed using either Neutron Multiplicity Counters (NMC) in concert with Gamma-Ray Isotopic Spectrometers (GIS) or by using Segmented Gamma Scanners (SGS).

Final Drum Packaging

Following NDA, residue containers that meet the WIPP/WAC fissile material limits will be transferred into Module F for final drum packaging. Two containers will be loaded into a pipe component which will be staged inside a 55- gallon drum. The sealed drums will be placed into interim Site storage awaiting shipment to WIPP.

C. PERSONNEL RADIATION EXPOSURE

The Furnace Vitrification System will require close monitoring of both gamma and neutron radiation levels at the work stations. The radiation levels are projected to be as follows:

	Operator W/B Dose	Personnel W/B Dose
Drum Movement	2.5 mrem/hr	0.65 mrem/hr
Drum Unloading	14 mrem/hr	1.37 mrem/hr
Feed Prep	0.0 mrem/hr	0.5 mrem/hr
Vitrify	1.5 mrem/hr	0.6 mrem/hr
NDA	1.5 mrem/hr	0.6 mrem/hr
Final Drum Pkg	1.5 mrem/hr	0.6 mrem/hr

Operator actions are performed inside gloveboxes or in direct handling of packaged materials. Personnel doses are calculated at background plus the amount received at 6 feet from the source. Engineered safety systems and personal protective equipment will be used to provide adequate protection to operators and support personnel involved in the process. Radiation levels at each step are based on the methodology used in the RFETS ALARA Program for Ash Residues and Dry Combustible Residue Stabilization and Repack Project.

D. OPERATIONS REQUIREMENTS

Operation of a single furnace vitrification system will require 6 principal activities. Six furnaces will be required. The principal activities will be staffed for three-shift, five-day per week

operation. The system will vitrify 12 batches per shift. One shift consists of 8 hours per day with a maximum of 6 hours within the area of potential exposure.

Support personnel such as maintenance are assigned part-time to the operation.

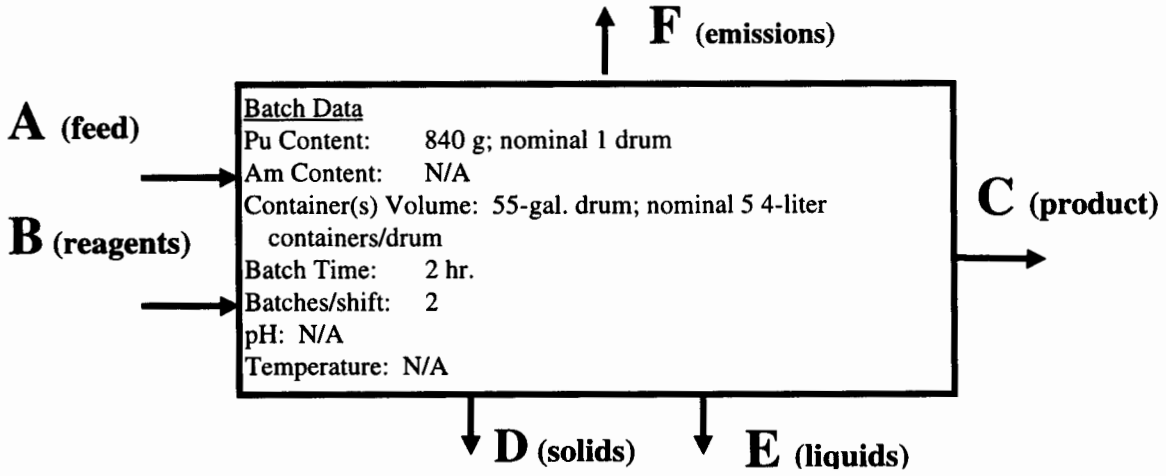
Time Requirements At Principal Activities and Associated Dose Rates (per shift)

	Operations Personnel		Total Personnel		TOTAL			
Principal Activity	Exposure Duration [man-hrs / shift][1]	Dose Rate mrem/hr.[3]	Exposure Duration [man-hrs / shift][1]	Dose Rate, mrem/hr. [2]	mrem/shift	shift/week	man-hr/5-day week	dose rate/5-day week
Drum Movement to Module	3	2.5	6	0.65	11.4	15	90	171
Drum Unloading	1.5	14.0	10	1.37	34.7	15	150	520.5
Feed Preparation	12	0	36	0.5	18	15	540	270
Vitrify/Bagout[4]	1.5	1.5	30	0.6	20.3	15	450	304.5
NDA	2	1.5	18	0.6	13.8	15	270	207
Final Packaging	2	1.5	24	0.6	17.4	5	120	87
TOTAL					115.6			1560

[1]Operator in direct contact with source
[2]Dose is background plus exposure at 6 feet from source
[3]Dose is 0, if 10^{-6} or less
[4]Dose calculated for Bag-out activity only.

E. INPUT/OUTPUT DIAGRAM

The material flows for the Furnace Vitrification system are shown in the attached Data Sheets. The amounts of feed, product, and waste streams along with the airborne and liquid effluents to the environment, in kg for non-radioactive materials and by specific radionuclide for radioactive material, are shown.



Total Components	A	B	C	D	E	F
Pu (kg)	1,164		1,164			<1E-12
Am						
Residue Matrix (kg)	20,057		20,057			
Water/Acid						
Other						
No. of containers in drums	6,400		6,400			
No. of drums	1,280			1,280		
No. of other containers	530		530			
Total No. of containers			6,930			

Radiation levels: - 14 mrem/hr whole body on contact
- 1.37 mrem/hr whole body (Background & 6' from source)

Operations Data

Workstations:
- Transportation
- Contam. Cntrl. Enclosure
- Bag-in at glovebox
-

Staffing:
- 3 shifts/day; 5 days/week
- 3 Operators at unit
- 0.5 hours/shift in gloves
- 14 Opr exp. dose rate in gloves
- 5 Total personnel at unit
- 2 hours/shift in area
- 1.37 Exp. dose rate

Batches/week: 2x8=16 (RAM factor)

Special Requirements: - None

Process Data

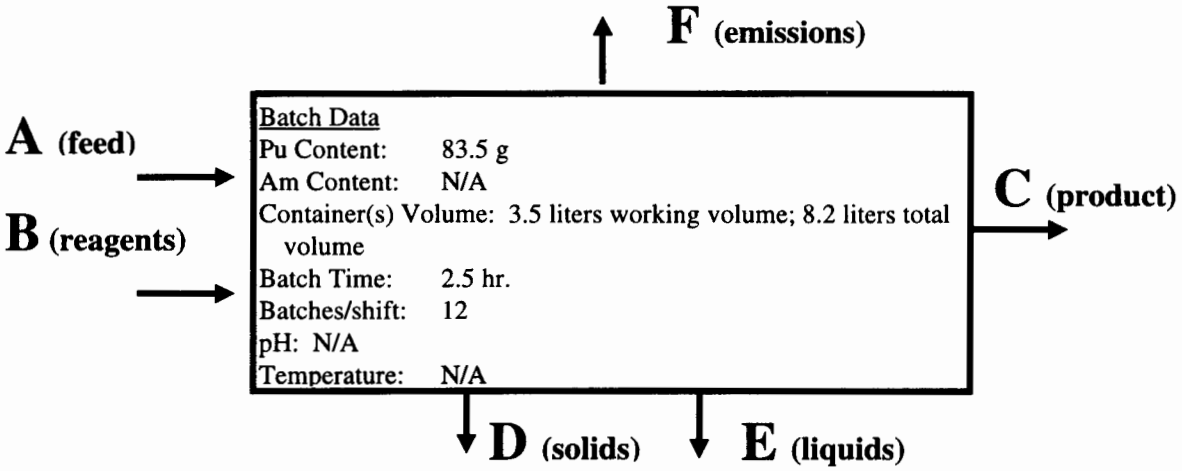
Equipment:
- Contam. Cntrl. Enclosure
- Hand tools
- Glovebox bag-in
- Drum Handling Equip.

Space Requirements: - 2250 ft^3

Utilities:
- No Electricity
- No Water
- No Air
- No Steam
- No Other
- No Other

Location: - Building 707,Modules D/E

New Equipment Cost: - $0K



Total Components	A	B	C	D	E	F
Pu (kg)	1,164		1,152	12		1E-8
Am						
Residue Matrix (kg)	20,057			207		
Residue and Frit Matrix (kg)			39,700			
Water/Acid						
Glass Frit (kg)		19,850				
No. of 8.2-liter containers		13,800	13,800			
No. of 4-liter/other feed containers	6,930			6,930		
No. of Batches	6,930		13,800			

Radiation levels: - 0 mrem/hr whole body on contact
- 0.5 mrem/hr whole body (Background & 6' from source)

Operations Data

Workstations:
- Sort
- Crush
- Sieve/Batch/Blend
- Trash Removal

Staffing:
- 3 shifts/day; 5 days/week
- 4 Operators at unit
- 3 hours/shift in gloves
- 0 Opr exp. dose rate in gloves
- 6 Total personnel at unit
- 6 hours/shift in area
- 0.5 Exp. dose rate

Batches/week: - 12x8=96 (RAM factor)

Special Requirements: - None

Process Data

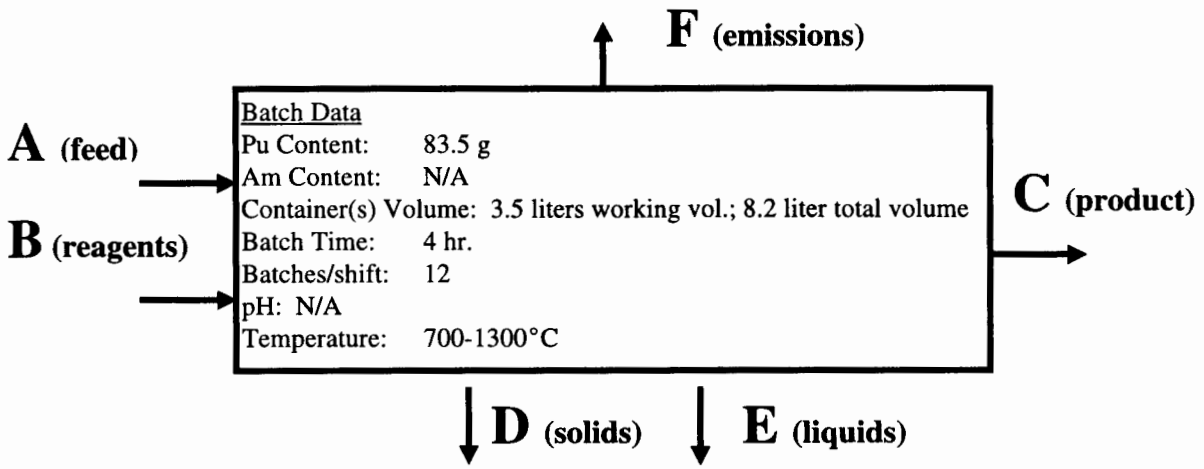
Equipment:
- Crusher
- Rototap/Sieves
- Scales
- Gram Estimator
- Blender
- Glovebox Bag-out

Space Requirements: - 360 ft^3 (glovebox)

Utilities:
- Yes Electricity
- No Water
- No Air
- No Steam
- No Other
- No Other

Location: - Building 707, Module E

New Equipment Cost: - $0K



Total Components	A	B	C	D	E	F
Pu (Kg)	1,152		1,152			1E-8
Am (Kg)						
Residue + Frit (kg)	39,700		34,500			
Water/Acid (liters)						
Scrubber K_2CO_3 (kg)		397		397		
No. of 8.2-liter containers	13,800		13,800			
No. of convenience cans		13,800	13,800			
Nominal Carbon (kg) (as CO_2)						5,200 (19,100)

Radiation levels: - 15 mrem/hr whole body on contact
- 0.6 mrem/hr whole body (background + 6' from source)

Operations Data

Workstations:
- Furnace Load/Unload
- Cooling/Staging/Weighing
- Sealing/Taping Can
- Bag-out at Glovebox
- Convenience Canning

Staffing:
- 3 shifts/day; 5 day/week
- 3 Operators at unit
- 0.5 hours/shift in gloves
- 1.5 Opr exp. dose rate in gloves
- 5 Total personnel at unit
- 6 hours/shift in area
- 0.6 Exp. dose rate

Batches/week: - 12X8=96 (RAM factor)

Special Requirements: - None

Process Data

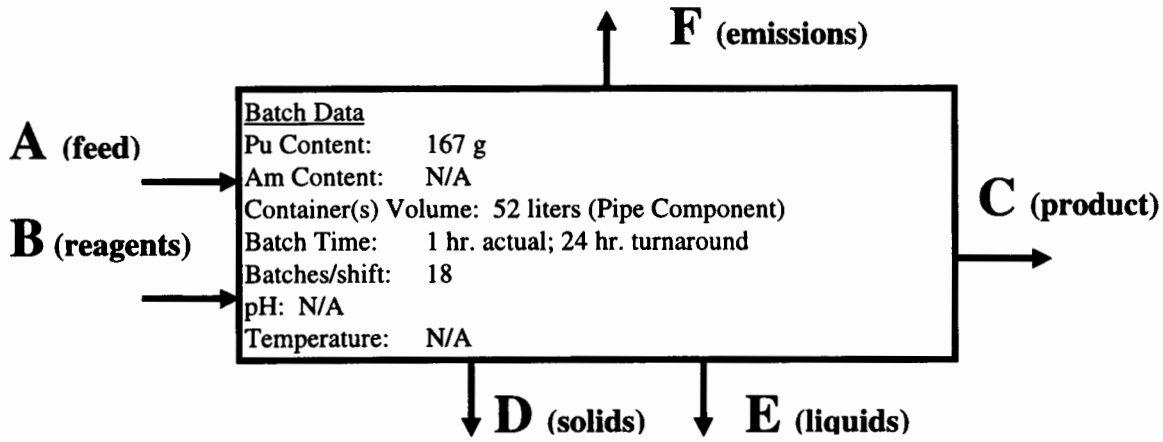
Equipment:
- Furnace (6)
- Solid-phase Scrubber (6)
- Heat Exchanger (6)
- Scale
- Glovebox Bag-out

Space Requirements: - 480 ft^3 (glovebox)

Utilities:
- Yes Electricity
- No Water
- Yes Air
- No Steam
- Yes Nitrogen
- Yes Vacuum

Location: - Building 707, Module E

New Equipment Cost: - $100K



Total Components	A	B	C	D	E	F
Pu (kg)	1,152		1,152			<1E-12
Am (kg)						
Residue + Frit (kg)	34,500		34,500			
Water/Acid (liters)						
No. of 8.2-liter containers	13,800		13,800			
No. of convenience cans	13,800		13,800			
No. of Pipe Components		6,900	6,900			
No. of drums w/Celetex		6,900	6,900			

Radiation levels: - 1.5 mrem/hr whole body on contact
- 0.6 mrem/hr whole body (Background & 6' from source)

Operations Data

Workstations:
- Drum Packaging
- Transportation
- Storage

Process Data

Equipment:
- Drum Moving Equip
-
-

Staffing:
- 1 shifts/day; 5 days/week
- 2 Operators at unit
- 1 hours/shift in gloves
- 1.5 Opr exp. dose rate in gloves
- 4 Total personnel at unit
- 6 hours/shift in area
- 0.6 Exp. dose rate

Space Requirements: - No gloveboxes

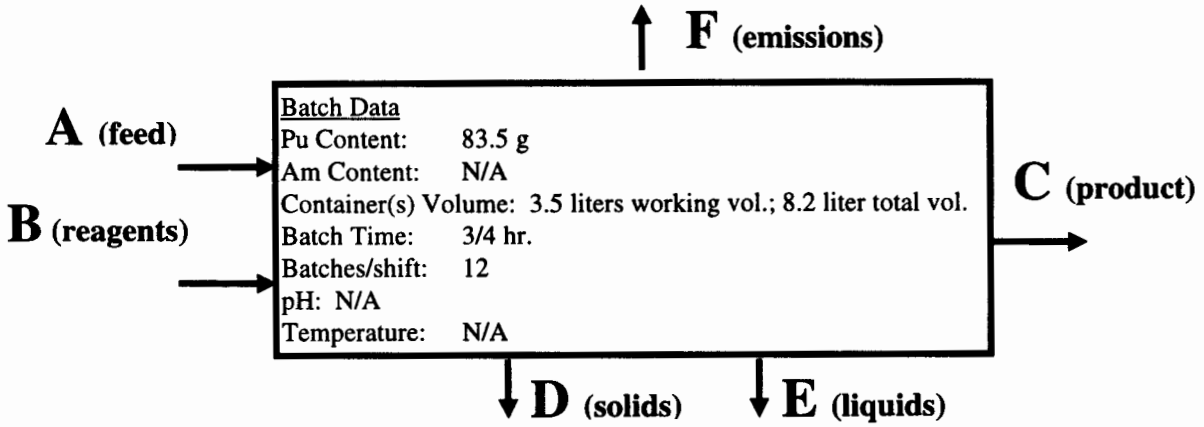
Utilities:
- No Electricity
- No Water
- No Air
- No Steam
- No Other
- No Other

Batches/week: -18X3=54 (RAM factor)

Location: - Various

Special Requirements: - None

New Equipment Cost: - $0K



Total Components	A	B	C	D	E	F
Pu (kg)	1,152		1,152			<1E-12
Am (kg)						
Residue + Frit (kg)	34,500		34,500			
Water/Acid (liters)						
No. of 8.2-liter containers	13,800		13,800			
No. of convenience cans	13,800		13,800			

Radiation levels: - 1.5 mrem/hr whole body on contact
- 0.6 mrem/hr whole body (Background & 6' from source)

Operations Data

Workstations:
- NDA
- Transportation
-
-

Staffing:
- 3 shifts/day; 5 days/week
- 2 Operators at unit
- 1 hours/shift in gloves
- 1.5 Opr exp. dose rate in gloves
- 3 Total personnel at unit
- 6 hours/shift in area
- 0.6 Sppt exp. dose rate

Batches/week: - 12x8=96 (RAM factor)

Special Requirements: - None

Process Data

Equipment:
- Segmented Gamma Scanner
- Carts
-
-

Space Requirements: - No gloveboxes

Utilities:
- Yes Electricity
- No Water
- No Air
- No Steam
- No Other
- No Other

Location: - Building 707, Module E

New Equipment Cost: - $300-600K

D.2 NORMAL OPERATIONAL RADIOLOGICAL RELEASES AND IMPACTS TO THE ENVIRONMENT

This section presents compilations of radiological releases to the environment as well as resulting impact ranges from processes associated with all alternatives assessed in this EIS. The total releases of radioactivity to the environment associated with processes common to processing/storage activities are given in **Table D–22**. The releases, by radionuclide, include those for applicable operations at each site in question and differ according to site location. **Table D–23** presents the unit source terms for the release of 1 gram-mix of weapons-grade plutonium. **Tables D-24** through **D-26** present the maximum impacts associated with each site. These tables are provided to illustrate the largest possible incident-free impacts associated with each residue type that could exist at each site for all possible alternatives examined in this EIS. The detailed results of the impact assessments are given in Chapter 4 of this EIS.

Table D–22 Total Radioactive Releases During Normal Operation of Processing/Storage Processes (Ci) [a]

Process Radionuclides	*Rocky Flats*	*Savannah River Site*	*Los Alamos National Laboratory*
Calcining/Cementation of Ash			
Plutonium 238	2.2×10^{-7}	—	—
Plutonium 239	2.5×10^{-6}	—	—
Plutonium 240	5.6×10^{-7}	—	—
Plutonium 241	0.000015	—	—
Plutonium 242	5.2×10^{-11}	—	—
Americium 241	2.6×10^{-8}	—	—
Immobilization (Vitrification/Ceramification) of Ash			
Plutonium 238	1.0×10^{-7}	—	—
Plutonium 239	1.2×10^{-6}	—	—
Plutonium 240	2.6×10^{-7}	—	—
Plutonium 241	6.9×10^{-6}	—	—
Plutonium 242	2.4×10^{-11}	—	—
Americium 241	1.2×10^{-8}	—	—
Blend Down of Ash			
Plutonium 238	1.7×10^{-7}	—	—
Plutonium 239	2.0×10^{-6}	—	—
Plutonium 240	4.4×10^{-7}	—	—
Plutonium 241	0.000011	—	—
Plutonium 242	4.1×10^{-11}	—	—
Americium 241	2.0×10^{-8}	—	—
Repackaging of Ash at Rocky Flats for Transport to the Savannah River Site (for Mediated Electrochemical Oxidation at the Savannah River Site)			
Plutonium 238	1.5×10^{-7}	—	—
Plutonium 239	1.7×10^{-6}	—	—
Plutonium 240	3.8×10^{-7}	—	—
Plutonium 241	0.000010	—	—
Plutonium 242	3.6×10^{-11}	—	—
Americium 241	1.8×10^{-8}	—	—
Repackaging of Ash at Rocky Flats for Transport to the Savannah River Site (for Purex at the Savannah River Site)			
Plutonium 238	1.5×10^{-7}	—	—
Plutonium 239	1.7×10^{-6}	—	—
Plutonium 240	3.8×10^{-7}	—	—
Plutonium 241	0.000010	—	—
Plutonium 242	3.6×10^{-11}	—	—
Americium 241	1.8×10^{-8}	—	—
Sand, Slag, and Crucible Purex Process—Rocky Flats Size Reduced			
Plutonium 238	—	0.000025	—
Plutonium 239	—	0.000026	—
Americium 241/243	—	0.000017	—

Process Radionuclides	Rocky Flats	Savannah River Site	Los Alamos National Laboratory
Fusion/Purex Process for Ash			
Plutonium 238	—	0.00029	—
Plutonium 239	—	0.00031	—
Americium 241/243	—	0.00020	—
Mediated Electrochemical Oxidation for Ash			
Plutonium 238	—	0.00017	—
Plutonium 239	—	0.00018	—
Americium 241/243	—	0.00012	—
Pyro-oxidation of Salts			
Plutonium 238	1.0×10^{-7}	—	—
Plutonium 239	1.2×10^{-6}	—	—
Plutonium 240	2.6×10^{-7}	—	—
Plutonium 241	6.8×10^{-6}	—	—
Plutonium 242	2.4×10^{-11}	—	—
Americium 241	3.5×10^{-7}	—	—
Pyro-oxidation/Blend Down of Salts			
Plutonium 238	2.5×10^{-7}	—	—
Plutonium 239	2.9×10^{-6}	—	—
Plutonium 240	6.4×10^{-7}	—	—
Plutonium 241	0.000017	—	—
Plutonium 242	6.0×10^{-11}	—	—
Americium 241	8.8×10^{-7}	—	—
Salt Distillation			
Plutonium 238	1.8×10^{-7}	—	4.3×10^{-8}
Plutonium 239	2.0×10^{-6}	—	5.0×10^{-7}
Plutonium 240	4.5×10^{-7}	—	1.1×10^{-7}
Plutonium 241	0.000012	—	2.9×10^{-6}
Plutonium 242	4.2×10^{-11}	—	1.0×10^{-11}
Americium 241	2.9×10^{-7}	—	7.3×10^{-8}
Salt Scrub for Pyro Salts/Ship Scrub Alloy to the Savannah River Site			
Plutonium 238	1.5×10^{-7}	—	—
Plutonium 239	1.7×10^{-6}	—	—
Plutonium 240	3.9×10^{-7}	—	—
Plutonium 241	0.000010	—	—
Plutonium 242	3.6×10^{-11}	—	—
Americium 241	4.9×10^{-7}	—	—
Dissolution of Salt Residues from Plutonium Oxide (Water Leach)			
Plutonium 238	3.7×10^{-7}	—	9.4×10^{-9}
Plutonium 239	4.3×10^{-6}	—	1.1×10^{-7}
Plutonium 240	9.7×10^{-8}	—	2.4×10^{-8}
Plutonium 241	0.000025	—	6.3×10^{-7}
Plutonium 242	8.9×10^{-11}	—	2.2×10^{-12}
Americium 241	1.3×10^{-6}	—	1.1×10^{-7}
Preprocess Salt Residues at Rocky Flats for Transport to Los Alamos National Laboratory			
Plutonium 238	1.1×10^{-7}	—	—
Plutonium 239	1.3×10^{-6}	—	—
Plutonium 240	2.9×10^{-7}	—	—
Plutonium 241	7.4×10^{-6}	—	—
Plutonium 242	2.6×10^{-11}	—	—
Americium 241	3.7×10^{-7}	—	—

Process Radionuclides	Rocky Flats	Savannah River Site	Los Alamos National Laboratory
Neutralize/Dry (Aqueous) Combustibles			
Plutonium 238	1.6×10^{-9}	—	—
Plutonium 239	1.6×10^{-8}	—	—
Plutonium 240	3.9×10^{-9}	—	—
Plutonium 241	9.5×10^{-8}	—	—
Plutonium 242	3.4×10^{-13}	—	—
Americium 241	1.7×10^{-10}	—	—
Thermal Desorption/Steam Passivation (Organic) Combustibles			
Plutonium 238	1.0×10^{-9}	—	—
Plutonium 239	1.2×10^{-8}	—	—
Plutonium 240	2.6×10^{-9}	—	—
Plutonium 241	6.8×10^{-8}	—	—
Plutonium 242	2.4×10^{-13}	—	—
Americium 241	1.2×10^{-10}	—	—
Repackage (Dry Combustibles)			
Plutonium 238	5.5×10^{-10}	—	—
Plutonium 239	6.0×10^{-9}	—	—
Plutonium 240	1.0×10^{-9}	—	—
Plutonium 241	3.7×10^{-8}	—	—
Plutonium 242	1.3×10^{-13}	—	—
Americium 241	6.6×10^{-11}	—	—
Sonic Wash (Aqueous, Organic, and Dry Combustibles)			
Plutonium 238	5.0×10^{-9}	—	—
Plutonium 239	5.8×10^{-8}	—	—
Plutonium 240	1.3×10^{-8}	—	—
Plutonium 241	3.4×10^{-7}	—	—
Plutonium 242	1.2×10^{-12}	—	—
Americium 241	6.0×10^{-10}	—	—
Digestion (Aqueous, Organic, and Dry Combustibles)			
Plutonium 238	3.2×10^{-9}	—	—
Plutonium 239	3.7×10^{-8}	—	—
Plutonium 240	8.4×10^{-9}	—	—
Plutonium 241	2.2×10^{-7}	—	—
Plutonium 242	7.7×10^{-13}	—	—
Americium 241	3.9×10^{-10}	—	—
Thermal Destruction (Aqueous, Organic, and Dry Combustibles)			
Plutonium 238	2.2×10^{-9}	—	—
Plutonium 239	2.5×10^{-8}	—	—
Plutonium 240	5.6×10^{-9}	—	—
Plutonium 241	1.5×10^{-7}	—	—
Plutonium 242	5.2×10^{-13}	—	—
Americium 241	2.6×10^{-10}	—	—
Shred and Blend Down (Aqueous, Organic, and Dry Combustibles)			
Plutonium 238	2.0×10^{-9}	—	—
Plutonium 239	2.5×10^{-8}	—	—
Plutonium 240	6.0×10^{-9}	—	—
Plutonium 241	1.4×10^{-7}	—	—
Plutonium 242	5.2×10^{-13}	—	—
Americium 241	2.6×10^{-10}	—	—

Process Radionuclides	Rocky Flats	Savannah River Site	Los Alamos National Laboratory
Mediated Electrochemical Oxidation for Aqueous/Organic-Contaminated and Dry Combustibles			
Plutonium 238	5.2×10^{-9}	—	—
Plutonium 239	6.0×10^{-8}	—	—
Plutonium 240	1.4×10^{-8}	—	—
Plutonium 241	3.5×10^{-7}	—	—
Plutonium 242	1.2×10^{-12}	—	—
Americium 241	6.2×10^{-10}	—	—
Acid Dissolution/Plutonium Oxide Recovery for Plutonium Fluorides			
Plutonium 238	3.6×10^{-8}	—	—
Plutonium 239	4.1×10^{-7}	—	—
Plutonium 240	9.1×10^{-8}	—	—
Plutonium 241	2.4×10^{-6}	—	—
Plutonium 242	8.5×10^{-12}	—	—
Americium 241	4.8×10^{-9}	—	—
Blend Down of Plutonium Fluorides			
Plutonium 238	N/E	—	—
Plutonium 239	N/E	—	—
Plutonium 240	N/E	—	—
Plutonium 241	N/E	—	—
Plutonium 242	N/E	—	—
Americium 241	N/E	—	—
Pretreat and Package Plutonium Fluorides for Shipment to the Savannah River Site			
Plutonium 238	7.5×10^{-9}	—	—
Plutonium 239	8.1×10^{-8}	—	—
Plutonium 240	1.8×10^{-8}	—	—
Plutonium 241	4.7×10^{-7}	—	—
Plutonium 242	1.7×10^{-12}	—	—
Americium 241	8.4×10^{-10}	—	—
Fluorides Purex Process			
Plutonium 238	—	0.000038	—
Plutonium 239	—	0.000041	—
Americium 241/243	—	0.000027	—
Neutralize/Dry All Filter Media			
Plutonium 238	1.7×10^{-8}	—	—
Plutonium 239	1.9×10^{-7}	—	—
Plutonium 240	4.3×10^{-8}	—	—
Plutonium 241	1.1×10^{-6}	—	—
Plutonium 242	4.0×10^{-12}	—	—
Americium 241	2.0×10^{-9}	—	—
Immobilization (Vitrification) of High-Efficiency Particulate Air Filter Media			
Plutonium 238	1.0×10^{-8}	—	—
Plutonium 239	1.2×10^{-7}	—	—
Plutonium 240	2.6×10^{-8}	—	—
Plutonium 241	6.7×10^{-7}	—	—
Plutonium 242	2.4×10^{-12}	—	—
Americium 241	1.0×10^{-9}	—	—
Shred and Blend Down Filter Media			
Plutonium 238	1.1×10^{-8}	—	—
Plutonium 239	1.3×10^{-7}	—	—
Plutonium 240	2.8×10^{-8}	—	—
Plutonium 241	7.3×10^{-7}	—	—
Plutonium 242	2.6×10^{-12}	—	—
Americium 241	1.0×10^{-9}	—	—

Process Radionuclides	Rocky Flats	Savannah River Site	Los Alamos National Laboratory
Thermal Destruction of Filter Media (Fluidized Bed)			
Plutonium 238	1.7×10^{-8}	—	—
Plutonium 239	2.0×10^{-7}	—	—
Plutonium 240	4.4×10^{-8}	—	—
Plutonium 241	1.2×10^{-6}	—	—
Plutonium 242	4.1×10^{-12}	—	—
Americium 241	2.0×10^{-9}	—	—
Sonic Wash of Filter Media			
Plutonium 238	2.3×10^{-8}	—	—
Plutonium 239	2.6×10^{-7}	—	—
Plutonium 240	5.9×10^{-8}	—	—
Plutonium 241	1.5×10^{-6}	—	—
Plutonium 242	5.5×10^{-12}	—	—
Americium 241	3.0×10^{-9}	—	—
Mediated Electrochemical Oxidation for Filter Media			
Plutonium 238	2.2×10^{-8}	—	—
Plutonium 239	2.5×10^{-7}	—	—
Plutonium 240	5.7×10^{-8}	—	—
Plutonium 241	1.5×10^{-6}	—	—
Plutonium 242	5.2×10^{-12}	—	—
Americium 241	2.6×10^{-9}	—	—
Filter/Dry Sludges			
Plutonium 238	3.0×10^{-9}	—	—
Plutonium 239	3.1×10^{-8}	—	—
Plutonium 240	7.0×10^{-9}	—	—
Plutonium 241	1.8×10^{-7}	—	—
Plutonium 242	6.4×10^{-13}	—	—
Americium 241	3.2×10^{-10}	—	—
Immobilization (Vitrification) of Sludges			
Plutonium 238	3.0×10^{-9}	—	—
Plutonium 239	3.5×10^{-8}	—	—
Plutonium 240	8.0×10^{-9}	—	—
Plutonium 241	2.0×10^{-7}	—	—
Plutonium 242	7.2×10^{-13}	—	—
Americium 241	3.6×10^{-10}	—	—
Blend Down of Sludges			
Plutonium 238	2.7×10^{-9}	—	—
Plutonium 239	3.1×10^{-8}	—	—
Plutonium 240	7.1×10^{-9}	—	—
Plutonium 241	1.8×10^{-7}	—	—
Plutonium 242	6.4×10^{-13}	—	—
Americium 241	3.2×10^{-10}	—	—
Dissolution (Nitric Acid) of Sludges			
Plutonium 238	6.1×10^{-9}	—	—
Plutonium 239	7.1×10^{-8}	—	—
Plutonium 240	1.6×10^{-8}	—	—
Plutonium 241	4.1×10^{-7}	—	—
Plutonium 242	1.5×10^{-12}	—	—
Americium 241	7.6×10^{-10}	—	—

Process Radionuclides	Rocky Flats	Savannah River Site	Los Alamos National Laboratory
Neutralize/Dry Raschig (Glass) Rings			
Plutonium 238	N/E	—	—
Plutonium 239	N/E	—	—
Plutonium 240	N/E	—	—
Plutonium 241	N/E	—	—
Plutonium 242	N/E	—	—
Americium 241	N/E	—	—
Immobilization (Vitrification) of Raschig (Glass) Rings			
Plutonium 238	5.0×10^{-10}	—	—
Plutonium 239	5.8×10^{-9}	—	—
Plutonium 240	2.2×10^{-10}	—	—
Plutonium 241	3.3×10^{-8}	—	—
Plutonium 242	1.2×10^{-13}	—	—
Americium 241	6.0×10^{-11}	—	—
Blend Down of Raschig (Glass) Rings			
Plutonium 238	5.0×10^{-10}	—	—
Plutonium 239	5.8×10^{-9}	—	—
Plutonium 240	2.2×10^{-10}	—	—
Plutonium 241	3.3×10^{-8}	—	—
Plutonium 242	1.2×10^{-13}	—	—
Americium 241	6.0×10^{-11}	—	—
Sonic Wash of Raschig (Glass) Rings			
Plutonium 238	N/E	—	—
Plutonium 239	N/E	—	—
Plutonium 240	N/E	—	—
Plutonium 241	N/E	—	—
Plutonium 242	N/E	—	—
Americium 241	N/E	—	—
Mediated Electrochemical Oxidation for Raschig (Glass) Rings			
Plutonium 238	1.3×10^{-9}	—	—
Plutonium 239	1.5×10^{-8}	—	—
Plutonium 240	3.3×10^{-9}	—	—
Plutonium 241	8.5×10^{-8}	—	—
Plutonium 242	3.0×10^{-13}	—	—
Americium 241	1.5×10^{-10}	—	—
Direct Repackaging of Graphite			
Plutonium 238	N/E	—	—
Plutonium 239	N/E	—	—
Plutonium 240	N/E	—	—
Plutonium 241	N/E	—	—
Plutonium 242	N/E	—	—
Americium 241	N/E	—	—
Repackaging Graphite at Rocky Flats for Transport to the Savannah River Site			
Plutonium 238	4.9×10^{-9}	—	—
Plutonium 239	5.6×10^{-8}	—	—
Plutonium 240	1.3×10^{-8}	—	—
Plutonium 241	3.3×10^{-7}	—	—
Plutonium 242	1.2×10^{-12}	—	—
Americium 241	5.8×10^{-10}	—	—

Process Radionuclides	Rocky Flats	Savannah River Site	Los Alamos National Laboratory
Immobilization (Cementation) of Graphite			
Plutonium 238	2.0×10^{-8}	—	—
Plutonium 239	2.3×10^{-7}	—	—
Plutonium 240	5.2×10^{-8}	—	—
Plutonium 241	1.3×10^{-6}	—	—
Plutonium 242	4.8×10^{-12}	—	—
Americium 241	2.4×10^{-9}	—	—
Immobilization (Vitrification) of Graphite			
Plutonium 238	9.5×10^{-9}	—	—
Plutonium 239	1.1×10^{-7}	—	—
Plutonium 240	2.5×10^{-8}	—	—
Plutonium 241	6.4×10^{-7}	—	—
Plutonium 242	2.3×10^{-12}	—	—
Americium 241	1.1×10^{-9}	—	—
Blend Down of Graphite			
Plutonium 238	9.5×10^{-9}	—	—
Plutonium 239	1.1×10^{-7}	—	—
Plutonium 240	2.5×10^{-8}	—	—
Plutonium 241	6.4×10^{-7}	—	—
Plutonium 242	2.3×10^{-12}	—	—
Americium 241	1.1×10^{-9}	—	—
Mediated Electrochemical Oxidation for Graphite			
Plutonium 238	2.4×10^{-8}	0.000024	—
Plutonium 239	2.8×10^{-7}	0.000026	—
Plutonium 240	6.2×10^{-8}	—	—
Plutonium 241	1.6×10^{-6}	—	—
Plutonium 242	5.8×10^{-12}	—	—
Americium 241/243	2.9×10^{-9}	0.000017	—
Direct Repackage of Inorganic Residue			
Plutonium 238	N/E	—	—
Plutonium 239	N/E	—	—
Plutonium 240	N/E	—	—
Plutonium 241	N/E	—	—
Plutonium 242	N/E	—	—
Americium 241	N/E	—	—
Repackage Inorganics at Rocky Flats for Transport to the Savannah River Site			
Plutonium 238	9.0×10^{-10}	—	—
Plutonium 239	1.1×10^{-8}	—	—
Plutonium 240	2.3×10^{-9}	—	—
Plutonium 241	6.1×10^{-8}	—	—
Plutonium 242	2.1×10^{-13}	—	—
Americium 241	1.1×10^{-10}	—	—
Immobilization (Vitrification) of Inorganics			
Plutonium 238	2.0×10^{-9}	—	—
Plutonium 239	2.3×10^{-8}	—	—
Plutonium 240	5.2×10^{-9}	—	—
Plutonium 241	1.3×10^{-7}	—	—
Plutonium 242	4.8×10^{-13}	—	—
Americium 241	2.4×10^{-10}	—	—

Process Radionuclides	***Rocky Flats***	***Savannah River Site***	***Los Alamos National Laboratory***
Blend Down of Inorganics			
Plutonium 238	1.8×10^{-9}	—	—
Plutonium 239	2.0×10^{-8}	—	—
Plutonium 240	4.6×10^{-9}	—	—
Plutonium 241	1.1×10^{-7}	—	—
Plutonium 242	4.2×10^{-13}	—	—
Americium 241	2.1×10^{-10}	—	—
Mediated Electrochemical Oxidation for Inorganics			
Plutonium 238	4.4×10^{-9}	0.000004	—
Plutonium 239	5.2×10^{-8}	0.000004	—
Plutonium 240	1.2×10^{-8}	—	—
Plutonium 241	3.0×10^{-7}	—	—
Plutonium 242	1.1×10^{-12}	—	—
Americium 241/243	5.3×10^{-10}	2.9×10^{-6}	—
Direct Repackage of Scrub Alloy Residue			
Plutonium 238	2.0×10^{-8}	—	—
Plutonium 239	2.3×10^{-7}	—	—
Plutonium 240	5.2×10^{-8}	—	—
Plutonium 241	1.4×10^{-6}	—	—
Plutonium 242	4.8×10^{-12}	—	—
Americium 241	1.3×10^{-6}	—	—
Repackaging of Scrub Alloy at Rocky Flats for Shipment to the Savannah River Site			
Plutonium 238	6.5×10^{-9}	—	—
Plutonium 239	7.5×10^{-8}	—	—
Plutonium 240	1.7×10^{-8}	—	—
Plutonium 241	4.4×10^{-7}	—	—
Plutonium 242	1.6×10^{-12}	—	—
Americium 241	6.5×10^{-7}	—	—
Immobilization (Calcination/Vitrification) of Scrub Alloy Buttons			
Plutonium 238	3.0×10^{-8}	—	—
Plutonium 239	3.5×10^{-7}	—	—
Plutonium 240	7.7×10^{-8}	—	—
Plutonium 241	2.0×10^{-6}	—	—
Plutonium 242	7.2×10^{-12}	—	—
Americium 241	1.9×10^{-6}	—	—
Existing Scrub Alloy Purex System			
Plutonium 238	—	0.000045	—
Plutonium 239	—	0.000048	—
Americium 241/243	—	0.000032	—
Pyrochemical Salts Scrub Alloy Purex System			
Plutonium 238	—	0.00022	—
Plutonium 239	—	0.00023	—
Americium 241/243	—	0.00015	—

N/E = no emissions

[a] All releases were to the atmosphere.

Note: Ash includes the general categories of incinerator ash/firebrick fines (78%), graphite fines (6%), sand, slag, crucible (11%), and inorganic (5%).
Salt includes the categories of sodium chloride/potassium chloride (88%) and calcium chloride (12%).
Combustibles includes the categories of aqueous (44%), organic (30%), and dry (26%).
Filter media includes the categories of high-efficiency particulate air (83%) and Ful Flo (17%).

Source: WSRC 1997a - Process Descriptions, RFFO 1997 - Process Descriptions, LANL 1997b - Process Descriptions.

Table D–23 Releases [a] per 1 gram-mix of Weapons-Grade Plutonium (Ci) for Processing Alternatives (Normal Operations) at Rocky Flats

Process Radionuclides	*Releases (per 1 gram-mix)*
Plutonium 238	0.005
Plutonium 239	0.058
Plutonium 240	0.013
Plutonium 241	0.34
Plutonium 242	1.2×10^{-6}
Americium 241 [b]	0.0006

[a] All releases were to the atmosphere.
[b] For all salt and scrub alloy processes, there was an extra independent quantity (not within the weapons-grade mix) of Americium-241 released from operational procedures. For every microgram of this Americium-241, there was an associated 3.4 microcuries released.
Source: Sanford 1996.

Table D–24 Radiological Impacts Due to Incident-Free Management of Plutonium Residues and Scrub Alloy—Rocky Flats Maximum Impacts

	Offsite Population		*Offsite Maximally Exposed Individual*		*Worker Population*	
Material	*Collective Dose (person-rem)*	*Latent Cancer Fatalities (number of cancers)*	*Annual Dose (mrem)*	*Cancer Probability*	*Collective Dose (person-rem)*	*Latent Cancer Fatalities (number of cancers)*
Incinerator Ash	0.0051	2.55×10^{-6}	0.00024	1.20×10^{-10}	320	0.128
Sand, Slag, and Crucible	0.00073	3.65×10^{-7}	0.000035	1.75×10^{-11}	151	0.0604
Inorganic Ash	0.00029	1.45×10^{-7}	0.000013	6.50×10^{-12}	60	0.024
Graphite Fines	0.00042	2.10×10^{-7}	0.000020	1.00×10^{-11}	26	0.0104
Molten Salt Extraction/ Electrorefining Salts	0.0099	4.95×10^{-6}	0.00043	2.15×10^{-10}	719	0.288
Direct Oxide Reduction Salts	0.00311	1.56×10^{-6}	0.00015	7.50×10^{-11}	115	0.0456
Combustibles	0.00016	8.00×10^{-8}	7.40×10^{-6}	3.70×10^{-12}	42	0.0168
Plutonium Fluorides	0.00098	4.90×10^{-7}	0.000043	2.15×10^{-11}	356	0.142
High-Efficiency Particulate Air Filter Media	0.00057	2.85×10^{-7}	0.000027	1.35×10^{-11}	68	0.027
Ful Flo Filter Media	0.00012	6.00×10^{-8}	5.70×10^{-6}	2.85×10^{-12}	15	0.006
Sludge Residues	0.00017	8.50×10^{-8}	7.60×10^{-6}	3.80×10^{-12}	39	0.016
Glass Residues	0.000038	1.90×10^{-8}	1.80×10^{-6}	9.00×10^{-13}	1.90	0.00076
Graphite Residues	0.00072	3.60×10^{-7}	0.000034	1.70×10^{-11}	36	0.0144
Inorganic Residues	0.00013	6.50×10^{-8}	6.30×10^{-6}	3.15×10^{-12}	7.4	0.0030
Scrub Alloy	0.0025	1.25×10^{-6}	0.000066	3.30×10^{-11}	142	0.0568
TOTALS	0.0249	0.0000125	0.00109	5.43×10^{-10}	2,100	0.839

Table D–25 Radiological Impacts Due to Incident-Free Management of Plutonium Residues and Scrub Alloy—Savannah River Site Maximum Impacts

Material	Offsite Population		Offsite Maximally Exposed Individual		Worker Population	
	Collective Dose (person-rem)	Latent Cancer Fatalities (number of cancers)	Annual Dose (mrem)	Cancer Probability	Collective Dose (person-rem)	Latent Cancer Fatalities (number of cancers)
Incinerator Ash	0.17	0.000085	0.0015	7.50×10^{-10}	231	0.0924
Sand, Slag, and Crucible	0.014	7.00×10^{-6}	0.00013	6.50×10^{-11}	17	0.0068
Inorganic Ash	N/A	N/A	N/A	N/A	N/A	N/A
Graphite Fines	0.0071	3.55×10^{-6}	0.000064	3.20×10^{-11}	12	0.0048
Salts	0.12	0.000060	0.0012	6.00×10^{-10}	120	0.048
Combustibles	N/A	N/A	N/A	N/A	N/A	N/A
Plutonium Fluorides	0.022	0.000011	0.00020	1.00×10^{-10}	34	0.0136
High-Efficiency Particulate Air Filter Media	N/A	N/A	N/A	N/A	N/A	N/A
Ful Flo Filter Media	N/A	N/A	N/A	N/A	N/A	N/A
Sludge Residues	N/A	N/A	N/A	N/A	N/A	N/A
Glass Residues	N/A	N/A	N/A	N/A	N/A	N/A
Graphite Residues	0.014	7.00×10^{-6}	0.00012	6.00×10^{-11}	25	0.010
Inorganic Residues	0.0023	1.15×10^{-6}	0.000021	1.05×10^{-11}	4.50	0.0018
Scrub Alloy	0.0255	0.0000128	0.00024	1.20×10^{-10}	25	0.010
TOTALS	0.375	0.000187	0.00348	1.74×10^{-9}	469	0.187

N/A = not applicable (these materials are not processed at the Savannah River Site)

Table D–26 Radiological Impacts Due to Incident-Free Management of Plutonium Residues—Los Alamos Maximum Impacts

Material	Offsite Population		Offsite Maximally Exposed Individual		Worker Population	
	Collective Dose (person-rem)	Latent Cancer Fatality (number of cancers)	Annual Dose (mrem)	Cancer Probability	Collective Dose (person-rem)	Latent Cancer Fatality (number of cancers)
Incinerator Ash	N/A	N/A	N/A	N/A	N/A	N/A
Sand, Slag, and Crucible	N/A	N/A	N/A	N/A	N/A	N/A
Inorganic Ash	N/A	N/A	N/A	N/A	N/A	N/A
Graphite Fines	N/A	N/A	N/A	N/A	N/A	N/A
Salts	0.00095	4.75×10^{-7}	0.00032	1.60×10^{-10}	29	0.0116
Combustibles	N/A	N/A	N/A	N/A	N/A	N/A
Plutonium Fluorides	N/A	N/A	N/A	N/A	N/A	N/A
High-Efficiency Particulate Air Filter Media	N/A	N/A	N/A	N/A	N/A	N/A
Ful Flo Filter Media	N/A	N/A	N/A	N/A	N/A	N/A
Sludge Residues	N/A	N/A	N/A	N/A	N/A	N/A
Glass Residues	N/A	N/A	N/A	N/A	N/A	N/A
Graphite Residues	N/A	N/A	N/A	N/A	N/A	N/A

Material	Offsite Population		Offsite Maximally Exposed Individual		Worker Population	
	Collective Dose (person-rem)	Latent Cancer Fatality (number of cancers)	Annual Dose (mrem)	Cancer Probability	Collective Dose (person-rem)	Latent Cancer Fatality (number of cancers)
Inorganic Residues	N/A	N/A	N/A	N/A	N/A	N/A
Scrub Alloy	N/A	N/A	N/A	N/A	N/A	N/A
TOTALS	0.00095	4.75×10^{-7}	0.00032	1.60×10^{-10}	29	0.0116

N/A = not applicable (these materials are not processed at Los Alamos National Laboratory)

Tables D-24 through D-26 present the largest possible incident-free impacts associated with each residue type, that could exist at each site for all possible alternatives examined in this EIS. They should be viewed as a set of bounding values which cannot be exceeded for any of the processes under any feasible combination. The preferred and strategic alternatives also fall under the realm of being bounded by the impact quantities presented in the tables. It should be noted that not all residue processes are applicable to each site; in these situations, N/A ("not applicable") is denoted in the appropriate locations.

D.3 Accident and Risk Analysis Methodology, Assumptions, and Results

This appendix describes the methodology and assumptions used for estimating radiation exposure (dose) and the risk to individuals and the general public from releases of radioactivity resulting from potential accident scenarios during processing and stabilization of certain Rocky Flats plutonium residues.

D.3.1 Exposure Impacts To Be Evaluated

The impact of radiation exposure on the following segments of the population is calculated for each accident scenario:

- **Worker**—An individual (a noninvolved worker) located 100 m (330 ft) from the radioactive material release point.[1] The dose to the worker is calculated for the 50th-percentile meteorology only, as specified in DOE-STD-1027-92 (DOE 1992). Workers are exposed unprotected to the plume for a limited time (a maximum of 5 minutes). Workers are exposed to radioactivity via inhalation, air immersion, and ground surface pathways only.

- **Maximally Exposed Individual**—A hypothetical individual living at the management site boundary and receiving the maximum exposure. The hypothetical member of the public is located directly downwind of the accident and is exposed to radioactivity via inhalation, ingestion, air immersion, and ground surface pathways. The individual would be exposed to the plume for the entire release duration.

- **Population**—The general public living within an 80-km (50-mi) radius of the facility, residing directly downwind of the accident, and receiving the maximum exposure via inhalation, ingestion, air immersion, and ground surface pathways.

The doses to the maximally exposed individual and the general public are calculated for the 50th- and 95th-percentile meteorological conditions. The details of exposure times for maximally exposed individuals, workers, and the general public are given in Section D.1.2.2.

[1] *For elevated release, the worker dose was calculated at a point of maximum dose. The distance at which the maximum dose occurs is frequently greater than 100 m (330 ft) for an elevated release.*

The radiation dose to individuals and the public resulting from exposure to radioactive contamination was calculated using the following potential pathways:

- *Air Immersion*—External direct exposure from immersion in the airborne radioactive material
- *Ground Surface*—External direct exposure from radioactive material deposited on the ground
- *Inhalation*—Internal exposure from inhalation of radioactive aerosols and suspended particles
- *Ingestion*—Internal exposure from ingestion of contaminated terrestrial food and animal products.

The radiation dose is estimated by the GENII computer program in a manner recommended by the International Commission on Radiological Protection in Publications 26 and 30 (ICRP 1977, ICRP 1982). Committed dose equivalents[2] are calculated individually for organs such as the gonads, breast, red bone marrow, lungs, thyroid, and bone surface; calculations are combined for the liver, upper large intestine, lower large intestine, small intestine, and stomach. Weighting factors are used for various body organs to calculate weighted or committed effective dose equivalent from radiation inside the body due to inhalation or ingestion. The committed effective dose equivalent value is the summation of the committed dose equivalent to a specific organ weighted by the relative risk to that organ compared to an equivalent whole-body exposure. Deep-dose equivalent for the external exposure pathways (immersion in the radioactive material and exposure to the ground contamination) and 50-year committed effective dose equivalent for the internal exposure pathways are calculated. The sum of the deep-dose equivalent for external pathways and committed effective dose equivalent for internal pathways is called the total dose in this EIS.

The exposure from ingestion of contaminated terrestrial food and animal products is calculated on a yearly basis. It is expected, however, that continued consumption of contaminated food products by the public would be suspended if the projected dose should exceed that of the protective action guidelines in a radiological accident event (EPA 1991). No reduction of exposure because of protective actions or evacuation of the public was accounted for in this analysis, however. This conservative approach may result in overestimating health effects within an exposed population but allows for consistent comparisons between alternatives.

D.3.2 Selection of Facility Accidents for Detailed Evaluations

The large number of material categories and the processing technologies under consideration in this EIS produce more than 50 different process/material combinations that need to be evaluated (see Figure 2–2 of this EIS). The selected technologies are either (1) well established with active facilities currently in operation or (2) considered to be feasible (existing laboratory scale) and becoming operational in the near future. For the well-established processing technologies with active facilities, the selection of accident scenarios is based on those evaluated in the facility safety analysis reports. For those processing technologies that have not been in full production, a set of similar process-independent accidents are postulated.

Postulated facility accident scenarios were developed based on the review of the analyzed accidents in previous safety analysis, risk assessment, and environmental assessment documents at Rocky Flats, Savannah River Site, and Los Alamos National Laboratory facilities where plutonium is handled or processed.

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[2]*The definitions of committed dose equivalents, committed effective dose equivalents, and total effective dose equivalents are consistent with those given in 10 Code of Federal Regulations (CFR) Part 835, "Occupational Radiation Protection; Final Rule" (DOE 1993a).*

After reviewing a wide range of documents, postulated accident scenarios were developed based on information contained in the following:

- *Safety Analysis-200 Area, Savannah River Site F-Canyon Operation, F-Canyon SAR Addendum* (WSRC 1994)

- *Basis for Interim Operation, Savannah River Site H-Canyon and Outside Facilities, H-Canyon Basis for Interim Operation* (WSRC 1996b)

- *Safety Analysis, H-Canyon Basis for Interim Operation Addendum, Addendum 1, Revision 0* (WSRC 1997b)

- *Nuclear Safety Technical Report, Safety Analysis in Support of the Environmental Assessment for Consolidation and Interim Storage of Special Nuclear Material in Building 371* (EG&G 1995)

- *Environmental Assessment, Finding of No Significant Impact, and Response to Comments, Solid Residue Treatment, Repackaging, and Storage* (DOE 1996d)

- *Basis for Interim Operation Building 371/374 Complex, Rocky Flats Environmental Technology Site* (KHC 1997)

- *TA-55 Final Safety Analysis Report* (LANL 1996).

Based on this review of analyzed accident scenarios at Rocky Flats, Savannah River Site, and Los Alamos National Laboratory facilities that deal with plutonium, a spectrum of potential accidents was identified. This process started with systematically identifying initiating events, subsequent accident progressions, and onsite or offsite releases. Then, based on accident initiators, selected accidents were grouped into the following three categories:

- Natural phenomena (e.g., earthquake, tornado)
- External events (e.g., aircraft crash)
- Process-related events (e.g., explosion, nuclear criticality, fire, spills).

The potential process-related events include high-, medium-, and low-energetic events, which are defined as follows:

- *High-Energetic*—A high-energetic event is defined as one that releases sufficient energy to destroy the first confinement barrier and breach the secondary confinement barrier, allowing radioactive materials to directly reach rooms occupied by personnel or directly reach the environment outside the facility. An example of such event would be an explosion of a magnitude that potentially could produce severe damage to the glovebox and cause damage to the filtration system or the building confinements (walls), creating a direct path to the environment. If an explosion could not create a direct path to the environment, it is covered as a medium-energetic impact event.

- *Medium-Energetic*—A medium-energetic event is defined as one that would cause penetration of the primary confinement barrier and potentially cause materials to bypass the second confinement barrier for a short period of time. Events which could lead to medium-energetic events are nuclear criticality, uncontrolled chemical reaction (including a sudden eruption or belching of a content of vessel, foaming, boil over, gassing, or simply an undesirable high temperature resulting in material degradation or toxic vapor evolution), fire (spontaneous combustion involving plutonium, cellulose, and other strong oxidizing agents such as nitric acid), and impacts (a projectile or a dropped object impacting process equipment).

- *Low-Energetic*—A low-energetic event is defined as one that would not destroy the primary confinement barrier, but activity may penetrate it. These events usually occur due to human errors such as transfer errors, overflows, chemical addition errors, spills, over pressurization, and equipment failures such as leaks.

The energy categorization is one of the indices that affects the outcome of all components of the building source term except the material at risk (see Section D.3.3.2). Under some circumstances, therefore, the health effects of a medium-energetic event could exceed those of a high-energetic event. A careful review of the accidents will lead to the amount of materials at risk as being the major contributing factor to the results that appear to be counterintuitive at first glance.

A review of the accident scenarios indicated that only severe accident conditions could result in a significant release of radioactive material to the environment or an increase in radiation levels. Some types of accidents, such as procedure violations, spills of small materials containing radioactive particles, and most other types of common human error occur more frequently than the more severe accidents analyzed. However, these accidents do not involve enough radioactive material or radiation to result in significant release to the environment. Natural phenomena (e.g., earthquake) and fire accidents creating a direct path for releases to the environment represented the situation with the most consequences to the public. The process-related accidents occurred inside the building, and, therefore, represented the situation with the most significant consequences to the operational personnel. The airborne particles from a process-related accident would normally pass through at least one bank and possibly two to four banks of high-efficiency particulate air filters before entering the environment. Plutonium handling and operations are performed inside such confinement barriers as gloveboxes or canyon walls. The gloveboxes are equipped with safety significant features, such as inert gas atmosphere, pressure control, and heat detection. These features are credited when their operabilities can be assured.

Based on these reviews and on guidance provided by DOE in Section 6.9 of *Recommendations for the Preparation of Environmental Assessments and Environmental Impact Statements* (DOE 1993d), the following types of accidents were selected for each processing technology:

- Explosions
- Nuclear criticality
- Fire
- Earthquake
- Aircraft crash
- Spills.

Finally, no specific analyses of the results of terrorist or sabotage acts were considered. This is because the existing security measures in effect at the management sites would essentially preclude any sabotage or terrorist activity. In addition, any acts of terrorism are expected to result in consequences that are bounded by the results of the accident scenarios selected for detailed evaluation.

Table D–27 summarizes the selected accident scenarios and the associated frequency ranges. Details of the actual frequency, given in the following sections, are site specific.

Table D–27 Selected Accident Scenarios

Accident Type	*Scenario*	*Frequency Range (per year)*
High-Energy Impact	Explosion	10^{-3} > Frequency>10^{-6}
Medium-Energy Impact	Nuclear Criticality [a] Fire: a. Room b. Dock	10^{-2} > Frequency > 10^{-5} 10^{-2} > Frequency > 10^{-4}
Low-Energy Impact	Spills: a. Outside Glovebox b. Inside Glovebox c. Loading Dock	Frequency > 10^{-3}
Natural Phenomena	Earthquake (DBE)	10^{-2} > Frequency≥ 10^{-4}
External Event	Aircraft Crash	10^{-5} > Frequency
Severe Accident	Earthquake (BDBE) Earthquake with Fire	10^{-4} > Frequency ≥10^{-7}

DBE = design (evaluation) basis earthquake BDBE = beyond design basis earthquake.

[a] Only plutonium criticalities are evaluated. The potential for an americium criticality was considered but dismissed because of the limited americium mass and purity. Americium is only present in plutonium residues in small quantities.

Note: Event frequencies are site dependent.

For the beyond design basis events (severe accidents) only events with frequencies above 10^{-7} per year are considered. Events with lower frequencies are considered to be not reasonably foreseeable.

D.3.3 Accident Evaluation

D.3.3.1 Basic Assumptions

Unless otherwise stated, the following conditions were used in the calculations:

❒ Meteorological Data

- Site-specific joint frequency distribution weather data are used to define 50- and 95-percentile meteorological conditions for each processing technology at management sites.
- The release is assumed to occur at an elevated level, unless otherwise stated, consistent with the site's effluent emission stack height. No credit is taken for jet plume rise through the stack.
- Mixing layer height is 1,000 m (3,280 ft). Airborne materials freely diffuse in the atmosphere near the ground level in what is known as the mixing depth. A stable layer exists above the mixing depth and restricts vertical diffusion above 1,000 m.
- Wet deposition is zero (it is assumed that no rains occur to accelerate deposition and reduce the size of area affected by the release).
- Dry deposition of the cloud is modeled. During movement of the radioactive plume, a fraction of the radioactive material in the plume is deposited on the ground due to gravitational forces. The quantity of deposited radioactive material is proportional to the particle size and deposition velocities (in meters per second). For the plutonium isotopes, the deposition velocity is 0.001 m/sec. The deposited material contributes to the exposure from ground surface radiation and ingestion.

❒ Inhalation Data

- Breathing rate is 330 cubic centimeters (cm^3)/sec (0.7 cubic feet per minute [ft^3/min]) for the worker and the general public at the site boundary and beyond (maximally exposed individual and population) during the passage of the plume; it is 270 cm^3/sec (0.57 ft^3/min) for the general public during the other times.

- Particle size is 1.0 microns (0.04 mils).
- Solubility (or lung clearance) class[3] (for dose effect when inhaled) in this analysis will use class "Y" for plutonium oxides and class "W" for other plutonium compounds such as fluorides and metals.
- The internal exposure period is 50 years for the individual organs and tissues evaluated.

D.3.3.2 Source Term

The source term (or building source term) is the amount of respirable radioactive material that is released to the air, in terms of curies or grams. The airborne source term is typically estimated by the following five-component linear equation:

$$\text{Source term} = \text{MAR} \times \text{DR} \times \text{ARF} \times \text{RF} \times \text{LPF}$$

where:

MAR	=	Material-at-Risk (grams or curies)
DR	=	Damage Ratio
ARF	=	Airborne Release Fraction (or Airborne Release Rate for continuous release)
RF	=	Respirable Fraction
LPF	=	Leak Path Factor.

- **Material at Risk**—The material at risk is the amount of the radionuclides (in curies or gram of activity for each radionuclide) available to be acted upon by a given physical stress (i.e., an accident). The material at risk is specific to a given process in the facility of interest. It is not necessarily the total quantity of material present but is that amount of material in the scenario of interest postulated to be available for release.

- **Damage Ratio**—This is the fraction of material exposed to the effects of the energy/force/stress generated by the postulated event. For the accident scenarios discussed in this document, the value of the damage ratio is assumed to be one, unless otherwise specified.

- **Airborne Release Fraction**—This is the fraction of the material that becomes airborne due to the accident. In this analysis, airborne release fraction values from the DOE Handbook on airborne release fraction are used (DOE 1994).

- **Respirable Fraction**—This is the fraction of the material, with particle size of 10-micrometers (microns) aerodynamic equivalent diameter or less, that could be retained in the respiratory system following inhalation. The respirable fraction values are also taken from the DOE Handbook on airborne release fractions (DOE 1994).

- **Leak Path Factor**—The leak path factor accounts for the action of removal mechanisms (e.g., containment systems, filtration, deposition) to reduce the amount of airborne radioactivity that is ultimately released to occupied spaces of the facility or the environment. A leak path factor of one (i.e., no reduction) is assigned in accident scenarios involving a major failure of confinement barriers.

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[3] *A classification of inhaled material based on its clearance half-time, in order of days "D," weeks "W," or years "Y," from the pulmonary region of the lung to the blood and gastrointestinal tract.*

D.3.3.3 Accident Scenario Description and Source Terms

This section describes the accident scenarios and corresponding source terms developed for Rocky Flats, the Savannah River Site, and Los Alamos National Laboratory. The spectrum of accidents described below were used to determine the incremental consequences (public and worker doses) and risks associated with the processing of certain Rocky Flats' residues at each site. These accident scenarios are consistent with those evaluated in either the facility safety analysis report, facility/site environmental reports, or various related DOE safety documents. Secondary accidents were considered when identified in the safety documents. The selected documents were identified and referenced in each of the accident scenarios described. When information was required to further clarify the accident condition, update some of the parameters, and facilitate the evaluation process, additional assumptions were made. Sometimes it was necessary to have different assumptions than those that were used in the referenced report. These are also identified. For example, the material at risk during an earthquake is different for the residue processing in this EIS than those considered in the facility safety analysis report. This change in assumption is necessary because the evaluations in this EIS focus only on the incremental risk resulting from the implementation of alternatives. Cumulative risks can be determined by adding the incremental risks to the existing risks.

D.3.3.3.1 Accident Scenarios Description and Source Terms at Rocky Flats

❒ **Description of Accident Scenarios**—The following accident scenarios are evaluated for each processing technology and material category considered in this EIS. Each accident scenario description sets the condition of the accident and provides a summary of material involved. As stated earlier, these accident scenarios are generic, but their applications are consistent with those evaluated in various Rocky Flats environmental and safety analyses documents (EG&G 1995, KHC 1997, DOE 1996d). It is important to note that even though these accident scenarios are based on the existing production technologies, they will also be applicable to the new technologies because the new technologies are similar to the production technologies at operational levels. Additionally, these accidents are generic and process-independent.

- *Explosion*—Two explosion scenarios were postulated: acetylene and ion exchange explosions. The acetylene explosion was postulated to occur in both Building 707 and Building 771, whereas the ion exchange explosion was postulated to occur in Building 371 only. The acetylene explosion scenario was considered credible and analyzed for Buildings 371 and 707 (EG&G 1995). The scenario assumed for the analysis in this EIS is consistent with that analyzed earlier. The scenario assumes the development of a flammable cloud of acetylene in the vicinity of a glovebox. The source of the acetylene gas is the failure of an oxy-acetylene welding rig. The subsequent deflagration can result in damage to equipment and containers within the immediate vicinity of the explosion. The ensuing pressure wave from deflagration could breach the module wall and blow open a set of egress doors in Building 707, creating a path to the environment (EG&G 1995). The explosion force from an acetylene accident in Building 371 would be insufficient to damage the 40-cm (16-in) thick reinforced concrete outer building walls (EG&G 1995). Therefore, the release path would be through at least two banks of high-efficiency particulate air filters. The frequency of this accident was estimated at 5×10^{-5} per year (EG&G 1995). The material at risk for this EIS was considered to be the equivalent content of two drums, one at the maximum level of plutonium and the second at the administrative control limit of plutonium. For combustible residues, both drums were assumed at the maximum level of 500 g (1.1 pounds [lb]) of plutonium each. For all other residues, the first drum contained 3,000 g (6.6 lb) of plutonium and the second drum contained 1,000 g (2.2 lb) of plutonium.

  Ion exchange purification of plutonium is a secondary process for the plutonium separation processing alternative that uses the mediated electrochemical oxidation process. There are two alternative protocols possible—the purification of each batch using lab-scale columns or the accumulation of sufficient batches to make up an appropriate quantity of plutonium for use of a process-size column. Because the accumulation of plutonium results in a larger source term (a conservative assumption), this

option is selected for evaluation. The accident was assumed to result from a strong exothermic reaction between nitric acid and the base resin during the elution phase of the plutonium purification process. The material at risk was assumed to be 1.6 kilograms (kg) (3.53 lb) of plutonium based on the processing schedule and throughput estimates of batch sizes. The accident scenario assumptions and evolutions are similar to those of the FB-Line ion-exchange explosion described in Section D.3.3.2 with the exception that no release is postulated for the feed tank. This is because the event is postulated to occur after the feed tank is emptied into the column and additional material has not had a chance to accumulate. The Rocky Flats ion exchange columns are made up of 15-cm (6-in) borosilicate glass pipe wrapped in heavy mesh screen and are not assumed to generate fragments with an adequate force to defeat the carbonate plastic windows. Airborne release from the formation of a "flashing spray" from the eluate with boiling of the remaining solution due to the burning of the released resin on the floor of the glovebox are evaluated. The released materials would pass through at least two banks of high-efficiency particulate air filters, giving a leak path factor of 2×10^{-6}. The release from the building stack is estimated to be 0.245 mg (5.4×10^{-7} lb) of plutonium. The frequency of such an event was estimated to be 1×10^{-4} per year, consistent with that used for the same event at the Savannah River Site.

- *Room Fire*—A fire originating in the room could involve multiple gloveboxes. The fire could be initiated by welding, an electrical short, or other causes. The frequency of a room fire involving two gloveboxes was estimated to be 5×10^{-4} per year (EG&G 1995). This fire frequency was used in this EIS to represent a fire involving the entire room. Workers would evacuate the fire zone in about 20 seconds, and it is assumed that only one glovebox would be involved in the fire during this period. The amount of the combustibles in the room is insufficient to plug the filters, and the sprinklers would cool the fire plume sufficiently; therefore, no buoyancy effect is considered. The sprinkler effect would limit the amount of material that could be involved in the fire. The material at risk was assumed to be a 5-day supply for operation. The types of materials considered are high americium residues for the salts and aged weapon-grade plutonium for other residues. It was assumed that at least two banks of filters would be available. A fraction of the released material could bypass the ventilation system by escaping the room through cracks in egress doors. Because the ventilation system was assumed to be operating, approximately 10 percent of the material (due to temperature and air volume increase before the sprinkler started) was assumed to escape through the cracks.

- *Dock Fire*—A dock fire resulting in a direct release to the atmosphere is estimated to have a likelihood of 2×10^{-6} per year, based on the consideration that historically there were no dock fires, and the dock doors are open only one percent of the time (EG&G 1995). For the worker handling the materials inside the dock, the likelihood of the fire would be 2×10^{-4} per year. Various ranges of dock fires have been postulated at Rocky Flats (KHC 1997, EG&G 1995). The scenario that was evaluated here assumes a large dock fire similar to the scenario evaluated in the Building 371 Basis for Interim Operation report (KHC 1997). In this scenario, the material at risk was considered to be the contents of four plutonium residue drums. A conservative bounding mass, assuming that the content is in powder form, was used to estimate the mass (plutonium content) of a drum. The material at risk for the combustible residues is a total of 2 kg (4.4 lb), four at the maximum limit of 500 g (1.1 lb); and for the other residues, it is a total of 6 kg (13.2 lb), one at its maximum of 3 kg (6.6 lb) and 3 at the limit of 1 kg (2.2 lb) of aged weapon-grade plutonium. Because the ventilation system would be in operation, it was assumed that approximately 50 percent of the released material would enter the atmosphere directly. The remaining airborne releases would pass through at least two banks of high-efficiency particulate air filters before entering the atmosphere.

- *Dock Spill*—A dock spill could occur if a package is dropped on the dock while loading and unloading a truck, resulting in breach of the drum and inner container and release of plutonium. This assumption is very conservative, because all containers used at Rocky Flats are required to withstand a 120-cm (4-ft) drop without loss of contents. The spill could result if the container is damaged or improperly sealed. The likelihood of occurrence of such an event was estimated to be 10^{-3} per year (EG&G 1995).

The material at risk was assumed to be the content of one drum at its maximum limit. The event at worst would impact approximately 25 percent of the content. Upon a spill, the workers, both those involved with the operation and those not directly involved (e.g., security and drivers), would evacuate the area within 20 seconds. The workers handling the packages are required to wear respirators that would reduce their intake of contaminants by 99 percent. Because the ventilation system would be in operation, it was assumed that about 10 percent of the released material would directly enter the atmosphere. The remaining airborne releases would pass through at least two banks of high-efficiency particulate air filters before entering the atmosphere.

- *Room Spill*—A room spill could be caused by human error or deteriorated packaging materials during a transfer process. The material could be dry (metal/powder) or liquid. The workers handling the packaging materials are required to wear respirators. The frequency of occurrence of a dry spill was estimated to be 8×10^{-3} per year, based on a human error probability of 1×10^{-3} of dropping a container, a probability of 1×10^{-2} that the container fails and releases its contents as a result of drop, and an assumption that a bag-in occurs once per shift (3 shifts/day × 5 days/week × 50 weeks/year). The material at risk is assumed to be the content of one container at its limit. Liquid spill is a potential for activities in Building 371. In the Building 371 Basis for Interim Operation report (KHC 1997), several scenarios for liquid spills (small to large) have been analyzed. In this EIS, the analysis considers a spill equivalent to a batch size solution volume. The spilled solution is assumed to flow by gravity into the criticality drain system. For the environmental assessment purposes, this analysis assumes that the likelihood of such an event in Building 371 is 8×10^{-3} per year.

- *Glovebox Spill*—A spill inside a glovebox could occur due to human error. This spill would be confined inside the glovebox. The probability of occurrence of such an event is estimated to be 0.8 per year, based on similar assumptions of human reliability and operational activities as stated for the room spill scenario. The immediate workers would be exposed to the spilled materials if a tear occurred in the gloves simultaneously with the spill and some of the materials escaped from the glovebox. For the purposes of this EIS, it was assumed that, at most, 1 percent of the materials released to the glovebox could escape through the tear and enter the room. The probability of such an event was estimated to be 8×10^{-2} per year, based on the probability of a glove tear of 0.10 per year (EG&G 1995). The material at risk is assumed to be the content of one feed preparation container (the size of one batch).

- *Earthquake*—An evaluation (design) basis earthquake would cause different consequences to Buildings 707 and 371 at Rocky Flats. Building 707 is expected to collapse from an earthquake having a peak ground acceleration of 0.13 g with a return period of about 556 years (frequency of 1.8×10^{-3} per year), whereas Building 371 is not expected to collapse from earthquakes with a return period of less than 10,700 years (frequency of 9.4×10^{-5} per year) (Foppe 1995). For Building 707, a 0.13 peak ground acceleration (design basis earthquake) earthquake was assumed. Such an earthquake would cause widespread damage throughout Building 707, which houses Modules A through H, but would not collapse Building 707A. Building 707A, which houses modules J through K, has an earthquake collapse frequency of 8×10^{-4} per year, or an earthquake with a 1,250-year return period. The consequences of such an accident involving various plutonium and transuranic waste materials have already been analyzed in the building safety analysis report. For this EIS, the material at risk was assumed to be that of a 5-day supply in different packages and gloveboxes within the operational area. The released materials were assumed to enter the environment through a leak path factor of 0.10.

  The assumption of a leak path factor of 0.1 in an earthquake is based on the following combination of factors considered: (1) after an earthquake, the building fails before the materials are released (due to impact); (2) the released materials are buried, or confined, under the rubble; (3) minimal air flow is available to force the material out; and (4) structural debris acts as a filter, absorbing the particulates as they pass through before entering the environment. In addition, DOE-HDBK-3010 (DOE 1994) recommends an order of magnitude reduction of the airborne release fraction for powders buried under

debris. The values given for the airborne release fraction did not consider such a reduction, and this reduction was assigned to the leak path factor.

The consequences of several levels of earthquakes have also been evaluated in the Building 371 Basis for Interim Operation report (KHC 1997). The minimum peak ground acceleration that could cause equipment damage resulting in material release was estimated to be 0.15 g with a 900-year return period (frequency of 1.1×10^{-3} per year). At this peak ground acceleration level (design basis earthquake), the following accidents could occur: spills, fire, and explosion. A criticality event was not considered as likely, because no damage to the equipment containing liquids was expected at this earthquake level. Spills were assumed to occur in the laboratories, downdraft tables, and gloveboxes. Fire was postulated to occur anywhere within Building 371. It was assumed that a large fire could occur and could pressurize the facility resulting in a high ambient leak path factor of 0.1. The fire was considered to eventually burn itself out, or be extinguished by the fire department. Explosion was postulated to occur in the analytical laboratory involving propane gas. The propane explosion was assumed to topple a glovebox, causing its contents to spread in the room. The explosion was assumed to cause a high leak path factor of 0.10.

With a 2,000-year return period (frequency of 5×10^{-4} per year) earthquake, 0.25 peak ground acceleration, it was postulated that in addition to events identified above, a criticality event could also occur from a mixture of materials in the collapsed gloveboxes and water from failed fire suppression systems (moderated and fully reflected metal criticality). A nuclear criticality may be characterized by a flash of fissions that produce a pulse of penetrating radiation, followed by a period of much lower radiation lasting from a few minutes to several hours depending on the self limiting properties of critical mass. A criticality event is very different from a nuclear detonation, which is almost instantaneous fissions of all materials. There is no potential for a nuclear detonation at the site. Due to the uncertainties in the ways that a criticality accident could occur, for the purposes of analysis in this EIS, a criticality event with a 10^{18} fission yield was assumed, that is, a single burst or pulse of fissions (DOE 1994). The fission gas release source term for this criticality event was assumed to be 1/10 of the values provided in the Nuclear Regulatory Commission's Regulatory Guide 3.35 (NRC 1979); the source term in this regulatory guide is for a plutonium solution criticality event with 10^{19} fissions.

Building 776, which will be used for fluidized bed incineration process of the filter and combustible residues, has an earthquake collapse frequency of 1×10^{-3} per year (Foppe 1995). All other assumptions are similar to those used for Building 707.

- *Criticality*—Various criticality events were postulated to occur during plutonium processing and handling activities. These are bare plutonium metal criticality, water moderated and reflected plutonium criticality, and plutonium solution criticality. Among these accidental events, criticality in plutonium solutions is expected to yield the highest amount of fissions. DOE-HDBK-3010-94 (DOE 1994) identifies the following fission yields for each of the above criticality events:

  - Bare metal — 10^{17} fissions
  - Fully moderated and reflected solid metal — 10^{18} fissions
  - Solution — 10^{19} fissions

  The amount of fission gas and halogen nuclide source terms from a criticality event is proportional to the number of fissions per event. A solution criticality will have 100 times more of these nuclides than will a bare metal criticality and also will release aerosols (particulate plutonium), which a bare metal criticality will not. A fully moderated and reflected solid metal criticality will produce 10 percent of the amount of fission gas and halogen source terms that is released in a solution criticality, and it will release no plutonium particulates. The solution criticality will dominate any other criticality event. The

10^{-4} per year frequency for a criticality event already considers violation of two administrative controls. The frequency of a solid criticality event will not be higher than 10^{-4} per year. Therefore, for analysis purposes, only solution criticality is modeled and evaluated. The frequency of a plutonium solution criticality is estimated at 1×10^{-4} per year (EG&G 1995). The source term for the solution criticality is given in **Table D–28**.

Table D–28 Criticality Source Term for 10^{19} Fissions in Plutonium Solution

Isotope	Radioactivity (Ci) [a]			ARF [b]	LPF [c]	Source Term (Ci)
	0-30 minutes	30 m-8 hours	Total			
Kr-83m	15	95	110	1	1	110
Kr-85m	9.9	61	70.9	1	1	70.9
Kr -85	0.00012	0.00072	0.00084	1	1	0.00084
Kr-87	60	370	430	1	1	430
Kr-88	32	200	232	1	1	232
Kr-89	1,800	11,000	12,800	1	1	12,800
Xe-131m	0.014	0.086	0.1	1	1	0.1
Xe-133m	0.31	1.9	2.21	1	1	2.21
Xe-133	3.8	23	26.8	1	1	26.8
Xe-135m	460	2,800	3,260	1	1	3,260
Xe-135	57	350	407	1	1	407
Xe-137	6,900	42,000	48,900	1	1	48,900
Xe-138	1,500	9,500	11,000	1	1	11,000
I-131	1.5	9.5	11	0.25	1	2.75
I-132	170	1,000	1,170	0.25	1	293
I-133	22	140	162	0.25	1	40.5
I-134	600	3,700	4,300	0.25	1	1,080
I-135	63	390	453	0.25	1	113
Pu-238 [c, d]			3.6	0.0005	0.005	0
Pu-239 [c, d]			170	0.0005	0.005	0.00043
Pu-240 [c, d]			39	0.0005	0.005	0.0001
Pu-241 [c, d]			2,400	0.0005	0.005	0.006
Pu-242 [c, d]			0.003	0.0005	0.005	7.50×10^{-9}

Ci = curie ARF = airborne release fraction LPF = leak path factor

[a] Regulatory Guide 3.35 (NRC 1979).

[b] Airborne release fractions are equal to 1.0 for noble gases, 0.25 for iodine, and 0.0005 for plutonium; all particles are assumed to be in the respirable range (i.e., Respirable Fraction = 1.0).

[c] Plutonium in 100 liters of solution.

[d] This plutonium is assumed to be released to the atmosphere through a high-efficiency particulate air filter (e.g., the Savannah River Site's sand filter) with a 0.995 efficiency. For Rocky Flats, the plutonium source terms are smaller by a factor of 0.0004 due to a higher number of filter banks. The plutonium values are the maximum solution concentration in the FB-Line (DOE 1993b).

- *Aircraft Crash*—Rocky Flats is located between 6.4 to 8 km (4 to 5 mi) from Jeffco airport and approximately 32 km (20 mi) from Denver International Airport. A hypothetical aircraft crash accident scenario into Buildings 707, 707A, and/or 371 was postulated. The frequency of such an event was estimated using the DOE Standard on *Accident Analysis for Aircraft Crash into Hazardous Facilities*, DOE-STD-3014-96 (DOE 1996b). This standard identifies that the aircraft (general aviation aircraft)

crashes occurring during in-flight and takeoff and landing operations at Jeffco airport along with the potential crashes during in-flight operation of other aircrafts (e. g., air carriers, military aircraft) would need to be considered as potential hazards to Rocky Flats facilities. Using the facility dimensions of Building 707, it was determined that the frequency with which a large commercial (air taxi and larger sizes) and/or a high-powered military aircraft could crash into this building would be less than 10^{-7} per year. For the general aviation aircraft, an upper bound frequency of a crash into Buildings 707, 707A, or 371 was estimated to be 3×10^{-5}, 1×10^{-5} and 4×10^{-5} per year, respectively. The likelihood that a general aviation aircraft would hit the dock areas of Building 707 is approximately two orders of magnitude less (i.e., 2.2×10^{-7} per year). The crash of a general aviation aircraft into the building would not be as severe (both in magnitude and frequency) as that of an earthquake. Therefore, the consequences/risks of an earthquake would bound that of an aircraft crash. For analysis purposes, the material at risk for this scenario was assumed to be equal to that used in a 0.13 peak ground acceleration design basis earthquake.

- **Assumptions of Airborne Release Fraction and Respirable Fraction Values for Rocky Flats' Accident Scenarios—Table D–29** summarizes the airborne release fraction and respirable fraction values for each of the accidents and the types of materials involved. To differentiate the risks between various residue-processing combinations, an attempt is made to highlight the responses of the residue forms to different stresses. Airborne release fraction and respirable fraction factors are selected based on the best information available that would provide this separation between material forms. These values may be different from those used in the safety analysis documentation where the objectives are to "bound" potential releases. The technical bases for selection of these values are given in the next paragraph.

  Assignment of the appropriate airborne release fractions and respirable fractions for residue materials was based on the categorization of the residue materials by pertinent physical characteristics that affect airborne suspension and assumption of the most suspendible form of the material. For the purposes of these analyses, the residue forms were categorized as follows:

  - *Powders*—Ash residues; sand, slag, and crucible residues; fluoride residues; pyrochemical salt residues; and graphite residues
  - *Surface Contamination on Solid Surfaces*—Combustible residues, including Ful Flo filter residues; glass residues; high-efficiency particulate air filter medium residues; inorganic residues
  - *Metal*—Scrub alloy residues.

  The accidents and the assumptions used to estimate the airborne release fraction and respirable fraction values are summarized in the following paragraphs.

- Acetylene Explosion—This is an event that releases energy external to the residue material containers and generates a pressure impulse that impacts sealed 208-liter (L) (55-gallon [gal]) metal drums and gloveboxes nearby. It may displace or topple drums and gloveboxes and could potentially damage them. The displacement/toppling of the drums subjects both the surface contamination on the plastic wrap/container holding the residue materials and the residue materials themselves. The contamination displaced from the plastic wrap and the container can be vented by failure of the plastic wrap and can be released to the ambient atmosphere. The residue materials suspended inside the container have an additional barrier, the container seal, nonetheless, a conservative assumption is made that any materials airborne within the container also are vented.

Table D–29 Airborne Release Fraction and Respirable Fraction Values for the Accident Scenarios at Rocky Flats

	Ash Residue [a]		*Pyro-Salts*		*Combustibles*		*Fluorides*		*Filter-Media*		*Glass Residue*		*Inorganic*		*Scrub Alloy* [b]	
Accident	*ARF*	*RF*	*ARF*	*RF*	*ARF*	*RF*	*ARF*	*RF*	*ARF*	*RF*	*ARF*	*RF*	*ARF*	*RF*	*ARF*	*RF*
Explosion	0.001	0.1	0.001	0.001	0.001	0.1	0.001	0.01	0.001	0.01	0.001	0.1	0.001	0.10	0.001	0.01
Dock Fire [c]	0.006	0.01	0.006	0.01	0.0005	1.00	0.001	0.001	0.006	0.01	0.006	0.01	0.006	0.01	0.006	0.01
Room Fire [d]	0.006	0.01	0.006	0.01	0.0005	1.00	0.001	0.001	0.006	0.01	0.006	0.01	0.006	0.01	0.006	0.01
Dock Spill	0.00008	0.5	0.00008	0.001	1.00×10^{-6}		0.00008	0.5	1.00×10^{-6}		1.00×10^{-6}		1.00×10^{-6}		1.00×10^{-6}	
Room Spill	0.00002	0.5	0.00002	0.001	See filter media		0.00002	0.01	Materials opened in the glovebox. No spill is considered						1.00×10^{-6}	
Glovebox Spill	0.00002	0.5	0.00002	0.001	1.00×10^{-6}		0.00002	0.01	1.00×10^{-6}		1.00×10^{-6}		1.00×10^{-6}		1.00×10^{-6}	
Earthquake Powder Spill [e]	0.002	0.3	0.002	0.3	0.001	0.1	0.002	0.3	0.002	0.3	0.001	0.1	0.001	0.1	0.001	0.1
Earthquake Liquid Spill	0.00005	0.7	0.00005	0.7	0.00005	0.7	0.00005	0.7	0.00005	0.7	0.00005	0.7	0.00005	0.7	0.00005	0.7

ARF = airborne release fraction RF = respirable fraction

[a] The airborne release fraction and respirable fraction values given for ash residues apply to graphites; sand, slag, and crucible; dried sludge residues; and other ash residues.

[b] A damage ratio of 0.01 is applied to scrub alloy. This is based on the assumption that less than 1 percent of the alloy undergoes corrosion on the surface of the metal. The values given below are for the surface corrosion/contamination products.

[c] Damage ratio of 1.0 for combustible and 0.01 for all others

[d] For graphites ARF=0.01, and RF=0.001, for Ful Flo filters ARF=0.0005 and RF=1.0. Damage ratio of 0.01 for the scrub alloy.

[e] For scrub alloy, the airborne release fraction value is applied to the surface corrosion; assume 1 percent of the mass is corroded, or a damage ratio of 0.01. The airborne release fraction and respirable fraction values do not include the potential for resuspension of particulates after the earthquake. A resuspension value of 1.92×10^{-4} needs to be added to all ARF×RF values.

- *Powder*—The values for suspension of a powder due to the impact of falling debris (DOE 1994), an airborne release fraction of 1×10^{-3} with a respirable fraction of 0.1, are applied for residue materials categorized as powders. Two exceptions are noted for the respirable fraction of residue materials in this category:

  - Unpublished test data for the respirable fraction for the finer fraction of pyrochemical salt residues, developed at Rocky Flats, indicate the respirable fraction for the residue does not exceed 0.001. This respirable fraction value is applied here, because the effects of explosions are not expected to further reduce the size of the material (i.e., make it more respirable).

  - The size distribution of the initial fluoride residue are coarse and do not generate high respirable fractions under the accident stresses tested (e.g., thermal stress of fluoride powder generated overall respirable fractions ranging from 1×10^{-5} to 1×10^{-7}); therefore, a respirable fraction of 0.01 is applied here.

- *Surface Contamination on Solid Surfaces*—For residue materials categorized as surface contamination of solid surfaces, the airborne release fraction and respirable fraction values cited previously are also applied, except for the respirable fraction value for the high-efficiency particulate air filter medium residue. The high-efficiency particulate air filter medium is a very fine (4-micrometer diameter) glass fiber matrix. Larger airborne particles are collected on the surface on the mat and smaller particles are collected in the matrix. The collected particles tend to be agglomerated (stuck together). The finer fraction that would be part of the respirable fraction is surrounded and attached to the internal surfaces of the glass fiber and is difficult to suspend. Therefore, a respirable fraction value of 0.01 is applied for this material.

- *Metal*—Only one residue material, scrub alloy, has the physical characteristics corresponding to the elastic-plastic deformation properties of metals. The shock-vibration stress induced by this event would not result in fragmentation of a metal and only corrosion products in particulate form on the outer surface of a metal would be affected. The respirable fraction has been diminished to reflect the assumption that less than 1 percent of the surface is corroded.

◆ Dock Fire—The event postulated is an external fire that ignites the combustible materials in four sealed 208-L (55-gal) metal drums containing packaged residue materials. In most cases, the materials ignited are the combustible packaging materials. One category, combustibles, can ignite and burn and these materials are not always packaged inside the drums but are often a mixture of small plastic wrapped bundles of contaminated combustibles and loose potentially contaminated combustibles.

- *Powder*—Residue forms categorized as powder are predominantly plutonium oxide, a chemically unreactive material. The airborne release fraction and respirable fraction for this category of particles under thermal stress are 6×10^{-3} and 0.01, respectively (DOE 1994). The airborne suspension for fluorides was experimentally measured, and the values—an airborne release fraction of 1×10^{-3} with a respirable fraction of 0.001—are applied here.

- *Surface Contamination on Solid Surface*—One material form in this category, combustibles, can be ignited, and the airborne release has been experimentally measured (DOE 1994). An airborne release fraction of 5×10^{-4} with a conservative assumption of 1.0 for the respirable fraction are applied. The remaining materials are considered chemically unreactive particles under thermal stress, and the airborne release fraction and respirable fraction applied for powder is used.

- *Metal*—Although the aluminum alloy may melt at higher temperatures, the airborne release from the residue form is considered the suspension of a chemically inert particle resulting from corrosion

(conservatively assumed to be 1 percent of the total mass of the material) of the alloy under thermal stress and the airborne release fraction and respirable fraction applied for powder is used.

- Room Fire—The event postulated is the ignition of the combustible contents of sealed 208-L (55-gal) metal drums by an external heat source and the same airborne release fraction and respirable fraction values applied for the dock fire are used.

- Dock Spill—Two events could result in the spill of the contents of the sealed 208-L (55-gal) metal drums during unloading. One or more drums could fall from the pallet during movement by a forklift and unseal by the force of the impact with the floor. The contents could spill from their containers due to the loss of the container seal and fall out of the containers due to the impact. The distance the material would spill is very small, less than 30 cm (1 ft).

  The contents could be released by the inadvertent puncture of the drum and package by the forks of the vehicle during an attempt to off load the pallet. The forks are normally inserted at the bottom of the pallet and punctures near the base of the drum would be necessary for released material to fall from the drum after withdrawal of the forks. Since the level of the vehicle and dock are nearly at the same elevation, the fall distance for the material is less than 1 meter (3.3 ft).

  - *Powder*—The maximum experimentally measured airborne release for a dry, cohesionless powder, with a density approximately that of plutonium oxide, for a fall distance of 1 m (3.3 ft) is an airborne release fraction of 8×10^{-5} with a respirable fraction of 0.5. These values are used for this category of residue material.

  - *Surface Contamination on Solid Surfaces*—Under the conditions postulated (the puncture of the sealed 208-L [55-gal] metal drums and packaging by the forks of a forklift and the release of materials by withdrawal of the forks), the solid materials are not expected to fall from the drums except for incidental pieces that may be near the holes and are of the size to pass through the holes. Any suspension of the surface contamination would result from the shock-vibration due to the impact of the small piece with the floor. Some materials, such as combustibles, are not dense and their impact would not generate substantial forces. Therefore, the [airborne release fraction][respirable fraction] values of this material are assumed to be $\leq 1\times10^{-6}$. The combined airborne release fraction and respirable fraction values for surface-contaminated materials (filter media, glass residue, inorganic residues) are assumed to be less than those for the free-fall spill of a powder because the release from these material results from dislodgement by shock-vibration and suspension by turbulence generated by the falling object. Because the postulated scenario assumes that the drums are toppled during transport, even if these residue forms are released from the drums (which in reality have to pass through an inner container, two layers of plastic wrap, and the sealed metal drum), the material falls a short distance (inches) and rolls rather than impacting the hard, unyielding surface assumed for shock-vibration effects. Furthermore, the powder associated with high-efficiency particulate air filter media are attached to the surface of the medium in the filter frame, and the physical form of the filters discourages rolling.

    The combined value for the scrub alloy is based on the assumption that (1) the material is a metal that would not be deformed significantly by such a short fall and (2) the airborne release would only affect any surface corrosion products. Scrub alloy may be stored for appreciable periods of time before processing; some surface corrosion is inevitable and the [airborne release fraction] [respirable fraction] for shock vibration for surface contamination is 10^{-4}. If the corrosion is assumed to affect 1 percent of the total mass of scrub alloy, then the [airborne release fraction][respirable fraction] value of 10^{-6} is reasonably bounding for this phenomenon.

- Room Spill—For powder-like residues in containers, a spill may occur inside the gloveboxes due to handling and pouring of the materials during the residue processing. The floors of the gloveboxes are

elevated approximately 0.90 m (3 ft) in most cases to allow handling at the normal height for personnel. The potential fall distances are very small, ranging from a few centimeters (a few inches) during some pouring operations to 30 cm (1ft) if the container topples off a stand.

- *Powder*—The airborne release fraction and respirable fraction have been experimentally measured for the free-fall spill of dry, cohesionless powders of materials with high (uranium dioxide) and low (titanium dioxide) density with very fine size distributions of particles (the mass median diameters of both powders were approximately 1 to 2 micrometers geometric diameter). The minimum fall distance of 1 m (3.3 ft) was used. The airborne release fraction values ranged from 2×10^{-5} to 5×10^{-4} with respirable fraction values from 0.40 to 0.93 (DOE 1994). Given that the maximum fall distance postulated for the event is approximately one-third the fall distance used in the experiments, the smallest measured value for the airborne release fraction of 2×10^{-5} and an average respirable fraction value for the data set of 0.5 are applied here. One exception is noted for fluoride residues; because of their demonstrated behavior, a respirable fraction of 0.01 is applied.

- *Surface Contamination on Solid Surfaces*—This category of materials is not bagged into the gloveboxes; the drum opening is inserted into the glovebox and the materials removed or poured onto the glovebox floor. Thus, spills are a normal activity during processing and are not considered an inadvertent event.

- *Metal*—Spills involving metal that exhibit elastic-plastic deformation falling short distances do not normally result in fragmentation of the metal. The impact with an unyielding surface could generate adequate shock-vibration forces to dislodge some particulate surface contamination. Because very little corrosion products on the outer surfaces of the scrub alloys are expected, an [airborne release fraction][respirable fraction] value of $\leq 1\times10^{-6}$ is applied.

◆ Earthquake-Initiated Spill, Building 707—The event postulated is the complete failure of the structure and the spill of the glovebox contents due to toppling of the gloveboxes. It is assumed that materials are stored in sealed 208-L (55-gal) drums and that the metal drums fail. Crushing of the inner packages holding the residue materials is not anticipated due to the protection of the drums' contents by physical barriers.

- *Powders in the Glovebox*—It is assumed that residues in powder form may be in open containers and could be violently spilled during the toppling of the glovebox. The maximum measured values for the free-fall spill of dry, cohesionless particles for a distance of 3 m (10 ft) are an airborne release fraction of 2×10^{-3} with a respirable fraction of 0.3 (DOE 1994) and are applied to this category of residues.

- *Surface Contamination on Solid Surfaces*—The suspension stress for this category of residue is the shock-vibration due to seismic acceleration, the impact of the glovebox with the floor due to toppling, and the impact of debris from the structure failure on the toppled glovebox structure. The maximum measured values for the impact of debris on powders are an airborne release fraction of 1×10^{-3} with a respirable fraction of 0.1 (DOE 1994). For filter media, the powder values cited above were applied, due to a potential for the presence of fine, loose powder shaken from the media during handling and transport.

- *Metals in Glovebox*—The assumption is made that the shock-vibration forces described above suspend the surface corrosion products on the outer surface of the scrub alloy. It is conservatively assumed that 1 percent of the scrub alloy has corroded. Thus, the damage ratio is 0.01.

◆ Earthquake-Initiated Free-Fall Spill, Building 371—For the operations in Building 371, all residue forms would be in liquid form due to the activities performed during processing (e.g., neutralization and shredding, sonic washing) and all materials are assigned the airborne release fraction and respirable fraction values for the release resulting from the free-fall spill of aqueous solutions, because the liquids are too dilute to act as slurries and are not viscous. Although the liquid is not a concentrated aqueous solution of heavy metal, it is assumed that the liquid would behave as such due to the presence of the heavy metal

oxide particles. The maximum measured value for the free-fall spill of concentrated heavy metal solution from a 3-m (10-ft) or less height is 2×10^{-5} with a respirable fraction of 0.26 and 0.3 (DOE 1994). Larger respirable fractions are found with other airborne release fraction values. For a respirable fraction value of 0.7, the maximum measured value, an airborne release fraction of 5×10^{-5} is applied here.

- Earthquake-Initiated Fire, Building 371—At the acceleration level postulated for the design basis earthquake, analyses show that Building 371 would not fail. An airborne release would be due to the behavior and interaction of equipment and materials within the facility. The most severe consequences would result from the effect of fire initiated by the seismic event. Thus, the values cited for room fires are applicable to this situation.

- Earthquake-Initiated Explosion, Building 371—As stated above, failure of the structure is not postulated for the design basis earthquake level of ground acceleration and the most severe consequences result from an explosion initiated by the seismic event.

D.3.3.3.2 Accident Scenarios Description and Source Terms at the Savannah River Site

❒ **Description of Accident Scenarios at the Savannah River Site**—The following facilities would be used to store or process Rocky Flats' plutonium residues at the Savannah River Site—F-Canyon (or H-Canyon), FB-Line (or HB-Line), plutonium storage facility, new special recovery facility, and Building 235 storage vault. The F-Canyon, FB-Line, new special recovery facility, and plutonium storage facility are part of the Building 221-F (or F-Canyon) structure. The H-Canyon and HB-Line are part of Building 221-H. Two processes will be used to separate the plutonium from the residues at the Savannah River Site: the mediated electrochemical oxidation process and the Purex process. In the mediated electrochemical oxidation process, the Rocky Flats plutonium residues are processed by dissolving ashes, graphite, and inorganics at the new special recovery facility; transferring the solution to the F-Canyon for separating and concentrating the plutonium solution; then pumping the solution to FB-Line for purification and solidification of plutonium metal (see the processing descriptions in Appendix C of this EIS). In the Purex process, the residues will be dissolved in the F-Canyon dissolvers and the process follows similar to the one stated earlier. The flow process at H-Canyon, in the mediated electrochemical oxidation process, starts with the dissolution of ashes, graphites, and inorganics in two new (to be installed later) silver dissolvers; thus is followed by the separation and concentration of plutonium; then the solution is pumped to the HB-Line facility for purification and oxidation, filtration, and separation of the plutonium oxide. The Purex process at H-Canyon can use the existing dissolvers, and the process will be similar to that of the mediated electrochemical oxidation process after the dissolution of residues. There are two main differences between the operations at F-Canyon and at H-Canyon. First, the final product from the H-Canyon processes is plutonium oxide powder, and that from F-Canyon is plutonium metal button. Second, when the Rocky Flats residues are processed at H-Canyon, the whole facility, including the HB-Line, will be dedicated to this operation; at F-Canyon, however, processing may be dedicated to the Rocky Flats residues or may include site-specific materials along with the Rocky Flats residues. Therefore, when the process becomes dissolver limited, the HB-Line operation will become intermittent.

Because processing operations at the Savannah River Site differ from those at Rocky Flats, process-dependent accident scenarios were postulated. These accident scenarios, defined in the following paragraphs, are applicable to the processing facilities as a whole (i.e., F-Canyon, H-Canyon, FB-Line, HB-Line, and new special recovery facilities). The mix of principal radionuclide releases from new special recovery, F-Canyon (H-Canyon), and FB-Line (HB-Line) was assumed to be similar to that of the Rocky Flats residues processed.

The consequences of potential accident scenarios for the vault and storage facilities are subsumed by the consequences of the hypothesized process accidents. This is because the repackaged residue materials received at the Savannah River Site would remain in their shipping containers while they are in storage

vaults. The materials will be taken from the shipping containers outside of the storage vaults at the new special recovery, H-Canyon, or F-Canyon facility before being dissolved. Therefore, no accident scenarios that could result in releases comparable to those postulated for the processing were identified.

- *Explosion*—Two major explosions are postulated: hydrogen and ion exchanger explosions. In defining these explosion scenarios, the facility safety analysis reports as well as the DOE safety survey reports were reviewed to identify the bounding accident in one of the three facilities. Hydrogen explosion is bounded by the accident in the F-Canyon or the H-Canyon dissolver. The analysis of maximum hydrogen generation and explosion in the safety survey concluded the accident would not cause any building damage (DOE 1993c). The released materials would pass through the sand filter before entering the atmosphere. The probability of such an explosion was estimated to be 1.5×10^{-5} per year (DOE 1993c). The combined [airborne release fraction][respirable fraction] for this accident was estimated to be 1×10^{-3} and would be independent of the type of materials dissolved. It was assumed that the dissolver content would be spread to the canyon floor.

  An explosion in an ion exchange column in the FB-Line or HB-Line is postulated to result from a strong exothermic reaction between nitric acid and the base resin in the cation (or anion) exchange column during plutonium solution exchange. This would result in a thermally induced pressure failure of the ion exchange vessel and the resulting shrapnel would damage the product run tank and the product hold tank for this ion exchange pair. The explosion would breach the glovebox confinement. The plutonium in nitrite solution in the run and hold tanks would spill onto the cabinet floor and boil due to a subsequent resin fire. Based on the assumptions that the column was at its maximum load before the explosion and the maximum quantity of liquid at the maximum allowable concentration was present, the estimated release of plutonium through the sand filter and the stack was calculated to be 0.241 g of plutonium (DOE 1993b). The frequency of such an event is estimated to be 1×10^{-4} per year (DOE 1993b).

- *Fire*—In the F-Canyon safety analysis report (WSRC 1994) and the H-Canyon Basis for Interim Operation report (WSRC 1997b), a fire was postulated to occur in the second plutonium cycle solvent extraction. The frequency of such a fire was estimated at 6.1×10^{-4} per year (WSRC 1994, WSRC 1997). The accident was assumed to burn the content of one tank. The material at risk, depending on the type of residue processed, would range from 1,000 to 12,000 g of plutonium. See **Table D–30** and **Table D–31** for details. The combined [airborne release fraction][respirable fraction] was estimated to be 1×10^{-2} (DOE 1994). The airborne materials would pass through sand filter, with a leak path factor of 0.005, before entering the atmosphere.

- *Criticality*—A plutonium solution criticality was postulated. The criticality was assumed to consist of an initial burst of 1×10^{18} fissions in 0.5 seconds, followed at 10-minute intervals for the next 8 hours by bursts of 2×10^{17} fissions, for a total of 1×10^{19} fissions as specified in the Nuclear Regulatory Commission's Regulatory Guide 3.35 (NRC 1979) and NUREG-1320 (NRC 1988) and in the DOE-HDBK-3010-94 (DOE 1994) report. The 10^{19} fission yield was based on the assumptions that the solution criticality occurred in a tank with a minimum volume of 3,785 L (100 gal) and that approximately 100 L of this volume evaporated due to heat released during the fission process. Based on the data provided in the DOE safety survey report (DOE 1993c), a 10^{19} criticality event in the FB-Line process would result in the bounding source term (Table D–31, at the end of this section, gives the source terms). The frequency of such an event was estimated to be 1×10^{-4} per year, consistent with that used in the Rocky Flats analysis.

Table D–30 Material at Risk, Airborne Release Fraction, Respirable Fraction, and Leak Path Factor Values for Savannah River Site F-Canyon Accident Scenarios

Accident	Material at Risk [a]								ARF×RF	LPF	Source Term (mg Pu)
	Ash MEO	Ash Purex	SSC	Graphite	Salt-Scrub	Fluoride	Inorganic	Scrub Alloy			
Explosion (hydrogen)	3	2	1	2	4	2	2	4	10^{-3}	0.005	Varies
Explosion (ion) [b]	180.75	120.5	60.25	120.5	241	120.5	120.5	241	N/A	N/A	Varies
Fire [c]	3	2	1	2	4	2	2	4	10^{-2}	0.005	Varies
Earthquake (F-Canyon)	9	6	3	6	12	6	6	12	0.000028 0.000019 [d]	0.10	Varies
Earthquake (FB-Line)	3	2	1	2	4	2	2	4	0.002 (p) [e] 0.0022 (m) 0.000047(l) 0(s)	0.10	Varies
Spill [f]	178	–	–	103	–	–	79	–	10^{-5}	0.005	Varies

MEO = mediated electrochemical oxidation SSC = sand, slag, and crucible ARF= airborne release fraction RF = respirable fraction
LPF = leak path factor Pu = plutonium N/A = not applicable

[a] The material-at-risk values are in terms of number of buttons produced. Each button is 2,000 g of plutonium.

[b] The values provided here are source term values in milligrams of plutonium released to the atmosphere through the stack. This value is arrived at by considering all combinations of accidents that follow an ion exchange explosion.

[c] Fire in the FB-Line would result in consequences that are a factor of 40 smaller than those presented here.

[d] This value corresponds to resuspended airborne respirable fraction. This number is added to 2.8×10^{-5} to get a combined value of 4.7×10^{-5} for the ARF×RF.

[e] These values include both the initial and resuspended ARF×RF values and p = powder, m = molten metal, l = liquid., and s = solid. (New buttons have no oxidation on the surface; thus, there is no release because of an earthquake.)

[f] The material-at-risk values given for the spill are in grams of plutonium.

Note: The combined value of ARF×RF is presented as opposed to individual values for each item as presented for Rocky Flats. This is because the ARF and RF values in Rocky Flats accident scenarios are material type and form dependent, whereas, those in Savannah River Site are in liquid (plutonium nitrite) or powder (plutonium oxide) form. The Savannah River Site ARF×RF values are independent of material type. This note is also applicable to Table D-31.

- *Earthquake*—Recent analyses of earthquake hazards at F-Canyon and H-Canyon indicate that a 0.24-g peak ground acceleration level earthquake—with a return period of 8,000 years (or a frequency of 1.25×10^{-4} per year) for the F-Canyon facility and a return period of 5,500 years (or a frequency of 1.82×10^{-4} per year) for the H-Canyon facility—could damage the structure and cause localized interior failures as well as interior and exterior wall cracks (DOE 1996c, DOE 1996d). Previous analyses of earthquake hazards at F-Canyon and H-Canyon estimated the consequences of such a magnitude earthquake with a higher frequency of occurrences—2×10^{-4} per year (DOE 1995a, WSRC 1994, and WSRC 1997b). Using the assumptions in the F-Canyon H-Canyon Facility Safety Analysis Reports (WSRC 1994, WSRC 1997b), a new source term was developed for an earthquake accident involving Rocky Flats residues. Given an earthquake, it was assumed that the plutonium contents in all the processes (F-Canyon and FB-Line or H-Canyon and HB-Line) would be spilled on the canyon floor (the total material at risk for each residue category is shown in Tables D–33 and D-34 [Section D.3.3.4]). It was further assumed that the airborne material would enter the environment through the building cracks, which are formed by the loss of sealant between the sections because of differential motion of the section, with a penetration leak path factor of 0.10.

Table D–31 Material at Risk, Airborne Release Fraction, Respirable Fraction, and Leak Path Factor Values for Savannah River Site H-Canyon Accident Scenarios

Accident	Material at Risk [a]								ARF×RF	LPF	Source Term (mg Pu)
	Ash MEO	Ash Purex	SSC	Graphite	Salt-Scrub	Fluoride	Inorganic	Scrub Alloy			
Explosion (hydrogen)	6	1	1	4	6	1	4	6	10^{-3}	0.005	Varies
Explosion (ion) [b, c]	241	241	241	241	241	241	241	241	N/A	N/A	241
Fire [d]	6	3	3	6	6	3	6	6	10^{-2}	0.005	Varies
Earthquake (H-Canyon)	18	54	54	27	18	54	27	18	0.000028 0.000019 [e]	0.10	Varies
Earthquake (HB-Line) [c]	8	8	8	8	8	8	8	8	0.002 (p) [f] 0.000047 (l)	0.10	Varies
Spill [g]	178	–	–	103	–	–	79	–	10^{-5}	0.005	Varies

MEO = mediated electrochemical oxidation SSC = sand, slag, and crucible ARF= airborne release fraction RF = respirable fraction
LPF = leak path factor Pu = plutonium N/A = not applicable

[a] The material-at-risk values are in terms of number of cans produced. Each can is approximately 1,000 g of plutonium.

[b] The values provided here are source term values in milligrams of plutonium released to the atmosphere through the stack. This value is arrived at by considering all combinations of accidents that follow an ion exchange explosion.

[c] These values are for full and dedicated operation of HB-Line. These values need to be multiplied by the HB-Line duty cycle for each process. The duty cycles are as follows: ash Purex, and fluoride processes = 12.5%; graphite and inorganic processes = 60%; and ash MEO, salt scrub, and scrub alloy processes = 100%.

[d] Fire in the HB-Line would result in consequences that are a factor of 40 smaller than those presented here.

[e] This value corresponds to resuspended airborne respirable fraction. This number is added to 2.8×10^{-5} to get a combined value of 4.7×10^{-5} for the ARF×RF.

[f] These values include both the initial and resuspended ARF×RF values and p = powder and l = liquid.

[g] The material-at-risk values given for the spill are in grams of plutonium.

- *Aircraft Crash*—The location of the F-Canyon or H-Canyon facility is far away from any airport; therefore, no takeoff and landing crash accidents need to be considered. The crashes that could occur during in-flight would need to be considered. According to the DOE Standard on aircraft crash analysis, DOE-STD-3014-96 (DOE 1996b), the expected crash frequency for the site is approximately 2×10^{-4} per square-mile per year from general aviation, 6×10^{-7} and 2×10^{-6} per square-mile per year from air carrier and air taxies, respectively, and 1×10^{-7} and 6×10^{-7} per square-mile per year from large military and small military aircraft, respectively. Using the building dimensions and the data provided in the DOE Standard for aircraft crash analysis, an upper bound frequency for an aircraft crash into the canyon buildings was estimated to be 4.6×10^{-6} and 1.5×10^{-7} per year for general aviation and commuter (air taxi) aircraft, respectively. These values were calculated without considering any site-specific effects (e.g., the topography and building structures around the facility). Considering the available skid distance of 60 m (200 ft) that an aircraft could skid before hitting the building, the frequency of an air taxi crashing into the building would be less than 10^{-8} per year. When only crashes that directly hit the structure were considered, general aviation aircraft would have the only estimated crash frequency greater than 10^{-7} per year. The F-Canyon or H-Canyon building is a maximum resistant construction structure designed to withstand a pressure of 47.9 kilopascal (1,000 lb/ft^2). Therefore, crashes of small aircraft (helicopter or a small observation/security aircraft) into these buildings are not expected to damage the buildings. If a general aviation aircraft were to crash into the buildings, its consequences (both in magnitude and frequency) would be smaller than that hypothesized for a design basis evaluation earthquake.

- *Spill*—An accidental spill was postulated. The scenario assumed that the operator accidentally dropped a plutonium powder container while unloading the materials from the shipping containers. The spill was assumed to occur at the new special recovery (or H-Canyon) facility's dissolver area because only materials opened in the new special recovery (or H-Canyon) facility would be in powder form. The materials in the shipping containers opened at the F-Canyon (or existing H-Canyon) dissolver area would

be in powder form or solid form but are sealed in dissolvable cans and placed in the dissolvers without being opened; therefore, the consequences of any accidental drop of one of these cans would be subsumed by that of the powder spill. The workers handling the shipping containers and unpacking of the materials are required to wear respirators. The airborne materials would pass through sand filter before entering the atmosphere. The frequency of occurrence of a spill was estimated to be 1×10^{-2} per year, based on the human error probability of 1×10^{-3} of dropping a container, a probability of 1×10^{-2} that the container was improperly bagged and packaged, and an assumption that, on the average, a bag-in occurs once per shift (3 shifts/day × 5 days/week × 50 week/year). The material at risk was estimated to contain 206 g of powdered ash residues. The airborne release fraction and respirable fraction values for powder were estimated to be 2×10^{-5} and 0.5, respectively, consistent with those applied to the Rocky Flats event from materials and conditions.

- **Assessment of Material at Risk, Airborne Release Fraction, Respirable Fraction, and Leak Path Factor for Accidents at the Savannah River Site**—Tables D–30 and D–31 provide a summary of material at risk, airborne release fraction, respirable fraction, and leak path factor for accidents at the Savannah River Site. The material-at-risk values are representative of mass values for each material category that could be present at the time of an accident. These values are set based on the throughput of FB-Line (HB-Line) configuration to process the Rocky Flats residues. When a material at risk is less than the maximum value, it means that the Rocky Flats residues are being processed along with other Savannah River Site–specific materials. The values provided for the airborne release fraction and the respirable fraction are independent of the type of material processed. Therefore, for simplicity, a combined value is given for the airborne respirable fraction (i.e., [airborne release fraction][respirable fraction]).

  As mentioned previously, the same airborne release fraction and respirable fraction values are applied to the events at the Savannah River Site for the same materials as were applied at Rocky Flats (see Section D.3.3.1). For the cases where more than one phenomenon resulted in airborne releases from a single event (e.g., an ion exchange explosion event), a composite value for [airborne release fraction][respirable fraction], weighted for the fraction of the material at risk involved with each phenomenon, is provided.

D.3.3.3.3 Accident Scenarios Description and Source Term at Los Alamos National Laboratory

- **Description of Accident Scenarios at Los Alamos National Laboratory**—Rocky Flats plutonium residues (pyrochemical oxides salts) will be received, processed, and stored in the Los Alamos National Laboratory plutonium facility, Building 4, at Technical Area 55. Two processing technologies will be used at Los Alamos National Laboratory (salt distillation of molten salt extraction and electrorefining residue salts and water leach of direct oxide reduction residue salts). The accident scenarios evaluated for these processing technologies follow. They are similar to those analyzed at Rocky Flats and the Savannah River Site and are consistent with those analyzed in the Technical Area 55 final safety analysis report (LANL 1996).

  - *Explosions*—The Technical Area 55 safety analysis report considered two evaluation basis explosions: hydrogen explosions and ion exchange explosions (LANL 1996). Neither of these process-related explosions would breach the integrity of the gloveboxes proposed for the processing of the Rocky Flats residues because the proposed processing technologies do not use ion exchange and neither produce nor use hydrogen gas. The secondary impact from these explosions would have neither the energy nor the proximity to impact the proposed processing facilities.

  - *Criticality*—The material and the proposed technology limit the potential criticality event to a fully moderated and reflected solid metal (solid particles) criticality event. DOE Handbook, DOE-HDBK-3010-94 (DOE 1994), identifies the fission yields for such an event as on the order of 10^{18} fissions (i.e., a single pulse) with no plutonium particulate evaporation. The fission gas and iodine released

from such a criticality event will be a factor of 10 less than those provided previously in Table D-23. The frequency of such an event was assumed to be 1×10^{-4} per year, consistent with that used for the same event at Rocky Flats and the Savannah River Site.

- *Fire*—The accident scenario assumes a room fire that breaches glovebox confinement coupled with the loss of room ventilation. This accident scenario is similar to the fire scenarios analyzed in the Technical Area 55 safety analysis report (LANL 1996). The likelihood of a room fire in this safety analysis report was estimated to be between 10^{-6} to 10^{-2} per year. For consistency with the room fire scenario analyzed for Rocky Flats, a room fire frequency of 5×10^{-4} was assumed. Analysis of the effect of a bounding evaluation basis fire in the Technical Area 55 safety analysis report concluded that the evaluation basis fire accident would not damage the glovebox exhaust high-efficiency particulate air filter plenums; based on the building airflow, it was estimated that only 1.1 percent of the airborne materials would enter the environment without passing through at least two banks of high-efficiency particulate air filters. The same assumption of leak path factor (i.e., 0.011) will be used in this EIS. The material at risk for this EIS was assumed to be the supply for 1 week (4 days per week) of operation, which is the maximum allowed plutonium mass that could be in the glovebox in each processing technology.

- *Spill*—A room spill scenario similar to that used for the Savannah River Site operation is assumed. The airborne materials would pass through three banks of high-efficiency particulate air filters before entering the environment. The material at risk is assumed to be the plutonium content in one of the containers of the shipping cask. The frequency of occurrence of a spill is assumed to be 3×10^{-3} per year, based on the human error probability of 1×10^{-3} of dropping a container, on a probability of 1×10^{-2} that the container was improperly bagged and packaged, and on the average likelihood that a bag-in occurs once per shift (1 shift/day × 5 days/week × 50 weeks/year).

- *Earthquake*—An evaluation basis earthquake with a mean peak ground acceleration of 0.3 g was assumed. The frequency of such a magnitude earthquake was estimated at be 5×10^{-4} per year (or having a 2,000-year return period). The building structure is designed to withstand an earthquake of this magnitude (LANL 1996). Such an earthquake, however, would result in the collapse of some process enclosures (e.g., glovebox, storage tanks, pipes) caused by anchorage failure, support stands, or interaction with other equipment. These failures are assumed to result in a free fall of material at risk within these enclosures. The Technical Area 55 safety analysis did not identify any other secondary event (i.e., criticality, fire, or explosion) resulting from an earthquake. The airborne released materials were assumed to enter the environment through a leak path factor of 0.10. The material at risk is assumed to be the maximum amount of plutonium that could be in the glovebox at the time of accident. For the water leach technology, the material at risk is 6 kg (13.2 lb) of plutonium/americium oxide composed of 1 kg (2.2 lb) salt oxide powder, 1 kg (2.2 lb) slurry solution, and 4 kg (8.8 lb) calcined powder. For the salt distillation technology, the material at risk is 4.5 kg (9.9 lb) of plutonium/americium oxide composed of approximately 500 g (1.1 lb) salt powder and 4 kg (8.8 lb) calcined powder.

❒ **Assessment of Air Release Fraction and Respirable Fraction Values for Accident at Los Alamos National Laboratory**—The residue materials processed at Los Alamos National Laboratory are in either powder or liquid slurry form. The airborne release fraction and respirable fraction values for the powder in similar accident scenarios given earlier for Rocky Flats and the Savannah River Site are applied here as well (see Sections D.3.3.3.1 and D.3.3.3.2 and Tables D-24 and D-25). For the liquid slurries, the combined [airborne release fraction][respirable fraction] values caused by an earthquake and a fire are estimated based on the data provided in the DOE Handbook (DOE 1994). For an earthquake, a conservative combined value of 7×10^{-6} for [airborne release fraction][respirable fraction] is assigned. For a fire, a value of 6×10^{-5}, which corresponds to the airborne respirable fraction of powder in a fire accident, is assumed.

D.3.3.4 Consequences and Risk Calculations

Once the source term for each accident scenario is determined, the radiological consequences are calculated. The calculations vary depending on how the release is dispersed, what material is involved, and which receptor is being considered. Risks are calculated based on the accident's frequency and its consequences. The composite risk from performing a specific processing technology can be calculated summing the individual risks for all scenarios analyzed.

Radiological consequences to four different receptors are evaluated: a maximally exposed offsite individual (an individual member of the public), general population, noninvolved worker (or a co-located worker), and facility worker. The consequences to the facility workers are qualitatively evaluated. For the other receptors, quantitative estimates of consequences are made; two types of dispersion conditions are considered—95th-percentile and 50th-percentile meteorological conditions (see Section D.3.1 for more detail). The 50th-percentile condition represents the median meteorological condition and is defined as that for which more severe conditions occur 50 percent of the time. The 95th-percentile condition represents relatively low probability meteorological conditions that produce higher calculated exposures; it is defined as that condition not exceeded more than 5 percent of the time. Both dispersion conditions are modeled using the GENII program, which determines the desired condition from the site-specific meteorological data in the form of a joint frequency distribution. Joint frequency data are usually produced from at least 3 consecutive years of site weather data in terms of percentage of time that the wind blows in specific directions (e.g., south, south-southwest, southwest) for the given midpoint (or average) wind speed class and atmospheric stability.

Radiological consequences to a receptor are estimated based on a calculated 50-year committed dose factor, (dose factor) resulting from releases of 1 g of respirable aged weapon-grade plutonium or high americium plutonium salts (building source term) to the atmosphere. **Tables D–32** and **D–33** provide the dose factor, in rem or person-rem per 1 g of respirable plutonium release to the atmosphere, for each receptor at a management site for two material types (e.g., aged weapon-grade plutonium and high americium plutonium salts) in either a metal or an oxide form and for two dispersion conditions. The dose factors given for the plutonium metal form in each category represent clearance half-time (solubility class) of "W," and the dose factors given for the plutonium oxide form represent clearance half-time of "Y" (see Section D.3.3.1).

The values given in these tables represent the maximum dose to the receptor and are obtained using the GENII program, as described in Sections D.3.1.1 and D.1.2.1 of this appendix. The compositions of the aged weapon-grade plutonium and the high americium plutonium salts are given in **Table D–34**. The selections of the aged weapon-grade plutonium and the high americium salts were made to bound the consequences of the accidents involving different plutonium residue materials. As weapon-grade plutonium ages, the concentration of americium increases. The specific activity of americium is significantly higher than that of weapon-grade plutonium. The radiological hazard in terms of committed effective dose equivalent associated with the 1 g of americium is approximately 43 times greater than for 1 g of weapon-grade plutonium, adjusting for the differences between specific activities and the committed effective dose equivalent dose conversion factors of each isotope. The aged weapon-grade plutonium reflects the highest amount of americium 241 that can be present in any of the weapon-grade plutonium residues except the molten salt extraction residues. For the salt residues, the composition of Item Description Codes (IDCs) 409–410 was used. Although these IDCs represent approximately 24 percent of the total salts, they have the highest content of americium 241.

Table D–32 Receptors' Dose Factors for Accidental Releases of 1 g Aged Weapon-Grade Plutonium at Management Sites

Receptor	Release Location	Rocky Flats Building 707		Rocky Flats Building 371		Savannah River Site Building 221-F		Savannah River Site Building 221-H		LANL TA-55
		Oxide	Metal	Oxide	Metal	Oxide	Metal	Oxide	Metal	Metal
Dose factors (rem or person-rem) from a release of 1 g aged weapon-grade plutonium and 95th-percentile meteorological condition										
MEI	Ground	1.20	2.40	1.80	3.60	0.050	0.0920	0.037	0.069	6.2
MEI	Elevated	0.160	0.320	1.50	3.0	0.0190	0.0340	0.017	0.032	5.1
Population	Ground	25,000	42,000	25,000	42,000	1,900	3,300	1,900	3,100	7,800
Population	Elevated	8,700	15,000	25,000	42,000	1,000	1,800	1,000	1,600	5,400
Dose factors (rem or person-rem) from a release of 1 g aged weapon-grade plutonium and 50th-percentile meteorological condition										
MEI	Ground	0.13	0.26	0.18	0.36	0.00940	0.017	0.0074	0.0014	0.81
MEI	Elevated	0.06	0.12	0.17	0.34	0.00680	0.012	0.005	0.0096	0.76
Population	Ground	600	1,000	600	1,000	140	230	130	200	840
Population	Elevated	450	770	600	1,000	99	160	90	150	840
Worker	Ground	21	28	21	28	17	22	17	22	65
Worker	Elevated	0.14	0.19	1.80	2.50	0.076	0.10	0.076	0.10	4.50

LANL = Los Alamos National Laboratory TA = Technical Area MEI = maximally exposed individual
Metal = plutonium compounds having clearance class "W" Oxide = plutonium oxides having clearance class "Y"

Table D–33 Receptors' Dose Factors for Accidental Releases of 1 g of High Americium Plutonium Salt at Management Sites

Receptor	Release Location	Rocky Flats Building 707		Rocky Flats Building 371		Savannah River Site Building 221-F		Savannah River Site Building 221-H		LANL TA-55
		Oxide	Metal	Oxide	Metal	Oxide	Metal	Oxide	Metal	Oxide
Dose factors (rem or person-rem) from a release of 1 g high americium plutonium salt and 95th-percentile meteorological condition										
MEI	Ground	14	16	22	24	0.56	0.60	0.42	0.45	38.0
MEI	Elevated	1.90	2.10	18	19	0.21	0.220	0.19	0.21	31.0
Population	Ground	2.60×10^5	2.80×10^5	2.60×10^5	2.80×10^5	20,000	21,000	19,000	20,000	50,000
Population	Elevated	90,000	96,000	2.60×10^5	2.70×10^5	11,000	12,000	10,000	11,000	36,000
Dose factors (rem or person-rem) from a release of 1 g high americium plutonium salt and 50th-percentile meteorological condition										
MEI	Ground	1.50	1.70	2.20	2.40	0.099	0.110	0.084	0.090	4.90
MEI	Elevated	0.72	0.79	2.10	2.20	0.077	0.082	0.059	0.063	4.60
Population	Ground	6,200	6,700	6,200	6,700	1,400	1,500	1,300	1,300	5,100
Population	Elevated	4,600	4,900	6,100	6,400	970	1,000	900	960	5,200
Worker	Ground	170	180	170	180	140	150	140	150	410
Worker	Elevated	1.20	1.20	16	16	0.63	0.66	0.63	0.66	2.80

LANL = Los Alamos National Laboratory TA = Technical Area MEI = maximally exposed individual
Metal = plutonium compounds having clearance class "W" Oxide = plutonium oxides having clearance class "Y"

Table D–34 Compositions of Different Types of Plutonium Mixture at Rocky Flats

Isotope	Processed Weapon-Grade Plutonium [a]		Aged Weapon-Grade Plutonium		High Americium Salt [b]	
	g/g-mix	Ci/g-mix	g/g-mix	Ci/g-mix	g/g-mix	Ci/g-mix
Plutonium 238	0.000292	0.005	0.000165	0.0028	0.00009	0.00147
Plutonium 239	0.926	0.0576	0.924	0.057	0.809	0.0503
Plutonium 240	0.0566	0.0129	0.0561	0.013	0.05	0.0114
Plutonium 241	0.00325	0.335	0.000102	0.011	0.0031	0.32
Plutonium 242	0.000306	1.20×10^{-6}	0.000306	1.2×10^{-6}	0.000259	1.02×10^{-6}
Americium 241	0.000175	0.0006	0.00305	0.011	0.138	0.473
Total	0.99	0.411	0.985	0.095	1	0.856

g/g-mix = gram/gram-mixture Ci/g-mix = curies per gram-mixture
[a] Rocky Flats weapon-grade plutonium compositions.
[b] Compositions of IDC 409 and IDC 410 were used.
Source: BIO Radiological Dose Consequence Template (RF 1996).

For each accident scenario except criticality, the radiological consequences (rem or person-rem) to each receptor are estimated by multiplying the calculated building source term with the receptor's dose factor, given in **Table D–35** and **Table D–36**. For example, the maximally exposed individual dose at the Savannah River Site for releases caused by an accidental plutonium oxide (ash) powder spill in the new special recovery facility is calculated by *multiplying* the building source term resulting from the spill, which is estimated to be ~0.01 mg ($[178]\times[10^{-5}]\times[10^{-3}]$) of plutonium from values given in Table D–25, *with* the dose factor of 0.019 rem/g plutonium from Table D–27 to get a maximally exposed individual dose of 1.9×10^{-7} rem, or 1.9×10^{-4} mrem, per spill.

Table D–35 Criticality Accident Consequences at the Management Sites (Consequences Are in Terms of Rem for the Individuals and Person-rem for the Population)

Receptor	Rocky Flats Building 371		SRS Building 221-F		SRS Building 221-H		LANL Building TA-55 [a]	
	95% Met	50% Met	95% Met	50% Met	95% Met	50% Met	95% Met	50% Met
MEI	0.79	0.11	0.011	0.0044	0.009	0.003	0.137	0.022
Population	6980	252	310	32	290	29	98.8	15.7
Worker	N/A	0.321	N/A	0.038	N/A	0.038	N/A	0.045

SRS = Savannah River Site LANL = Los Alamos National Laboratory TA = Technical Area
Met = meteorological data MEI = maximally exposed individual N/A = not applicable
[a] At Los Alamos National Laboratory, the doses are calculated for 10^{18} fissions; at other sites, the doses are for 10^{19} fissions.

Table D–36 Receptors' Dose Factors for Accidental Releases of 1 g Plutonium from Accident Initiated in FB-Line or HB-Line

Receptor	Plutonium Oxide		Plutonium Metal		High Americium Salts (Metal)	
	95% Met	50% Met	95% Met	50% Met	95% Met	50% Met
Accident Initiated in FB-Line						
MEI (rem)	0.015	0.0054	0.031	0.011	0.032	0.011
Population (person-rem)	900	82	1600	150	1600	150
Worker (rem)	N/A	0.066	N/A	0.093	N/A	0.096
Accident Initiated in HB-Line						
MEI (rem)	0.013	0.0041	0.029	0.0088	0.031	0.009
Population (person-em)	900	75	1420	141	1470	144
Worker (rem)	N/A	0.066	N/A	0.093	N/A	0.096

Met = meteorological condition MEI = maximally exposed individual N/A = not applicable

The maximally exposed individual risk from this event is the accident frequency, which is 0.01 per year (given in the accident scenario description in Section D.3.3.2) multiplied by the consequence (dose factor), resulting in 1.9×10^{-6} mrem/yr. The risk is also stated in terms of additional latent cancer fatalities resulting from a release using a conversion factor of 5×10^{-4} latent cancer fatalities per person rem for the individual member of the public and 4×10^{-4} latent cancer fatalities per person-rem for a worker. For this example, the risk to the maximally exposed individual is calculated by multiplying 1.9×10^{-6} mrem/yr, 0.001 rem/mrem, and 5×10^{-4} latent cancer fatalities per rem, which results in 9.5×10^{-13} latent cancer fatalities per year.

For the criticality accidents, direct calculations of consequences are made based on the fission gas and plutonium releases resulting from a solution criticality event of 1×10^{19} fissions at the Savannah River Site and at Rocky Flats. At Los Alamos National Laboratory, direct calculations of consequences are made based on fission gas releases during a criticality excursion event of 10^{18} fissions in terms of rem and/or person-rem for the 50th- and 95th-percentile meteorological conditions.

For the accidents in the FB-Line or HB-Line facility, the receptors' dose factors would be lower than those presented in Tables D–35 and D–36. This is because the plutonium solutions entering the FB-Line or HB-Line processes are essentially americium-free solutions. Table D–36 provides various receptors' dose factors from an FB-Line or HB-Line accidental release during the processing of Rocky Flats aged weapon-grade plutonium or high americium salts in terms of rem and/or person-rem for the 50th and 95th percentile meteorological conditions. The dose factors given in Table D-28 are applicable only to the ion exchange explosion accident. The plutonium materials released are metal compounds (i.e., have the clearance half-time of "W").

The consequences to involved workers are qualitatively assessed. This approach is used for two reasons: first, no adequate method exists for calculating meaningful consequences at or near the location where the accident occurs. Second, safety assurance for facility workers is demonstrated by both the workers' training and by the establishment of an Occupational Safety and Health Administration process safety management system (29 CFR 1910.119), the evaluations required by such a system, and the products derived from such evaluations (e.g., procedures, programs, emergency plans).

The consequences to the involved worker are accident dependent and site-specific. In facilities where the involved worker activities include remote operations, the consequences of accidents would be lower than in facilities where the workers are near the process. The following paragraphs summarize the various potential consequences to the involved workers from the hypothesized accidents at different management sites. Additionally, a limited number of fatalities could occur in an indirect or secondary manner—for example, the involved worker could be killed by an earthquake or explosion (see also **Table D–37** and **Table D–38**).

- **Explosion**—The explosion could result in serious, even fatal, injuries to involved workers from the accident itself. Some of the involved workers could inhale the dispersed radioactive material before using their respirators and evacuating the area. No fatality is expected from the radiological consequences.

- **Fire**—Involved workers could inhale some radioactive material before using their respirators and immediately evacuating the building. No fatality is expected from the radiological consequences.

- **Spill**—Depending on the location of the spill, nearby workers may inhale the airborne radioactive materials before evacuating the area. Involved workers normally would be wearing respirators when handling the radioactive material containers. No fatality is expected to result from such an accident.

- **Earthquake**—Involved workers could receive lethal injuries from the accident itself. No fatality is expected from radiological consequences.

Table D–37 Involved Worker Consequences from Various Hypothesized Accidents

Accident	*Rocky Flats*	*Savannah River Site*	*Los Alamos National Laboratory*
Explosion (acetylene)	Could potentially result in fatal injuries (nonradiological) to the nearby involved workers.	N/A	N/A
Explosion (Ion Exchange)	Could potentially result in fatal injuries (nonradiological) to the nearby involved workers.	Could potentially result in fatal injuries (nonradiological) to the nearby involved workers.	N/A
Explosion (Hydrogen)	N/A	No fatality is expected due to remote operation.	N/A
Criticality	Could potentially result in fatal dose to the nearby involved workers.	Could potentially result in fatal dose to the nearby involved workers.	Could potentially result in fatal dose to the nearby involved workers.
Fire	No fatality is expected, some nearby workers could inhale the dispersed radioactive materials before using respirator and leaving the area.	No fatality is expected, some nearby workers could inhale the dispersed radioactive materials before using respirator and leaving the area.	No fatality is expected, some nearby workers could inhale the dispersed radioactive materials before using respirator and leaving the area.
Earthquake	Some fatalities (nonradiological) are expected in Building 707.	No fatality is expected.	No fatality is expected.
Spill	Nearby workers could inhale the dispersed radioactive materials before using respirator and leaving the area.	Nearby workers could inhale the dispersed radioactive materials before using respirator and leaving the area.	Nearby workers could inhale the dispersed radioactive materials before using respirator and leaving the area.

N/A = not applicable

- **Aircraft Crash**—Consequences similar to those of an earthquake may result from the accident.

- **Criticality**—Involved workers could receive substantial, or potentially fatal, doses from prompt neutrons and gamma rays emitted from the first pulse. After the initial pulse, the workers would evacuate the area immediately on the initiation of the criticality monitoring alarms.

D.3.3.5 Analysis Conservatism and Uncertainty

To assist in evaluating the impact of the plutonium residue and scrub alloy processing options at Rocky Flats, the Savannah River Site, and Los Alamos National Laboratory on a common basis, a spectrum of generic accidents were postulated for each process location. The accident scenarios were based on similar accidents documented in various site documents. When required, accident assumptions were modified to enable comparison between the three sites. In cases where similar accidents were evaluated in site specific documents, the more conservative analysis assumptions were used for all sites to normalize the results for the purpose of comparison. The following accident analysis parameters have a major impact on accident consequence estimates (i.e., dose to the public and worker): the weather conditions existing at the time of the accident, the material at risk, the isotopic breakdown of the material at risk, and the source term released to the environment.

Table D–38 Involved Worker Summary

Accident Description	*Number of Involved Workers*	
Rocky Flats	**Building 707**	**Building 371**
Explosion, Acetylene	30	30
Explosion, Ion Exchange Column	N/A	30
Room Fire	30	30
Dock Fire	12	12
Room Spill	30	30
Glovebox Spill	0	0
Dock Spill	12	12
Earthquake	100	100
Savannah River Site—Purex Process (All Ash Residues)	**H-Canyon & H-B Line**	**F-Canyon & F-B Line**
Explosion, Hydrogen	16	21
Explosion, Ion Exchange Column	27	16
Nuclear Criticality	27	16
Fire	27	16
Earthquake	43	37
Savannah River Site—Purex Process (Not Ash Residue)	**H-Canyon & H-B Line**	**F-Canyon & F-B Line**
Explosion, Hydrogen	27	31
Explosion, Ion Exchange Column	27	16
Nuclear Criticality	27	16
Fire	27	16
Earthquake	54	47
Savannah River Site—Mediated Electrochemical Oxidation Process	**H-Canyon & H-B Line**	**F-Canyon & F-B Line**
Explosion, Hydrogen	16	23
Explosion, Ion Exchange Column	27	16
Nuclear Criticality	27	16
Fire	27	16
Spill	16	23
Earthquake	43	39
Los Alamos National Laboratory		
Nuclear Criticality	30	
Fire	30	
Spill	30	
Earthquake	30	

N/A = not applicable

Weather conditions assumed at the time of the accident have a large impact on dose estimates. Accident impacts to the public were estimated using both 95 percentile and median 50 percentile weather data. The public impacts documented in the body of the EIS are based on the conservative 95 percentile weather data. The GENII computer code was used to calculate doses to the public within 80 km (50 miles) of the accident release point. The code calculates the public dose in each of 16 sectors centered at the accident release point. The GENII computer code also assumes that total source term is released into each sector and that there is no change in the weather (i.e., wind direction, wind speed, and stability class) while the accident plume is traversing the 80 km sector. The use of the conservative 95 percentile weather data rather than the expected or median 50 percentile weather data increases the dose to the public by more than a factor of 40.

Conservative assumptions were used to estimate the material at risk. If an accident scenario involved the contents of a room or a facility, the analysis assumed that the material at risk was equivalent to the amount of material that could be processed in one week. If an accident scenario involved one or more containers of material, the analysis assumed that the first container contained the maximum amount of material and any additional containers contained the average amount of material. Only a small percentage of containers contain the maximum amount.

The isotopic breakdown of the material at risk was also conservatively estimated. The composition of the Item Code Descriptions (IDCs) for each group of materials were reviewed and the IDCs with the most unfavorable isotopic breakdown, from a dose point-of-view, were selected as being representative for the group.

Uncertainties in accident frequencies do not impact the accident consequences, but do impact accident risk. The site/facility specific accident frequencies (i.e., earthquake induced building collapse and aircraft crash) were based on data provided by the sites. Process specific accident frequencies were estimated based on analyses provided in site specific documentation. In cases where similar accidents were evaluated in site specific documents, the more conservative accident frequency was used for all sites to normalize the results for the purpose of comparison.

On August 29, 1997, an Unreviewed Safety Question was identified for Rocky Flats Building 707. A recently completed seismic analysis concluded that the facility does not have the structural capacity credited for in the current authorization basis. The earthquake frequency that could cause collapse of the facility increased by approximately a factor of 2. The EIS risk assessments did not adjust the estimated risk for earthquake damage to Building 707 because the seismic analysis and potential structural enhancements to Building 707 are being evaluated.

Due to the layers of conservatism built into the accident analysis for the spectrum of postulated accidents, the estimated consequences and risk to the public represents the upper limit for the individual classes of accidents. The uncertainties associated with the accident frequency estimates and process batch sizes documented in the process data sheets are enveloped by the analysis conservatism.

D.3.3.6 Comparison of Analysis Results with Site Documents

The accident analysis consequences and risks should not be expected to be in agreement with accident analyses presented in site documentation (e.g., safety analysis reports, cumulative impact documents). To assist in evaluating the impact of the plutonium residue and scrub alloy processing options at Rocky Flats, the Savannah River Site, and Los Alamos National Laboratory on a common basis, a spectrum of generic accidents were postulated for each process location. The accident scenarios were based on similar accidents documented in various site documents. When required, accident assumptions were modified to enable comparison between the three sites.

The material at risk for each accident was estimated based on the process data sheets. For the purpose of comparison, a common set of ground rules was used to estimate the source term released to the environment during the accidents. A common computer code and site specific weather data were used to assess the impact of each accident. Public impacts were estimated using both 95 percentile and 50 percentile weather data. The public impacts documented in the body of the EIS are based on the conservative 95 percentile weather data. The impacts to the non involved worker, nominally located 100 meters from the accident radiological release point, are based on the median 50 percentile weather data.

In the event that accident analysis consequences and risks in this EIS are compared with accident analyses presented in site documentation (e.g., safety analysis reports, cumulative impacts documents, etc.), do not expect the analysis results to be the same. The differences in the results may be attributed to differences in one or more of the following:

- Computer codes used for analysis
- Analysis data bases (e.g., population, weather, agriculture)
- Accident scenario
- Analysis ground rules and assumptions
- Material at risk
- Source term released to the environment
- Source term isotopic breakdown
- Accident frequency
- Process duration.

For example, a comparison was made of a similar accident documented in the Rocky Flats Cumulative Impacts Document for the 1996 Baseline with this EIS. Both analyses evaluated an earthquake-induced collapse of Building 707. The cumulative impacts document estimated 0.52 latent cancer fatalities and this EIS estimated 147 latent cancer fatalities. Several factors are responsible for the differences between the two documents. They are provided below in approximate order of importance or impact.

- The cumulative impacts document uses the median value for weather and the EIS uses the conservative 95 percentile weather. For the earthquake accident scenario in this EIS, the 95 percentile weather yields a calculated value of 293,000 person-rem (147 latent cancer fatalities) for the population and the 50 percentile weather yields a calculated value of 7,000 person-rem (3.5 latent cancer fatalities) for the population).

- The cumulative impacts document uses the MACCS computer code and the EIS uses the GENII computer code. There are major differences in the calculational approaches used in the codes. The MACCS code calculates the dose based on sectors being sampled from the weather database, and the GENII code calculates the dose to each of 16 sectors for the specified sector weather condition. The sector with the largest dose is reported.

- The material at risk and isotopic breakdown of the material was estimated differently in the cumulative impacts document and the EIS. The cumulative impacts document used the actual material known to be in the building and calculated the amount of dispersible material based on conversion of plutonium metal to oxides, amount of oxides present, amount of residues present (with associated americium amounts) and amount of transuranic and low level waste present. The EIS used a simpler approach, in that it used two plutonium residue Item Description Codes (IDCs), 409 and 410, both molten salt extraction salts containing the maximum quantity of americium, as the worst case scenario, and assumed a 5-day supply of the residue to be present in Building 707 upon collapse from the earthquake. The high content of americium in the plutonium residue significantly increases the radiological dose from that residue.

D.3.4 Accident Analyses Consequences and Risks Results

This section summarizes the consequences and risks to individuals and the general public from the operation of different residue processes (technologies) considered in this EIS. For each residue process, there are three alternatives: No Action, Processing without Plutonium Separation, and Processing with Plutonium Separation. The following subsections provide the summary results for each residue category and processing technology that were considered in this EIS. The details of each processing technology are provided in Appendix C and are summarized in Chapter 2 of this EIS; they will not be repeated here. The process data for each technology are provided by the DOE management sites (RFFO 1997, WSRC 1997a, and LANL 1997b). For example, the Rocky Flats Field Office (RFFO 1997) provided the process data sheets for those technologies that will be performed at Rocky Flats; the Westinghouse Savannah River Company (WSRC 1997a) provided process data sheets for the technologies that will be performed at the Savannah River Site; and Los Alamos National Laboratory (LANL 1997b) provided the process data sheets for the technologies that will be performed at Los Alamos National Laboratory.

The results provided on the following pages represent the incremental increase in risks associated with the implementation of each processing technology. In evaluating the risk for the processing technologies, this EIS used the following assumptions and simplifications:

For each processing technology, the material at risk is the residue material in its most vulnerable form.

For the room fire and the earthquake accident scenarios, the material at risk is a 5-day supply, or a weekly throughput. The supply is divided into 3 days of feed and 2 days of product.

For earthquakes, risk is calculated only for a frequency that results in the total collapse or breach of the building.

When there is no building damage, the Building 371 earthquake-initiated fire and explosion are limited to the affected rooms. The Building 371 Basis for Interim Operation report identified the analytical laboratory (Room 3412) as the source of the explosion and the Caustic Waste Treatment System area (Rooms 1103, 1105, 1113, and 1115) as the main source of the fire. Although the earthquake-initiated fire and explosion were important for the Basis for Interim Operation report, they will not be considered in this EIS because the location of the gloveboxes for proposed processing technologies (Room 3701) is separated from the affected rooms The explosion is localized and would not damage the building. The whole building must be involved for the fire to spread and involve Room 3701; and the probability of this happening is smaller than that of another fire scenario that will be evaluated in this EIS.

For earthquake-initiated criticality, the bound is the 1×10^{19} fission criticality event analyzed for the plutonium liquid processes.

When a process involves operations in more than one building, it will be treated as two independent subprocesses with an interim storage in between. For example, in the acid dissolution of residues, the process of changing the residue to a calcined plutonium starts in Building 371; the final calcination occurs in Building 707A after a temporary storage in that building vault. Two sets of accident scenarios, one in Building 371 and the second in Building 707A, will be applied to residue materials that use this processing technology.

D.3.4.1 Ash Residues

D.3.4.1.1 No Action

The ash residues processing technology considered for this alternative is calcination/cementation. The calcination/cementation process will be performed at Rocky Flats in Building 371, Room 3701. Building 707 is under consideration as an alternate location for the process. The accident analysis evaluates both the primary and alternate locations.

Table D–39 provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of calcination/cementation processing technology of ash at Rocky Flats. **Table D–40** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with the processing of ash residues. The risks associated with this processing technology are summarized in **Table D–41**.

Table D–39 Ash Residues Accident Scenarios Parameters Calcination/Cementation at Rocky Flats

Accident Scenario	*Frequency (per year)*	*Ash Residues*	*HEPA Banks*	*Material at Risk (grams)*
Explosion	0.00005	2 drums [a]	2/0 [b]	4,000 g
Nuclear Criticality [c]	–	–	–	–
Fire:				
a. Room	0.0005	5-day supply [d]	2	3,507 g supply + 2,338 g product [e]
b. Loading Dock	2.0×10^{-6}	4 drums [f]	0	6,000 g
Spill:				
a. Room	0.008	1 container at the limit [g]	2	600 g
b. Glovebox	0.8	1 feed prep container	2	83.5 g
c. Loading Dock	0.001	1 drum [h]	0	3,000 g
Earthquake				
a. Building 371	0.000094	5-day supply [d]	0	3,507 g supply + 2,338 g product [e]
b. Building 707	0.0018	5-day supply [d]	0	3,507 g supply + 2,338 g product [e]
Aircraft Crash				
a. Building 371	0.00004	The aircraft will not penetrate the building wall.	–	–
b. Building 707	0.00003	Consequences enveloped by the earthquake.	–	–

Accident Scenario	*DR*	*ARF*	*RF*	*LPF*	*Release Point*
Explosion					
a. Building 371	1.0	0.001	0.1	2.0×10^{-6}	Elevated
b. Building 707	1.0	0.001	0.1	1.0	Ground
Nuclear Criticality [c]	–	–	–	–	–
Fire:					
a. Room	1.0	0.006	0.01	0.1	Ground
b. Loading Dock	0.01	0.006	0.01	0.5	Ground

Accident Scenario	*DR*	*ARF*	*RF*	*LPF*	*Release Point*
Spill:					
a. Room	1.0	0.00002	0.5	2.0×10^{-6}	Elevated
b. Glovebox	1.0	0.00002	0.5	2.0×10^{-6}	Elevated
c. Loading Dock	0.25	0.00008	0.5	0.1	Ground
Earthquake	1.0	0.002 [j]	0.3 [j]	0.1	Ground
Aircraft Crash					
a. Building 371 [k]	–	–	–	–	–
b. Building 707 [l]	–	–	–	–	–

DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

a 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content.

b Building 371, 2 HEPA Banks; Building 707, 0 HEPA Banks.

c The wet nuclear criticality is not a viable accident scenario for the calcination/cementation technology assessment.

d 3-day supply of feed and 2-day supply of product.

e The product is cemented ash. The effect of the cemented ash product on the accident source term is negligible.

f 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.

g 5 containers per drum of feed.

h 1 drum at the maximum plutonium content level.

j Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000792).

k The aircraft will not penetrate the building.

l Consequences enveloped by the earthquake.

Table D–40 Summary of the Ash Residues Accident Analysis Doses Calcination/Cementation at Rocky Flats

	Building Source Term		*MEI (rem)*		*Population (person-rem)*		*Worker (rem)*
Accident Scenario	*(grams)*	*Type*	*95% Met*	*50% Met*	*95% Met*	*50% Met*	*50% Met*
Building 371							
Explosion	8.00×10^{-7}	Oxide	1.20×10^{-6}	1.36×10^{-7}	0.02	0.00048	1.44×10^{-6}
Fire (Room)	0.0351	Oxide	0.0631	0.00631	877	21.0	0.736
Fire (Dock)	0.0018	Oxide	0.00324	0.000324	45.0	1.08	0.0378
Spill (Room)	1.20×10^{-8}	Oxide	1.80×10^{-8}	2.04×10^{-9}	0.0003	7.20×10^{-6}	2.16×10^{-8}
Spill (Glovebox)	1.67×10^{-9}	Oxide	2.51×10^{-9}	2.84×10^{-10}	0.0000418	1.00×10^{-6}	3.01×10^{-9}
Spill (Dock)	0.003	Oxide	0.0054	0.00054	75.0	1.80	0.063
Earthquake	0.463	Oxide	0.833	0.0833	11,600	278	9.72
Building 707							
Explosion	0.400	Oxide	0.480	0.0520	10,000	240	8.40
Fire (Room)	0.0351	Oxide	0.0421	0.00456	877	21.0	0.736
Fire (Dock)	0.00180	Oxide	0.00216	0.000234	45.0	1.08	0.378
Spill (Room)	1.20×10^{-8}	Oxide	1.92×10^{-9}	7.20×10^{-10}	0.000104	5.4×10^{-6}	1.68×10^{-9}
Spill (Glovebox)	1.67×10^{-9}	Oxide	2.67×10^{-10}	1.00×10^{-10}	0.0000145	7.52×10^{-7}	2.34×10^{-10}
Spill (Dock)	0.00300	Oxide	0.00360	0.000390	75.0	1.80	0.0630
Earthquake	0.463	Oxide	0.556	0.0602	11,600	278	9.72

MEI = maximally exposed individual Met = meteorological data

Table D–41 Summary of the Ash Residues Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year—Calcination/Cementation at Rocky Flats

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr)		Population (LCF/yr)		Worker (LCF/yr)
		95% Met	50% Met	95% Met	50% Met	50% Met
Building 371						
Explosion	0.00005	3.00×10^{-14}	3.40×10^{-15}	5.00×10^{-10}	1.20×10^{-11}	2.88×10^{-14}
Fire (Room)	0.0005	1.58×10^{-8}	1.58×10^{-9}	0.000219	5.26×10^{-6}	1.47×10^{-7}
Fire (Dock)	2.0×10^{-6}	3.24×10^{-12}	3.24×10^{-13}	4.50×10^{-8}	1.08×10^{-9}	3.02×10^{-11}
Spill (Room)	0.008	7.20×10^{-14}	8.16×10^{-15}	1.20×10^{-9}	2.88×10^{-11}	6.91×10^{-14}
Spill (Glovebox)	0.8	1.00×10^{-12}	1.14×10^{-13}	1.67×10^{-8}	4.01×10^{-10}	9.62×10^{-13}
Spill (Dock)	0.001	2.70×10^{-9}	2.70×10^{-10}	0.0000375	9.00×10^{-7}	2.52×10^{-8}
Earthquake	0.000094	3.92×10^{-8}	3.92×10^{-9}	0.000544	0.0000131	3.66×10^{-7}
Building 707						
Explosion	0.00005	1.20×10^{-8}	1.30×10^{-9}	0.000250	6.00×10^{-6}	1.68×10^{-7}
Fire (Room)	0.0005	1.05×10^{-8}	1.14×10^{-9}	0.000219	5.26×10^{-6}	1.47×10^{-7}
Fire (Dock)	2.0×10^{-6}	2.16×10^{-12}	2.34×10^{-13}	4.50×10^{-8}	1.08×10^{-9}	3.02×10^{-11}
Spill (Room)	0.008	7.68×10^{-15}	2.88×10^{-15}	4.18×10^{-10}	2.16×10^{-11}	5.38×10^{-15}
Spill (Glovebox)	0.8	1.07×10^{-13}	4.01×10^{-14}	5.81×10^{-9}	3.01×10^{-10}	7.48×10^{-14}
Spill (Dock)	0.001	1.80×10^{-9}	1.95×10^{-10}	0.0000375	9.00×10^{-7}	2.52×10^{-8}
Earthquake	0.0018	5.00×10^{-7}	5.42×10^{-8}	0.0104	0.000250	7.00×10^{-6}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.1.2 Processing and Storage without Plutonium Separation

The ash residue processing technologies considered for this alternative are vitrification and blend down. The vitrification process will be performed at Rocky Flats in Building 707, Modules D and E; final drum packaging will be performed in Module F. The blend down process will be performed at Rocky Flats in Building 707, Module E. Building 371 is under consideration as an alternate location for the blend down process. The accident analysis evaluates both the primary and alternate locations for the blend down process. Similar accidents are applicable to both of these technologies. **Table D–42** provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of ash processing technology at Rocky Flats. **Table D–43** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with the processing of ash residues. The risks associated with these processing technologies are summarized in **Table D–44**.

Table D–42 Ash Residues Accident Scenarios Parameters Vitrification and Blend Down at Rocky Flats

Accident Scenario	Frequency (per year)	Ash Residues	HEPA Banks	Material at Risk (grams)	
				Vitrification Process [a]	Blend Down Process [b]
Explosion	0.000050	2 drums [c]	0/2 [d]	4,000 g	4,000 g
Nuclear Criticality [e]	–	–	–	–	–

Accident Scenario	Frequency (per year)	Ash Residues	HEPA Banks	Material at Risk (grams)	
				Vitrification Process [a]	Blend Down Process [b]
Fire:					
a. Room	0.0005	5-day supply [f]	2	4,810 g feed + 3,206 g product [g]	7,014 g
b. Loading Dock	2.0×10^{-6}	4 drums [h]	0	6,000 g	6,000 g
Spill:					
a. Room	0.008	1 container at the limit [j]	2	600 g	600 g
b. Glovebox	0.8	1 feed prep container		83.5 g	83.5 g
c. Loading Dock	0.001	1 drum [k]	0	3,000 g	3,000 g
Earthquake:					
a. Building 707	0.0018	5-day supply [f]	0	4,810 g feed + 3,206 g product [g]	7,014 g
b. Building 371	0.000094	5-day supply [f]	0	N/A	7,014 g
Aircraft Crash:					
a. Building 707	0.000030	Consequences enveloped by the earthquake.	–	–	–
b. Building 371	0.00004	The aircraft will not penetrate the building walls.	–	–	–

Accident Scenario	DR	ARF	RF	LPF	Release Point
Explosion:					
a. Building 707	1.0	0.001	0.1	1.0	Ground
b. Building 371	1.0	0.001	0.1	2.0×10^{-6}	Elevated
Nuclear Criticality [e]	–	–	–	–	–
Fire:					
a. Room	1.0	0.006	0.01	0.1	Ground
b. Loading Dock	0.01	0.006	0.01	0.5	Ground
Spill:					
a. Room	1.0	0.00002	0.5	2.0×10^{-6}	Elevated
b. Glovebox	1.0	0.00002	0.5	2.0×10^{-6}	Elevated
c. Loading Dock	0.25	0.00008	0.5	0.1	Ground
Earthquake	1.0	0.002 [l]	0.3 [l]	0.1	Ground
Aircraft Crash:					
a. Building 707 [m]	–	–	–	–	–
b. Building 371 [n]	–	–	–	–	–

a Building 707, Modules D, E, and F.
b Building 707, Module E or Building 371 (alternate location).
c 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level for plutonium content (1,000 g).
d Building 371, 2 HEPA Banks; Building 707, 0 HEPA Banks.
e The wet nuclear criticality is not a viable accident scenario for the vitrification and blend down technology assessments.
f 3-day supply of feed and 2-day supply of product.
g The product is glass. The effect of the vitrified product on the accident source term is negligible.
h 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.
j 5 containers per drum of feed.
k 1 drum at the maximum plutonium content level.
l Add 0.000192 to all (ARF×RF) values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000792).
m Enveloped by the earthquake.
n The aircraft will not penetrate the building walls.

Table D–43 Summary of the Ash Residues Accident Analysis Doses Vitrification and Blend Down at Rocky Flats

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Vitrification Process							
Explosion	0.4	Oxide	0.48	0.052	10,000	240	8.40
Fire (Room)	0.0289	Oxide	0.0346	0.00375	722	17.3	0.606
Fire (Dock)	0.0018	Oxide	0.00216	0.000234	45.0	1.08	0.0378
Spill (Room)	1.20×10^{-8}	Oxide	1.92×10^{-9}	7.20×10^{-10}	0.000104	5.40×10^{-6}	1.68×10^{-9}
Spill (Glovebox)	1.67×10^{-9}	Oxide	2.67×10^{-10}	1.00×10^{-10}	0.0000145	7.52×10^{-7}	2.34×10^{-10}
Spill (Dock)	0.003	Oxide	0.0036	0.00039	75.0	1.80	0.063
Earthquake	0.381	Oxide	0.457	0.0495	9,520	229	8.00
Blend Down Process—Building 707							
Explosion	0.4	Oxide	0.48	0.052	10,000	240	8.40
Fire (Room)	0.0421	Oxide	0.0505	0.00547	1,050	25.3	0.884
Fire (Dock)	0.0018	Oxide	0.00216	0.000234	45.0	1.08	0.0378
Spill (Room)	1.20×10^{-8}	Oxide	1.92×10^{-9}	7.20×10^{-10}	0.000104	5.40×10^{-6}	1.68×10^{-9}
Spill (Glovebox)	1.67×10^{-9}	Oxide	2.67×10^{-10}	1.00×10^{-10}	0.0000145	7.52×10^{-7}	2.34×10^{-10}
Spill (Dock)	0.003	Oxide	0.0036	0.00039	75.0	1.80	0.063
Earthquake	0.556	Oxide	0.667	0.0722	13,900	333	11.7
Blend Down Process—Building 371							
Explosion	8.00×10^{-7}	Oxide	1.20×10^{-6}	1.36×10^{-7}	0.0200	0.000480	1.44×10^{-6}
Fire (Room)	0.0421	Oxide	0.0758	0.00758	1,050	25.3	0.884
Fire (Dock)	0.00180	Oxide	0.00324	0.000324	45.0	1.08	0.0378
Spill (Room)	1.20×10^{-8}	Oxide	1.80×10^{-8}	2.04×10^{-9}	0.000300	7.20×10^{-6}	2.16×10^{-8}
Spill (Glovebox)	1.67×10^{-9}	Oxide	2.51×10^{-9}	2.84×10^{-10}	0.0000418	1.00×10^{-6}	3.01×10^{-9}
Spill (Dock)	0.00300	Oxide	0.00540	0.000540	75.0	1.80	0.0630
Earthquake	0.556	Oxide	1.00	0.100	13,900	333	11.7

MEI = maximally exposed individual Met = meteorological data

Table D–44 Summary of the Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr) 95% Met	MEI (LCF/yr) 50% Met	Population (LCF/yr) 95% Met	Population (LCF/yr) 50% Met	Worker (LCF/yr) 50% Met
Vitrification Process						
Explosion	0.00005	1.20×10^{-8}	1.30×10^{-9}	0.00025	6.00×10^{-6}	1.68×10^{-7}
Fire (Room)	0.0005	8.66×10^{-9}	9.38×10^{-10}	0.00018	4.33×10^{-6}	1.21×10^{-7}
Fire (Dock)	2.0×10^{-6}	2.16×10^{-12}	2.34×10^{-13}	4.50×10^{-8}	1.08×10^{-9}	3.02×10^{-11}
Spill (Room)	0.008	7.68×10^{-15}	2.88×10^{-15}	4.18×10^{-10}	2.16×10^{-11}	5.38×10^{-15}
Spill (Glovebox)	0.8	1.07×10^{-13}	4.01×10^{-14}	5.81×10^{-9}	3.01×10^{-10}	7.48×10^{-14}
Spill (Dock)	0.001	1.80×10^{-9}	1.95×10^{-10}	0.0000375	9.00×10^{-7}	2.52×10^{-8}
Earthquake	0.0018	4.11×10^{-7}	4.46×10^{-8}	0.00857	0.000206	5.76×10^{-6}

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr)		Population (LCF/yr)		Worker (LCF/yr)
		95% Met	50% Met	95% Met	50% Met	50% Met
Blend Down Process—Building 707						
Explosion	0.00005	1.20×10^{-8}	1.30×10^{-9}	0.00025	6.00×10^{-6}	1.68×10^{-7}
Fire (Room)	0.0005	1.26×10^{-8}	1.37×10^{-9}	0.000263	6.31×10^{-6}	1.77×10^{-7}
Fire (Dock)	2.0×10^{-6}	2.16×10^{-12}	2.34×10^{-13}	4.50×10^{-8}	1.08×10^{-9}	3.02×10^{-11}
Spill (Room)	0.008	7.68×10^{-15}	2.88×10^{-15}	4.18×10^{-10}	2.16×10^{-11}	5.38×10^{-15}
Spill (Glovebox)	0.8	1.07×10^{-13}	4.01×10^{-14}	5.81×10^{-9}	3.01×10^{-10}	7.48×10^{-14}
Spill (Dock)	0.001	1.80×10^{-9}	1.95×10^{-10}	0.0000375	9.00×10^{-7}	2.52×10^{-8}
Earthquake	0.0018	6.00×10^{-7}	6.50×10^{-8}	0.0125	0.0003	8.40×10^{-6}
Blend Down Process—Building 371						
Explosion	0.00005	3.00×10^{-14}	3.40×10^{-15}	5.00×10^{-10}	1.20×10^{-11}	2.88×10^{-14}
Fire (Room)	0.0005	1.89×10^{-8}	1.89×10^{-9}	0.000263	6.31×10^{-6}	1.77×10^{-7}
Fire (Dock)	2.0×10^{-6}	3.24×10^{-12}	3.24×10^{-13}	4.50×10^{-8}	1.08×10^{-9}	3.02×10^{-11}
Spill (Room)	0.008	7.20×10^{-14}	8.16×10^{-15}	1.20×10^{-9}	2.88×10^{-11}	6.91×10^{-14}
Spill (Glovebox)	0.8	1.00×10^{-12}	1.14×10^{-13}	1.67×10^{-8}	4.01×10^{-10}	9.62×10^{-13}
Spill (Dock)	0.001	2.70×10^{-9}	2.70×10^{-10}	0.0000375	9.00×10^{-7}	2.52×10^{-8}
Earthquake	0.000094	4.70×10^{-8}	4.70×10^{-9}	0.000653	0.0000157	4.39×10^{-7}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.1.3 Processing and Storage with Plutonium Separation

The ash residue processing technologies considered for this alternative are the Purex/plutonium metal (or oxide) recovery process and the mediated electrochemical oxidation process. Both of these processes will be performed in the Savannah River Site F-Canyon or H-Canyon. The ash residues will be preprocessed and packaged at Rocky Flats in Building 707, Module E, before shipment to the Savannah River Site for processing.

Similar accidents are applicable to both ash residue processing technologies and their associated ash residue preprocessing and packaging requirements. **Table D–45** provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of preprocessing and packaging the ash residue at Rocky Flats and processing the residue using the Purex/plutonium metal recovery process and mediated electrochemical oxidation process at the Savannah River Site. **Table D–46** summarizes the consequences to the maximally exposed individual, the public, and workers from the accidental releases associated with preprocessing and packaging the residues at Rocky Flats and processing the residues at the Savannah River Site. The risks associated with the preprocessing and packaging at Rocky Flats and the Purex/plutonium metal recovery process and mediated electrochemical oxidation process at the Savannah River Site are summarized in **Table D–47**. The processes at the Savannah River Site can be performed in either the F-Canyon and FB-Line or the H-Canyon and HB-Line. Data are presented in Table D–45, Table D–46, and Table D–47 for both options.

Table D–45 Ash Residues Accident Scenarios Parameters Purex/Plutonium Metal Recovery and Mediated Electrochemical Oxidation

Rocky Flats Preprocessing and Packaging of Ash Residues for Shipment to the Savannah River Site for Processing

Accident Scenario	*Frequency (per year)*	*Ash Residues*	*HEPA Banks*	*Material at Risk (grams)*		
				Purex/Plutonium Metal Recovery Process		*MEO Process*
				Ash (No SS&C)	*SS&C*	*Ash (No SS&C)*
Explosion	0.00005	2 drums [a]	0	4,000 g	4,000 g	4,000 g
Nuclear Criticality [b]	–	–	–	–	–	–
Fire:						
a. Room	0.0005	5-day supply [c]	2	12,288 g	8,083 g	17,088 g
b. Loading Dock	2.0×10^{-6}	4 drums [d]	0	6,000 g	6,000 g	6,000 g
Spill:						
a. Room	0.008	1 container at the maximum limit [e]	2	600 g	600 g	600 g
b. Glovebox	0.8	1 feed prep container	2	128 g	84.2 g	178 g
c. Loading Dock	0.001	1 drum [f]	0	3,000 g	3,000 g	3,000 g
Earthquake	0.0018	5-day supply [c]	0	12,288 g	8,083 g	17,088 g
Aircraft Crash [g]	0.00003	Consequences enveloped by the earthquake.	–	–	–	–

Accident Scenario	*DR*	*ARF*	*RF*	*LPF*	*Release Point*
Explosion	1.0	0.001	0.1	1.0	Ground
Nuclear Criticality [b]	–	–	–	–	–
Fire:					
a. Room	1.0	0.006	0.01	0.1	Ground
b. Loading Dock	0.01	0.006	0.01	0.5	Ground
Spill:					
a. Room	1.0	0.00002	0.5	2.0×10^{-6}	Elevated
b. Glovebox	1.0	0.00002	0.5	2.0×10^{-6}	Elevated
c. Loading Dock	0.25	0.00008	0.5	0.1	Ground
Earthquake	1.0	0.002 [h]	0.3 [h]	0.1	Ground
Aircraft Crash [g]	–	–	–	–	–

Ash Residue Processing at the Savannah River Site F-Canyon

Accident Scenario	*Frequency (per year)*	*Material at Risk (grams)*		
		Purex/Plutonium Metal Recovery Process		*MEO Process*
		Ash (No SS&C)	*SS&C*	*Ash (No SS&C)*
Explosion:				
a. Hydrogen	0.000015	4,000 g	2,000 g	6,000 g
b. Ion Exchange Column	0.0001	120.5 mg [j]	60.25 mg [j]	180.75 mg [j]
Nuclear Criticality [k]	0.0001	1.0×10^{19} fissions	1.0×10^{19} fissions	1.0×10^{19} fissions
Fire	0.00061	4,000 g	2,000 g	6,000 g
Spill	0.01	–	–	178 g
Earthquake:	0.000125			
a. F-Canyon Liquid		12,000 g	6,000 g	18,000 g
b. FB-Line:				
Powder		1,334 g	500 g	1,500 g
Molten Metal		1,333 g	500 g	1,500 g
Liquid		1,333 g	500 g	1,500 g

Accident Scenario	*DR*	*ARF×RF*	*LPF*	*Release Point*
Explosion:				
a. Hydrogen	1.0	0.001	0.005	Elevated
b. Ion Exchange Column	1.0	1.0	1.0	Elevated
Nuclear Criticality [k]	–	–	–	–
Fire	1.0	0.01	0.005	Elevated

Accident Scenario	*DR*	*ARF×RF*	*LPF*	*Release Point*
Spill	1.0	0.00001	0.005	Elevated
Earthquake:				
a. F-Canyon Liquid	1.0	0.000047	0.1	Ground
b. FB-Line:		0.002	0.1	
Powder	1.0	0.0022	0.1	Ground
Molten Metal	1.0	0.000047	0.1	Ground
Liquid	1.0			Ground

Ash Residue Processing at the Savannah River Site H-Canyon

Accident Scenario	*Frequency (per year)*	*Material at Risk (grams)*		
		Purex/Plutonium Oxide Recovery Process		*MEO Process*
		Ash (No SS&C)	*SS&C*	*Ash (No SS&C)*
Explosion:				
a. Hydrogen	0.000015	1,000 g	1,000 g	6,000 g
b. Ion Exchange Column	0.0001	241 mg [j,l]	241 mg [j,l]	241 mg [j]
Nuclear Criticality [k]	0.0001	1.0×10^{19} fissions	1.0×10^{19} fissions	1.0×10^{19} fissions
Fire	0.00061	3,000 g	3,000 g	6,000 g
Spill	0.01	–	–	178 g
Earthquake:	0.000182			
a. H-Canyon Liquid		54,000 g	54,000 g	18,000 g
b. HB-Line Powder		4,000 g [l]	4,000 g [l]	4,000 g
HB-Line Liquid		4,000 g [l]	4,000 g [l]	4,000 g

Accident Scenario	*DR*	*ARF×RF*	*LPF*	*Release Point*
Explosion:				
a. Hydrogen	1.0	0.001	0.005	Elevated
b. Ion Exchange Column	1.0	1.0	1.0	Elevated
Nuclear Criticality [k]	–	–	–	–
Fire	1.0	0.01	0.005	Elevated
Spill	1.0	0.00001	0.005	Elevated
Earthquake:				
a. H-Canyon Liquid	1.0	0.000047	0.1	Ground
b. HB-Line Powder	1.0	0.002	0.1	Ground
HB-Line Liquid	1.0	0.000047	0.1	Ground

MEO = mediated electrochemical oxidation SS&C = sand, slag, and crucible DR = damage ratio
ARF = airborne release fraction RF = respirable fraction

[a] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content. The analysis conservatively assumed the maximum content level and the administrative control level for drums containing ash.

[b] The wet nuclear criticality is not a viable accident scenario for the residue packaging process in Building 707.

[c] 3-day supply of feed and 2-day supply of product.

[d] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content. The analysis conservatively assumed the maximum content level and the administrative control level for drums containing ash.

[e] 5 containers per drum of feed. The analysis conservatively assumed the maximum content level and the administrative control level for drums containing ash.

[f] 1 drum at the maximum plutonium content level. The analysis conservatively assumed the maximum content level for a drum containing ash.

[g] Consequences enveloped by the earthquake.

[h] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000792).

[j] Respirable source term value in milligrams of plutonium released up the stack.

[k] Refer to Table D–28 for criticality source term.

[l] Duty cycle = 12.5%.

Table D–46 Summary of the Ash Residues Accident Analysis Doses Purex/Plutonium Metal Recovery and Mediated Electrochemical Oxidation

	Building Source Term		*MEI (rem)*		*Population (person-rem)*		*Worker (rem)*
Accident Scenario	*(grams)*	*Type*	*95% Met*	*50% Met*	*95% Met*	*50% Met*	*50% Met*
Rocky Flats Preprocessing and Packaging of Ash (No SS&C) Residue for Purex Process at the Savannah River Site							
Explosion	0.4	Oxide	0.48	0.052	10,000	240	8.40
Fire (Room)	0.0737	Oxide	0.0885	0.00958	1,840	44.2	1.55
Fire (Dock)	0.0018	Oxide	0.00216	0.000234	45.0	1.08	0.0378
Spill (Room)	1.20×10^{-8}	Oxide	1.92×10^{-9}	7.20×10^{-10}	10,400	5.40×10^{-6}	1.68×10^{-9}
Spill (Glovebox)	2.56×10^{-9}	Oxide	4.10×10^{-10}	1.54×10^{-10}	0.0000223	1.15×10^{-6}	3.58×10^{-10}
Spill (Dock)	0.003	Oxide	0.0036	0.00039	75.0	1.80	0.063
Earthquake	0.973	Oxide	1.17	0.127	24,300	584	20.4
Rocky Flats Preprocessing and Packaging of SS&C Residue for Purex Process at the Savannah River Site							
Explosion	0.4	Oxide	0.48	0.052	10,000	240	8.40
Fire (Room)	0.0485	Oxide	0.0582	0.0063	1,210	29.1	1.02
Fire (Dock)	0.0018	Oxide	0.00216	0.000234	45.0	1.08	0.0378
Spill (Room)	1.20×10^{-8}	Oxide	1.92×10^{-9}	7.20×10^{-10}	0.000104	5.40×10^{-6}	1.68×10^{-9}
Spill (Glovebox)	1.68×10^{-9}	Oxide	2.69×10^{-10}	1.01×10^{-10}	0.0000147	7.58×10^{-7}	2.36×10^{-10}
Spill (Dock)	0.003	Oxide	0.0036	0.00039	75.0	1.80	0.063
Earthquake	0.64	Oxide	0.768	0.0832	16,000	384	13.4
Rocky Flats Preprocessing and Packaging of Ash (No SS&C) Residue for MEO Process at the Savannah River Site							
Explosion	0.4	Oxide	0.48	0.052	10,000	240	8.40
Fire (Room)	0.103	Oxide	0.123	0.0133	2,560	61.5	2.15
Fire (Dock)	0.0018	Oxide	0.00216	0.000234	45.0	1.08	0.0378
Spill (Room)	1.20×10^{-8}	Oxide	1.92×10^{-9}	7.20×10^{-10}	0.000104	5.40×10^{-6}	1.68×10^{-9}
Spill (Glovebox)	3.56×10^{-9}	Oxide	5.70×10^{-10}	2.14×10^{-10}	0.000031	1.60×10^{-6}	4.98×10^{-10}
Spill (Dock)	0.003	Oxide	0.0036	0.00039	75.0	1.80	0.063
Earthquake	1.35	Oxide	1.62	0.176	33,800	812	28.4

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Purex/Plutonium Metal Recovery Process at the Savannah River Site F-Canyon—Ash (No SS&C) Residue							
Explosion (Hydrogen)	0.02	Metal	0.00068	0.00024	36.0	3.20	0.002
Explosion (Ion Exchange Column)	0.121	Metal-FB	0.00374	0.00133	193	18.1	0.0112
Criticality (Liquid)	[a]	–	0.011	0.0044	310	32.0	0.038
Fire	0.2	Metal	0.0068	0.0024	360	32.0	0.02
Earthquake	0.623	Metal	0.0573	0.0106	2,050	143	13.7
MEO Process at the Savannah River Site F-Canyon—Ash (No SS&C) Residue							
Explosion (Hydrogen)	0.03	Metal	0.00102	0.00036	54.0	4.80	0.003
Explosion (Ion Exchange Column)	0.181	Metal-FB	0.0056	0.00199	289	27.1	0.0168
Criticality	[a]	–	0.011	0.0044	310	32.0	0.038
Fire	0.3	Metal	0.0102	0.0036	540	48.0	0.03
Spill	8.90×10^{-6}	Metal	3.03×10^{-7}	1.07×10^{-7}	0.016	0.00142	8.90×10^{-7}
Earthquake	0.722	Metal	0.0664	0.0123	2,380	166	15.9
Purex/Plutonium Metal Recovery Process at the Savannah River Site F-Canyon—SS&C Residue							
Explosion (Hydrogen)	0.01	Metal	0.00034	0.00012	18.0	1.60	0.001
Explosion (Ion Exchange Column)	0.0603	Metal-FB	0.00187	0.000663	96.4	9.04	0.0056
Criticality (Liquid)	[a]	–	0.011	0.0044	310	32.0	0.038
Fire	0.1	Metal	0.0034	0.0012	180	16.0	0.01
Earthquake	0.241	Metal	0.0221	0.00409	794	55.3	5.29
Purex/Plutonium Oxide Recovery Process at the Savannah River Site H-Canyon—Ash (No SS&C) Residue							
Explosion (Hydrogen)	0.005	Metal	0.00016	0.000048	8.00	0.75	0.0005
Explosion (Ion Exchange Column)	0.241	Metal-HB	0.00699	0.00212	342	34.0	0.0224
Criticality	[a]	–	0.009	0.003	290	29.0	0.038
Fire	0.15	Metal	0.0048	0.00144	240	22.5	0.015
Earthquake	1.07	Metal	0.074	0.015	3,330	215	23.6

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
MEO Process at the Savannah River Site H-Canyon—Ash (No SS&C) Residue							
Explosion (Hydrogen)	0.03	Metal	0.00096	0.000288	48.0	4.50	0.003
Explosion (Ion Exchange Column)	0.241	Metal-HB	0.00699	0.00212	342	34.0	0.0224
Criticality	[a]	–	0.009	0.003	290	29.0	0.038
Fire	0.3	Metal	0.0096	0.00288	480	45.0	0.03
Spill	8.90×10^{-6}	Metal	2.85×10^{-7}	8.54×10^{-8}	0.0142	0.00134	8.90×10^{-7}
Earthquake	0.903	Metal	0.0623	0.0126	2,800	181	19.9
Purex/Plutonium Oxide Recovery Process at the Savannah River Site H-Canyon—SS&C Residue							
Explosion (Hydrogen)	0.005	Metal	0.00016	0.000048	8.00	0.75	0.0005
Explosion (Ion Exchange Column)	0.241	Metal-HB	0.00699	0.00212	342	34.0	0.0224
Criticality	[a]	–	0.009	0.003	290	29.0	0.038
Fire	0.15	Metal	0.0048	0.00144	240	22.5	0.015
Earthquake	1.07	Metal	0.074	0.015	3,330	215	23.6

MEI = maximally exposed individual Met = meteorological data SS&C = sand, slag, and crucible
MEO = mediated electrochemical oxidation
[a] 1.0×10^{19} fissions.

Table D–47 Summary of the Ash Residues Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year—Purex/Plutonium Metal Recovery and Mediated Electrochemical Oxidation

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr) 95% Met	MEI (LCF/yr) 50% Met	Population (LCF/yr) 95% Met	Population (LCF/yr) 50% Met	Worker (LCF/yr) 50% Met
Rocky Flats Preprocessing and Packaging of Ash (No SS&C) Residue for Purex Process at the Savannah River Site						
Explosion	0.00005	1.20×10^{-8}	1.30×10^{-9}	0.00025	6.00×10^{-6}	1.68×10^{-7}
Fire (Room)	0.0005	2.21×10^{-8}	2.40×10^{-9}	0.000461	0.0000111	3.10×10^{-7}
Fire (Dock)	2.00×10^{-6}	2.16×10^{-12}	2.34×10^{-13}	4.50×10^{-8}	1.08×10^{-9}	3.02×10^{-11}
Spill (Room)	0.008	7.68×10^{-15}	2.88×10^{-15}	4.18×10^{-10}	2.16×10^{-11}	5.38×10^{-15}
Spill (Glovebox)	0.8	1.64×10^{-13}	6.14×10^{-14}	8.91×10^{-9}	4.61×10^{-10}	1.15×10^{-13}
Spill (Dock)	0.001	1.80×10^{-9}	1.95×10^{-10}	0.0000375	9.00×10^{-7}	2.52×10^{-8}
Earthquake	0.0018	1.05×10^{-6}	1.14×10^{-7}	0.0219	0.000526	0.0000294

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr)		Population (LCF/yr)		Worker (LCF/yr)
		95% Met	50% Met	95% Met	50% Met	50% Met
Rocky Flats Preprocessing and Packaging of SS&C Residue for Purex Process at the Savannah River Site						
Explosion	0.00005	1.20×10^{-8}	1.30×10^{-9}	0.00025	6.00×10^{-6}	1.68×10^{-7}
Fire (Room)	0.0005	1.45×10^{-8}	1.58×10^{-9}	0.000303	7.27×10^{-6}	2.04×10^{-7}
Fire (Dock)	2.00×10^{-6}	2.16×10^{-12}	2.34×10^{-13}	4.50×10^{-8}	1.08×10^{-9}	3.02×10^{-11}
Spill (Room)	0.008	7.68×10^{-15}	2.88×10^{-15}	4.18×10^{-10}	2.16×10^{-11}	5.38×10^{-15}
Spill (Glovebox)	0.8	1.08×10^{-13}	4.04×10^{-14}	5.86×10^{-9}	3.03×10^{-10}	7.54×10^{-14}
Spill (Dock)	0.001	1.80×10^{-9}	1.95×10^{-10}	0.0000375	9.00×10^{-7}	2.52×10^{-8}
Earthquake	0.0018	6.91×10^{-7}	7.49×10^{-8}	0.0144	0.000346	9.68×10^{-6}
Rocky Flats Preprocessing and Packaging of Ash (No SS&C) Residue for MEO Process at the Savannah River Site						
Explosion	0.00005	1.20×10^{-8}	1.30×10^{-9}	0.00025	6.00×10^{-6}	1.68×10^{-7}
Fire (Room)	0.0005	3.08×10^{-8}	3.33×10^{-9}	0.000641	0.0000154	4.31×10^{-7}
Fire (Dock)	2.00×10^{-6}	2.16×10^{-12}	2.34×10^{-13}	4.50×10^{-8}	1.08×10^{-9}	3.02×10^{-11}
Spill (Room)	0.008	7.68×10^{-15}	2.88×10^{-15}	4.18×10^{-10}	2.16×10^{-11}	5.38×10^{-15}
Spill (Glovebox)	0.8	2.28×10^{-13}	8.54×10^{-14}	1.24×10^{-8}	6.41×10^{-10}	1.59×10^{-13}
Spill (Dock)	0.001	1.80×10^{-9}	1.95×10^{-10}	0.0000375	9.00×10^{-7}	2.52×10^{-8}
Earthquake	0.0018	1.46×10^{-6}	1.58×10^{-7}	0.0305	0.000731	0.0000409
Purex/Plutonium Metal Recovery Process at the Savannah River Site F-Canyon—Ash (No SS&C) Residue						
Explosion (Hydrogen)	0.000015	5.10×10^{-12}	1.80×10^{-12}	2.70×10^{-7}	2.40×10^{-8}	1.20×10^{-11}
Explosion (Ion Exchange Column)	0.0001	1.87×10^{-10}	6.63×10^{-11}	9.64×10^{-6}	9.04×10^{-7}	4.48×10^{-10}
Criticality (Liquid)	0.0001	5.50×10^{-10}	2.20×10^{-10}	0.0000155	1.60×10^{-6}	1.52×10^{-9}
Fire	0.00061	2.07×10^{-9}	7.32×10^{-10}	0.00011	9.76×10^{-6}	4.88×10^{-9}
Earthquake	0.000125	3.58×10^{-9}	6.62×10^{-10}	0.000128	8.95×10^{-6}	6.85×10^{-7}
MEO Process at the Savannah River Site F-Canyon—Ash (No SS&C) Residue						
Explosion (Hydrogen)	0.000015	7.65×10^{-12}	2.70×10^{-12}	4.05×10^{-7}	3.60×10^{-8}	1.80×10^{-11}
Explosion (Ion Exchange Column)	0.0001	2.80×10^{-10}	9.94×10^{-11}	0.0000145	1.36×10^{-6}	6.72×10^{-10}
Criticality (Liquid)	0.0001	5.50×10^{-10}	2.20×10^{-10}	0.0000155	1.60×10^{-6}	1.52×10^{-9}
Fire	0.00061	3.11×10^{-9}	1.10×10^{-9}	0.000165	0.0000146	7.32×10^{-9}
Spill	0.01	1.51×10^{-12}	5.34×10^{-13}	8.01×10^{-8}	7.12×10^{-9}	3.56×10^{-12}
Earthquake	0.000125	4.15×10^{-9}	7.67×10^{-10}	0.000149	0.0000104	7.94×10^{-7}

Accident Scenario	*Accident Frequency (per year)*	*MEI (LCF/yr)*		*Population (LCF/yr)*		*Worker (LCF/yr)*
		95% Met	*50% Met*	*95% Met*	*50% Met*	*50% Met*
Purex/Plutonium Metal Recovery Process at the Savannah River Site F-Canyon—SS&C Residue						
Explosion (Hydrogen)	0.000015	2.55×10^{-12}	9.00×10^{-13}	1.35×10^{-7}	1.20×10^{-8}	6.00×10^{-12}
Explosion (Ion Exchange Column)	0.0001	9.34×10^{-11}	3.31×10^{-11}	4.82×10^{-6}	4.52×10^{-7}	2.24×10^{-10}
Criticality (Liquid)	0.0001	5.50×10^{-10}	2.20×10^{-10}	0.0000155	1.60×10^{-6}	1.52×10^{-9}
Fire	0.00061	1.04×10^{-9}	3.66×10^{-10}	0.0000549	4.88×10^{-6}	2.44×10^{-9}
Earthquake	0.000125	1.38×10^{-9}	2.56×10^{-10}	0.0000496	3.46×10^{-6}	2.65×10^{-7}
Purex/Plutonium Oxide Recovery Process at the Savannah River Site H-Canyon—Ash (No SS&C) Residue						
Explosion (Hydrogen)	0.000015	1.20×10^{-12}	3.60×10^{-13}	6.00×10^{-8}	5.63×10^{-9}	3.00×10^{-12}
Explosion (Ion Exchange Column)	0.0001	4.37×10^{-11}	1.33×10^{-11}	2.14×10^{-6}	2.12×10^{-7}	1.12×10^{-10}
Criticality	0.0001	4.50×10^{-10}	1.50×10^{-10}	0.0000145	1.45×10^{-6}	1.52×10^{-9}
Fire	0.00061	1.46×10^{-9}	4.39×10^{-10}	0.0000732	6.86×10^{-6}	3.66×10^{-9}
Earthquake	0.000182	2.24×10^{-9}	4.54×10^{-10}	0.0001	6.48×10^{-6}	1.14×10^{-6}
MEO Process at the Savannah River Site H-Canyon—Ash (No SS&C) Residue						
Explosion (Hydrogen)	0.000015	7.20×10^{-12}	2.16×10^{-12}	3.60×10^{-7}	3.38×10^{-8}	1.80×10^{-11}
Explosion (Ion Exchange)	0.0001	3.49×10^{-10}	1.06×10^{-10}	0.0000171	1.70×10^{-6}	8.97×10^{-10}
Criticality	0.0001	4.50×10^{-10}	1.50×10^{-10}	0.0000145	1.45×10^{-6}	1.52×10^{-9}
Fire	0.00061	2.93×10^{-9}	8.78×10^{-10}	0.000146	0.0000137	7.32×10^{-9}
Spill	0.01	1.42×10^{-12}	4.27×10^{-13}	7.12×10^{-8}	6.68×10^{-9}	3.56×10^{-12}
Earthquake	0.000182	5.67×10^{-9}	1.15×10^{-10}	0.000255	0.0000164	1.45×10^{-6}
Purex/Plutonium Oxide Recovery Process at the Savannah River Site H-Canyon—SS&C Residue						
Explosion (Hydrogen)	0.000015	1.20×10^{-12}	3.60×10^{-13}	6.00×10^{-8}	5.63×10^{-9}	3.00×10^{-12}
Explosion (Ion Exchange Column)	0.0001	4.37×10^{-11}	1.33×10^{-11}	2.14×10^{-6}	2.12×10^{-7}	1.12×10^{-10}
Criticality	0.0001	4.50×10^{-10}	1.50×10^{-10}	0.0000145	1.45×10^{-6}	1.52×10^{-9}
Fire	0.00061	1.46×10^{-9}	4.39×10^{-10}	0.0000732	6.86×10^{-6}	3.66×10^{-9}
Earthquake	0.000182	2.24×10^{-9}	4.54×10^{-10}	0.0001	6.48×10^{-6}	1.14×10^{-6}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data SS&C = sand, slag, and crucible
MEO = mediated electrochemical oxidation

D.3.4.2 Pyrochemical Salt Residues

D.3.4.2.1 No Action

The processing technology considered for this alternative is pyro-oxidizing of the pyrochemical salt residues. The pyro-oxidizing process will be performed at Rocky Flats in Building 707, Module A.

Table D–48 provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of pyro-oxidizing the pyrochemical salt residue at Rocky Flats. **Table D–49** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with the processing of pyrochemical salt residues. The risks associated with this processing technology are summarized in **Table D–50**.

Table D–48 Pyrochemical Salt Residues Accident Scenarios Parameters

Accident Scenario	*Frequency (per year)*	*Pyrochemical Salt Residues*	*HEPA Banks*	*Material at Risk (grams)*	*DR*	*ARF*	*RF*	*LPF*	*Release Point*
Explosion	0.00005	2 drums [a]	0	4,000 g	1.0	0.001	0.001	1.0	Ground
Nuclear Criticality [b]	–	–	–	–	–	–	–	–	–
Fire:									
a. Room	0.0005	5-day supply [c]	2	13,200 g	1.0	0.006	0.01	0.1	Ground
b. Loading Dock	2.0×10^{-6}	4 drums [d]	0	6,000 g	0.01	0.006	0.01	0.5	Ground
Spill:									
a. Room	0.008	1 container at the limit [e]	2	600 g	1.0	0.00002	0.001	2.0×10^{-6}	Elevated
b. Glovebox	0.8	1 feed prep container	2	165 g	1.0	0.00002	0.001	2.0×10^{-6}	Elevated
c. Loading Dock	0.001	1 drum [f]	0	3,000 g	0.25	0.00008	0.001	0.1	Ground
Earthquake	0.0018	5-day supply [c]	0	13,200 g	1.0	0.002 [g]	0.3 [g]	0.1	Ground
Aircraft Crash	0.00003	Consequences enveloped by the earthquake.	–	–	–	–	–	–	–

DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] 1 drum at the maximum plutonium content level (3,000 grams) and 1 drum at the administrative control level (1,000 grams) for plutonium content.

[b] The wet nuclear criticality is not a viable accident scenario for the pyro-oxidizing technology assessment.

[c] 3-day supply of feed and 2-day supply of product.

[d] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.

[e] 5 containers per drum of feed.

[f] 1 drum at the maximum plutonium content level.

[g] Add 0.000192 to ARF×RF value for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000792).

Table D–49 Summary of the Pyrochemical Salt Residues Accident Analysis Doses

	Building Source Term		*MEI (rem)*		*Population (person-rem)*		*Worker (rem)*
Accident Scenario	*(grams)*	*Type*	*95% Met*	*50% Met*	*95% Met*	*50% Met*	*50% Met*
Explosion	0.004	Salt-M	0.064	0.0068	1,120	26.8	0.72
Fire (Room)	0.0792	Salt-M	1.27	0.135	22,200	531	14.3
Fire (Dock)	0.0018	Salt-M	0.0288	0.00306	504	12.1	0.324
Spill (Room)	2.40×10^{-11}	Salt-M	5.04×10^{-11}	1.90×10^{-11}	2.30×10^{-6}	1.18×10^{-7}	2.88×10^{-11}
Spill (Glovebox)	6.60×10^{-12}	Salt-M	1.39×10^{-11}	5.21×10^{-12}	6.34×10^{-7}	3.23×10^{-8}	7.92×10^{-12}
Spill (Dock)	6.00×10^{-6}	Salt-M	0.000096	0.0000102	1.68	0.0402	0.00108
Earthquake	1.05	Salt-M	16.7	1.78	293,000	7,000	188

Salt-M = metal salt

Table D–50 Summary of the Pyrochemical Salt Residues Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr)		Population (LCF/yr)		Worker (LCF/yr)
		95% Met	50% Met	95% Met	50% Met	50% Met
Explosion	0.00005	1.60×10^{-9}	1.70×10^{-10}	0.000028	6.70×10^{-7}	1.44×10^{-8}
Fire (Room)	0.0005	3.17×10^{-7}	3.37×10^{-8}	0.00554	0.000133	2.85×10^{-6}
Fire (Dock)	2.0×10^{-6}	2.88×10^{-11}	3.06×10^{-12}	5.04×10^{-7}	1.21×10^{-8}	2.59×10^{-10}
Spill (Room)	0.008	2.02×10^{-16}	7.58×10^{-17}	9.22×10^{-12}	4.70×10^{-13}	9.22×10^{-17}
Spill (Glovebox)	0.8	5.54×10^{-15}	2.09×10^{-15}	2.53×10^{-10}	1.29×10^{-11}	2.53×10^{-15}
Spill (Dock)	0.001	4.80×10^{-11}	5.10×10^{-12}	8.40×10^{-7}	2.01×10^{-8}	4.32×10^{-10}
Earthquake	0.0018	0.0000151	1.60×10^{-6}	0.263	0.0063	0.000271

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.2.2 Processing and Storage without Plutonium Separation

The pyrochemical salt residues processing technology considered for this alternative is blend down. The blend down process will be performed at Rocky Flats in Building 707, Modules A, D, and E. Building 371 is under consideration as an alternate location for the blend down process. The accident analysis evaluates both the primary and alternate locations for the blend down process. **Table D–51** provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of the pyrochemical salt processing technology at Rocky Flats. **Table D–52** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with the processing of pyrochemical salt residues. The risks associated with this processing technology are summarized in **Table D–53**.

Table D–51 Pyrochemical Salt Residues Accident Scenarios Parameters

Accident Scenario	Frequency (per year)	Pyrochemical Salt Residues	HEPA Banks	Material at Risk (grams)
Explosion	0.00005	2 drums [a]	0/2 [b]	4,000 g
Nuclear Criticality [c]	–	–	–	–
Fire:				
a. Room	0.0005	5-day supply [d]	2	1,650g
b. Loading Dock	2.0×10^{-6}	4 drums [e]	0	6,000 g
Spill:				
a. Room	0.008	1 container at the limit [f]	2	600 g
b. Glovebox	0.8	1 feed prep container	2	165 g
c. Loading Dock	0.001	1 drum [g]	0	3,000 g
Earthquake:				
a. Building 707	0.0018	5-day supply [d]	0	1,650 g
b. Building 371	0.000094	5-day supply [d]		1,650 g
Aircraft Crash:				
a. Building 707	0.00003	Consequences enveloped by the earthquake.	–	–
b. Building 371	0.00004	The aircraft will not penetrate the building walls.	–	–

Accident Scenario	DR	ARF	RF	LPF	Release Point
Explosion:					
a. Building 707	1.0	0.001	0.001	1.0	Ground
b. Building 371	1.0	0.001	0.001	2.0×10^{-6}	Elevated
Nuclear Criticality [c]	–	–	–	–	–
Fire:					
a. Room	1.0	0.006	0.01	0.1	Ground
b. Loading Dock	0.01	0.006	0.01	0.5	Ground
Spill:					
a. Room	1.0	0.00002	0.001	2.0×10^{-6}	Elevated
b. Glovebox	1.0	0.00002	0.001	2.0×10^{-6}	Elevated
c. Loading Dock	0.25	0.00008	0.001	0.1	Ground
Earthquake	1.0	0.002 [h]	0.3 [h]	0.1	Ground
Aircraft Crash:					
a. Building 707 [j]	–	–	–	–	–
b. Building 371 [k]	–	–	–	–	–

DR= damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content.

[b] Building 371, 2 HEPA Banks; Building 707, 0 HEPA Banks.

[c] The wet nuclear criticality is not a viable accident scenario for the blend down technology assessment.

[d] 3-day supply of feed and 2-day supply of product.

[e] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.

[f] 5 containers per drum of feed.

[g] 1 drum at the maximum plutonium content level.

[h] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000792).

[j] The aircraft will not penetrate the building walls.

[k] Consequences enveloped by the earthquake.

Table D–52 Summary of the Pyrochemical Salt Residues Accident Analysis Doses

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Building 707							
Explosion	0.004	Salt-M	0.064	0.0068	1,120	26.8	0.72
Fire (Room)	0.0099	Salt-M	0.158	0.0168	2,770	66.3	1.78
Fire (Dock)	0.0018	Salt-M	0.0288	0.00306	504	12.1	0.324
Spill (Room)	2.40×10^{-11}	Salt-M	5.04×10^{-11}	1.90×10^{-11}	2.30×10^{-6}	1.18×10^{-7}	2.88×10^{-11}
Spill (Glovebox)	6.60×10^{-12}	Salt-M	1.39×10^{-11}	5.21×10^{-12}	6.34×10^{-7}	3.23×10^{-8}	7.92×10^{-12}
Spill (Dock)	6.00×10^{-6}	Salt-M	0.000096	0.0000102	1.68	0.0402	0.00108
Earthquake	0.131	Salt-M	2.09	0.222	36,600	876	23.5
Building 371							
Explosion	8.00×10^{-9}	Salt-M	1.52×10^{-7}	1.76×10^{-8}	0.00216	0.0000512	1.28×10^{-7}
Fire (Room)	0.00990	Salt-M	0.238	0.0238	2,770	66.3	1.78
Fire (Dock)	0.00180	Salt-M	0.0432	0.00432	504	12.1	0.324
Spill (Room)	2.40×10^{-11}	Salt-M	4.56×10^{-10}	5.28×10^{-11}	6.48×10^{-6}	1.54×10^{-7}	3.84×10^{-10}
Spill (Glovebox)	6.60×10^{-12}	Salt-M	1.25×10^{-10}	1.45×10^{-11}	1.78×10^{-6}	4.22×10^{-8}	1.06×10^{-10}

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Spill (Dock)	6.00×10^{-6}	Salt-M	0.000144	0.0000144	1.68	0.0402	0.00108
Earthquake	0.131	Salt-M	3.14	0.314	36,600	876	23.5

MEI = maximally exposed individual Met = meteorological data Salt-M = metal salt

Table D–53 Summary of the Pyrochemical Salt Residues Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr) 95% Met	MEI (LCF/yr) 50% Met	Population (LCF/yr) 95% Met	Population (LCF/yr) 50% Met	Worker (LCF/yr) 50% Met
Building 707						
Explosion	0.00005	1.60×10^{-9}	1.70×10^{-10}	0.000028	6.70×10^{-7}	1.44×10^{-8}
Fire (Room)	0.0005	3.96×10^{-8}	4.21×10^{-9}	0.000693	0.0000166	3.56×10^{-7}
Fire (Dock)	2.0×10^{-6}	2.88×10^{-11}	3.06×10^{-12}	5.04×10^{-7}	1.21×10^{-8}	2.59×10^{-10}
Spill (Room)	0.008	2.02×10^{-16}	7.58×10^{-17}	9.22×10^{-12}	4.70×10^{-13}	9.22×10^{-17}
Spill (Glovebox)	0.8	5.54×10^{-15}	2.09×10^{-15}	2.53×10^{-10}	1.29×10^{-11}	2.53×10^{-15}
Spill (Dock)	0.001	4.80×10^{-11}	5.10×10^{-12}	8.40×10^{-7}	2.01×10^{-8}	4.32×10^{-10}
Earthquake	0.0018	1.88×10^{-6}	2.00×10^{-7}	0.0329	0.000788	0.0000339
Building 371						
Explosion	0.00005	3.80×10^{-15}	4.40×10^{-16}	5.40×10^{-11}	1.28×10^{-12}	2.56×10^{-15}
Fire (Room)	0.0005	5.94×10^{-8}	5.94×10^{-9}	0.000693	0.0000166	3.56×10^{-7}
Fire (Dock)	2.0×10^{-6}	4.32×10^{-11}	4.32×10^{-12}	5.04×10^{-7}	1.21×10^{-8}	2.59×10^{-10}
Spill (Room)	0.008	1.82×10^{-15}	2.11×10^{-16}	2.59×10^{-11}	6.14×10^{-13}	1.23×10^{-15}
Spill (Glovebox)	0.8	5.02×10^{-14}	5.81×10^{-15}	7.13×10^{-10}	1.69×10^{-11}	3.38×10^{-14}
Spill (Dock)	0.001	7.20×10^{-11}	7.20×10^{-12}	8.40×10^{-7}	2.01×10^{-8}	4.32×10^{-10}
Earthquake	0.000094	1.47×10^{-7}	1.47×10^{-8}	0.00172	0.0000412	1.77×10^{-6}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.2.3 Processing and Storage with Plutonium Separation

The pyrochemical salt residues processing technologies considered for this alternative are salt distillation, water leach, and salt scrub.

- **Salt Distillation Technology**—The salt distillation technology is only used to treat sodium chloride/potassium chloride salts. Processing of pyrochemical salt residues with the salt distillation process may be performed at either Rocky Flats or Los Alamos National Laboratory. At Rocky Flats, the process will be performed in Building 707, Modules A and B. For processing at Los Alamos National Laboratory, the preprocessing and packaging of the residues at Rocky Flats will be performed in Building 707, Module A. The salt distillation process will be performed in Los Alamos National Laboratory Technical Area 55.

  Similar accidents are applicable to all the technologies at all of the sites. **Table D–54** provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of pyrochemical salt processing with the salt distillation technology at Rocky Flats. **Table D–55** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental

releases associated with the processing of pyrochemical salt residues at Rocky Flats. The risks associated with this processing technology at Rocky Flats are summarized in **Table D–56**.

Table D–54 Pyrochemical Salt Residues Accident Scenarios Parameters Salt Distillation Process at Rocky Flats

Accident Scenario	*Frequency (per year)*	*Pyrochemical Salt Residues*	*HEPA Banks*	*Material at Risk (grams)*
Explosion	0.00005	2 drums [a]	0	4,000 g
Nuclear Criticality [b]	–	–	–	–
Fire:				
a. Room	0.0005	5-day supply [c]	2	7,014 g
b. Loading Dock	2.0×10^{-6}	4 drums [d]	0	6,000 g
Spill:				
a. Room	0.008	1 container at the maximum limit [e]	2	600 g
b. Glovebox	0.8	1 feed prep container	2	222 g
c. Loading Dock	0.001	1 drum [f]	0	3,000 g
Earthquake	0.0018	5-day supply [c]	0	7,014 g
Aircraft Crash	0.00003	Consequences enveloped by the earthquake.	–	–

Accident Scenario	*DR*	*ARF*	*RF*	*LPF*	*Release Point*
Explosion	1.0	0.001	0.001	1.0	Ground
Nuclear Criticality [b]	–	–	–	–	–
Fire:					
a. Room	1.0	0.006	0.01	0.1	Ground
b. Loading Dock	0.01	0.006	0.01	0.5	Ground
Spill:					
a. Room	1.0	0.00002	0.001	2.0×10^{-6}	Elevated
b. Glovebox	1.0	0.00002	0.001	2.0×10^{-6}	Elevated
c. Loading Dock	0.25	0.00008	0.001	0.1	Ground
Earthquake	1.0	0.002 [g]	0.3 [g]	0.1	Ground
Aircraft Crash [h]	–	–	–	–	–

DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content.

[b] The wet nuclear criticality is not a viable accident scenario for the Salt Distillation process in Building 707.

[c] 3-day supply of feed and 2-day supply of product.

[d] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.

[e] 5 containers per drum of feed.

[f] 1 drum at the maximum plutonium content level.

[g] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000792).

[h] Consequences enveloped by the earthquake.

Table D–55 Summary of the Pyrochemical Salt Residues Accident Analysis Doses Salt Distillation Process at Rocky Flats

	Building Source Term		*MEI (rem)*		*Population (person-rem)*		*Worker (rem)*
Accident Scenario	*(grams)*	*Type*	*95% Met*	*50% Met*	*95% Met*	*50% Met*	*50% Met*
Explosion	0.004	Salt-M	0.064	0.0068	1,120	26.8	0.72
Fire (Room)	0.0426	Salt-M	0.682	0.0725	11,900	286	7.67
Fire (Dock)	0.0018	Salt-M	0.0288	0.00306	504	12.1	0.324
Spill (Room)	2.40×10^{-11}	Salt-M	5.04×10^{-11}	1.90×10^{-11}	2.30×10^{-6}	1.18×10^{-7}	2.88×10^{-11}

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Spill (Glovebox)	8.88×10^{-12}	Salt-M	1.86×10^{-11}	7.02×10^{-12}	8.52×10^{-7}	4.35×10^{-8}	1.07×10^{-11}
Spill (Dock)	6.00×10^{-6}	Salt-M	0.000096	0.0000102	1.68	0.0402	0.00108
Earthquake	0.563	Salt-M	9.00	0.956	158,000	3,770	101

MEI = maximally exposed individual Met = meteorological data Salt-M = metal salt

Table D–56 Summary of the Pyrochemical Salt Residues Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year—Salt Distillation Process at Rocky Flats

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr) 95% Met	MEI (LCF/yr) 50% Met	Population (LCF/yr) 95% Met	Population (LCF/yr) 50% Met	Worker (LCF/yr) 50% Met
Explosion	0.00005	1.60×10^{-9}	1.70×10^{-10}	0.000028	6.70×10^{-7}	1.44×10^{-8}
Fire (Room)	0.0005	1.70×10^{-7}	1.81×10^{-8}	0.00298	0.0000714	1.53×10^{-6}
Fire (Dock)	2.00×10^{-6}	2.88×10^{-11}	3.06×10^{-12}	5.04×10^{-7}	1.21×10^{-8}	2.59×10^{-10}
Spill (Room)	0.008	2.02×10^{-16}	7.58×10^{-17}	9.22×10^{-12}	4.70×10^{-13}	9.22×10^{-17}
Spill (Glovebox)	0.8	7.46×10^{-15}	2.81×10^{-15}	3.41×10^{-10}	1.74×10^{-11}	3.41×10^{-15}
Spill (Dock)	0.001	4.80×10^{-11}	5.10×10^{-12}	8.40×10^{-7}	2.01×10^{-8}	4.32×10^{-10}
Earthquake	0.0018	8.10×10^{-6}	8.61×10^{-7}	0.142	0.00339	0.000146

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

Table D–57 provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of preprocessing and packaging the pyrochemical salt residue at Rocky Flats and processing the residue using the salt distillation technology at Los Alamos National Laboratory. **Table D–58** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with the preprocessing and packaging of the residues at Rocky Flats and the processing of pyrochemical salt residues at Los Alamos National Laboratory. The risks associated with the preprocessing and packaging at Rocky Flats and processing using the salt distillation technology at Los Alamos National Laboratory are summarized in **Table D–58**.

Table D–57 Pyrochemical Salt Residues Accident Scenarios Parameters Salt Distillation Process at Los Alamos National Laboratory

Rocky Flats Preprocessing and Packaging of Electrorefining and Molten Salt Extraction Residue for Shipment to Los Alamos National Laboratory				
Accident Scenario	Frequency (per year)	Pyrochemical Salt Residues	HEPA Banks	Material at Risk (grams)
Explosion	0.00005	2 drums [a]	0	4,000 g
Nuclear Criticality [b]	–	–	–	–
Fire:				
a. Room	0.0005	5-day supply [c]	2	7,104 g
b. Loading Dock	2.0×10^{-6}	4 drums [d]	0	6,000 g

Accident Scenario	*Frequency (per year)*	*Pyrochemical Salt Residues*	*HEPA Banks*	*Material at Risk (grams)*
Spill:				
a. Room	0.008	1 container at the maximum limit [e]	2	600 g
b. Glovebox	0.8	1 feed prep container	2	222 g
c. Loading Dock	0.001	1 drum [f]	0	3,000 g
Earthquake	0.0018	5-day supply [c]	0	7,104 g
Aircraft Crash	0.00003	Consequences enveloped by the earthquake.	–	–

Accident Scenario	*DR*	*ARF*	*RF*	*LPF*	*Release Point*
Explosion	1.0	0.001	0.001	1.0	Ground
Nuclear Criticality [b]	–	–	–	–	–
Fire:					
a. Room	1.0	0.006	0.01	0.1	Ground
b. Loading Dock	0.01	0.006	0.01	0.5	Ground
Spill:					
a. Room	1.0	0.00002	0.001	2.0×10^{-6}	Elevated
b. Glovebox	1.0	0.00002	0.001	2.0×10^{-6}	Elevated
c. Loading Dock	0.25	0.00008	0.001	0.1	Ground
Earthquake	1.0	0.002 [g]	0.3 [g]	0.1	Ground
Aircraft Crash [h]	–	–	–	–	–

Salt Distillation Processing at Los Alamos National Laboratory

Accident Scenario	*Frequency (per year)*	*Material at Risk (grams)*
Explosion [j]	–	–
Nuclear Criticality [k]	–	–
Fire	0.0005	4,500 g
Spill	0.003	222 g
Earthquake	0.0005	4,500 g
Aircraft Crash [l]	–	–

Accident Scenario	*DR*	*ARF×RF*	*LPF*	*Release Point*
Fire	1.0	0.00006	0.011	Ground
Spill	1.0	0.00001	4.00×10^{-9}	Elevated
Earthquake	1.0	0.000792	0.1	Ground

DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content.

[b] The wet nuclear criticality is not a viable accident scenario for the residue preprocessing and packaging process in Building 707.

[c] 3-day supply of feed and 2-day supply of product.

[d] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.

[e] 5 containers per drum of feed.

[f] 1 drum at the maximum plutonium content level.

[g] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000792).

[h] Consequences enveloped by the earthquake.

[j] Neither of the explosions postulated in the Technical Area 55 Safety Analysis Report (LANL 1996) would breach the integrity of the gloveboxes proposed for the processing of the Rocky Flats residues.

[k] The wet nuclear criticality is not a viable accident scenario for the salt distillation process in Building PF-4.

[l] The Technical Area 55 Safety Analysis Report (LANL 1996) stated that an aircraft crash into Technical Area 55 is not a credible event.

Table D–58 Summary of the Accident Analysis Doses Salt Distillation Process at Los Alamos National Laboratory

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Rocky Flats Preprocessing and Packaging of Electrorefining and Molten Salt Extraction Salt Residue for Shipment to Los Alamos National Laboratory							
Explosion	0.004	Salt-M	0.064	0.0068	1,120	26.8	0.72
Fire (Room)	0.0426	Salt-M	0.682	0.0725	11,900	286	7.67
Fire (Dock)	0.0018	Salt-M	0.0288	0.00306	504	12.1	0.324
Spill (Room)	2.40×10^{-11}	Salt-M	5.04×10^{-11}	1.90×10^{-11}	2.30×10^{-6}	1.18×10^{-7}	2.88×10^{-11}
Spill (Glovebox)	8.88×10^{-12}	Salt-M	1.86×10^{-11}	7.02×10^{-12}	8.52×10^{-7}	4.35×10^{-8}	1.07×10^{-11}
Spill (Dock)	6.00×10^{-6}	Salt-M	0.000096	0.0000102	1.68	0.0402	0.00108
Earthquake	0.563	Salt-M	9.00	0.956	158,000	3,770	101
Salt Distillation Processing of Electrorefining and Molten Salt Extraction Salt Residue at Los Alamos National Laboratory							
Fire	0.00297	Salt-O	0.113	0.0146	149	15.1	1.22
Spill	8.88×10^{-12}	Salt-O	2.75×10^{-10}	4.08×10^{-11}	3.20×10^{-7}	4.62×10^{-8}	2.49×10^{-11}
Earthquake	0.356	Salt-O	13.5	1.75	17,800	1,820	146

MEI = maximally exposed individual Met = meteorological data Salt-M = metal salt Salt-O = oxide salt

Table D–59 Summary of the Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year Salt Distillation Process at Los Alamos National Laboratory

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr) 95% Met	MEI (LCF/yr) 50% Met	Population (LCF/yr) 95% Met	Population (LCF/yr) 50% Met	Worker (LCF/yr) 50% Met
Rocky Flats Preprocessing and Packaging of Electrorefining and Molten Salt Extraction Salt Residues for Shipment to Los Alamos National Laboratory						
Explosion	0.00005	1.60×10^{-9}	1.70×10^{-10}	0.000028	6.70×10^{-7}	1.44×10^{-8}
Fire (Room)	0.0005	1.70×10^{-7}	1.81×10^{-8}	0.00298	0.0000714	1.53×10^{-6}
Fire (Dock)	2.00×10^{-6}	2.88×10^{-11}	3.06×10^{-12}	5.04×10^{-7}	1.21×10^{-8}	2.59×10^{-10}
Spill (Room)	0.008	2.02×10^{-16}	7.58×10^{-17}	9.22×10^{-12}	4.70×10^{-13}	9.22×10^{-17}
Spill (Glovebox)	0.8	7.46×10^{-15}	2.81×10^{-15}	3.41×10^{-10}	1.74×10^{-11}	3.41×10^{-15}
Spill (Dock)	0.001	4.80×10^{-11}	5.10×10^{-12}	8.40×10^{-7}	2.01×10^{-8}	4.32×10^{-10}
Earthquake	0.0018	8.10×10^{-6}	8.61×10^{-7}	0.142	0.00339	0.000146
Salt Distillation Processing of Electrorefining and Molten Salt Extraction Salt Residues at Los Alamos National Laboratory						
Fire	0.0005	2.82×10^{-8}	3.64×10^{-9}	0.0000371	3.79×10^{-6}	2.44×10^{-7}
Spill	0.003	4.13×10^{-16}	6.13×10^{-17}	4.80×10^{-13}	6.93×10^{-14}	2.98×10^{-17}
Earthquake	0.0005	3.39×10^{-6}	4.37×10^{-7}	0.00446	0.000454	0.0000584

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

- **Water Leach Technology**—The water leach technology can be used to process all salt residues: direct oxide reduction salts, electrorefining salts, and molten salt extraction salts. At Rocky Flats, this process will be performed on all salts in Building 371, Room 3701. The final calcination in the process will be

performed in Building 707A, Module J. The water technology also may be used at Los Alamos National Laboratory for the processing of direct oxide reduction salt residues. For processing at Los Alamos National Laboratory, the preprocessing and packaging of the residues at Rocky Flats will be performed in Building 707, Module A. The water leach process will be performed in Los Alamos National Laboratory Technical Area 55, Building PF-4, Room 420.

Table D–60 provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of pyrochemical salt processing with the water leach technology at Rocky Flats. **Table D–61** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with the processing of pyrochemical salt residues. The risks associated with this processing technology are summarized in **Table D–62**.

Table D–60 Pyrochemical Salt Residues Accident Scenarios Parameters Water Leach Process at Rocky Flats

Accident Scenario	*Frequency (per year)*	*Pyrochemical Salt Residues*	*HEPA Banks*	*Material at Risk (grams)*		
				Process DOR Salt Residue	*Process ER and MSE Salt Residues*	*Final Calcination*
				Building 371	*Building 371*	*Building 707A* [a]
Explosion	0.00005	2 drums	2/0 [b]	4,000 g [c]	4,000 g	2,000 g
Nuclear Criticality	0.0001	Solution	2	1.0×10^{19} fissions	1.0×10^{19} fissions	N/A [d]
Fire:						
a. Room	0.0005	5-day supply [e]	2	8,148 g	8,148 g	11,000 g
b. Loading Dock	2.0×10^{-6}	4 drums	0	6,000 g [f]	6,000 g	4,000 g
Spill:						
a. Room	0.008	1 container at the maximum limit	2	600 g [g]	600 g [g]	1,000 g
b. Glovebox	0.8	1 feed prep container	2	200 g	200 g	1,000 g
c. Loading Dock	0.001	1 drum	0	3,000 g [h]	3,000 g	1,000 g
Earthquake:						
a. Building 371	0.000094	5-day supply [e]	0	8,148 g	8,148 g	N/A
b. Building 707A	0.0008	5-day supply [e]	0	N/A	N/A	11,000 g
Aircraft Crash:						
a. Building 371	0.00004	The aircraft will not penetrate the building wall.	–	–	–	N/A
b. Building 707A	0.00001	Consequences enveloped by the earthquake.	–	N/A	N/A	–

Accident Scenario	*DR*	*ARF*	*RF*	*LPF*	*Release Point*
Explosion:					
a. Building 707A	1.0	0.001	0.001	1.0	Ground
b. Building 371	1.0	0.001	0.001	2.0×10^{-6}	Elevated
Nuclear Criticality [d,j]	–	–	–	–	Elevated
Fire:					
a. Room	1.0	0.006	0.01	0.1	Ground
b. Loading Dock	0.01	0.006	0.01	0.5	Ground
Spill:					
a. Room	1.0	0.00002	0.001	2.0×10^{-6}	Elevated
b. Glovebox	1.0	0.00002	0.001	2.0×10^{-6}	Elevated
c. Loading Dock	0.25	0.00008	0.001	0.1	Ground
Earthquake:					
Buildings 371 and 707A	1.0	0.002 [k]	0.3 [k]	0.1	Ground

Accident Scenario	*DR*	*ARF*	*RF*	*LPF*	*Release Point*
Aircraft Crash:					
a. Building 707A [l]	–	–	–	–	–
b. Building 371 [m]	–	–	–	–	–

DOR = direct oxide reduction ER = electrorefining MSE = molten salt extraction N/A = not applicable DR = damage ratio
ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] 1,000-g product containers are transported from Building 371 to Building 707A for processing.
[b] Building 707A, 0 HEPA Banks; Building 371, 2 HEPA Banks.
[c] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content.
[d] The wet nuclear criticality is not a viable accident scenario for the final calcination process in Building 707A.
[e] 3-day supply of feed and 2-day supply of product.
[f] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.
[g] 5 containers per drum of feed.
[h] 1 drum at the maximum plutonium content level.
[j] Refer to Table D–28 for Building 371 criticality accident source term.
[k] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000792).
[l] Consequences enveloped by the earthquake.
[m] The aircraft will not penetrate the building walls.

Table D–61 Summary of the Pyrochemical Salt Residues Accident Analysis Doses Water Leach Process at Rocky Flats

	Building Source Term		*MEI (rem)*		*Population (person-rem)*		*Worker (rem)*
Accident Scenario	*(grams)*	*Type*	*95% Met*	*50% Met*	*95% Met*	*50% Met*	*50% Met*
Process Direct Oxide Reduction Salt Residue—Building 371							
Explosion	8.00×10^{-9}	Salt-M	1.52×10^{-7}	1.76×10^{-8}	0.00216	0.0000512	1.28×10^{-7}
Criticality (Liquid)	[a]	–	0.79	0.11	6,980	252	0.321
Fire (Room)	0.0489	Salt-M	1.17	0.117	13,700	328	8.80
Fire (Dock)	0.0018	Salt-M	0.0432	0.00432	504	12.1	0.324
Spill (Room)	2.40×10^{-11}	Salt-M	4.56×10^{-10}	5.28×10^{-11}	6.48×10^{-6}	1.54×10^{-7}	3.84×10^{-10}
Spill (Glovebox)	8.00×10^{-12}	Salt-M	1.52×10^{-10}	1.76×10^{-11}	2.16×10^{-6}	5.12×10^{-8}	1.28×10^{-10}
Spill (Dock)	6.00×10^{-6}	Salt-M	0.000144	0.0000144	1.68	0.0402	0.00108
Earthquake	0.645	Salt-M	15.5	1.55	181,000	4,320	116
Process Electrorefining and Molten Salt Extraction Salt Residues—Building 371							
Explosion	8.00×10^{-9}	Salt-M	1.52×10^{-7}	1.76×10^{-8}	0.00216	0.0000512	1.28×10^{-7}
Criticality (Liquid)	[a]	–	0.79	0.11	6,980	252	0.321
Fire (Room)	0.0489	Salt-M	1.17	0.117	13,700	328	8.80
Fire (Dock)	0.0018	Salt-M	0.0432	0.00432	504	12.1	0.324
Spill (Room)	2.40×10^{-11}	Salt-M	4.56×10^{-10}	5.28×10^{-11}	6.48×10^{-6}	1.54×10^{-7}	3.84×10^{-10}
Spill (Glovebox)	8.00×10^{-12}	Salt-M	1.52×10^{-10}	1.76×10^{-11}	2.16×10^{-6}	5.12×10^{-8}	1.28×10^{-10}
Spill (Dock)	6.00×10^{-6}	Salt-M	0.000144	0.0000144	1.68	0.0402	0.00108
Earthquake	0.645	Salt-M	15.5	1.55	181,000	4,320	116
Final Calcination—Building 707A							
Explosion	0.002	Salt-O	0.028	0.003	520	12.4	0.34
Fire (Room)	0.066	Salt-O	0.924	0.099	17,200	409	11.2
Fire (Dock)	0.0012	Salt-O	0.0168	0.0018	312	7.44	0.204
Spill (Room)	4.00×10^{-11}	Salt-O	7.60×10^{-11}	2.88×10^{-11}	3.60×10^{-6}	1.84×10^{-7}	4.80×10^{-11}
Spill (Glovebox)	4.00×10^{-11}	Salt-O	7.60×10^{-11}	2.88×10^{-11}	3.60×10^{-6}	1.84×10^{-7}	4.80×10^{-11}
Spill (Dock)	2.00×10^{-6}	Salt-O	0.000028	3.00×10^{-6}	0.52	0.0124	0.00034
Earthquake	0.871	Salt-O	12.2	1.31	227,000	5,400	148

MEI = maximally exposed individual Met = meteorological data Salt-M = metal salt Salt-O = oxide salt

[a] 1.0×10^{19} fissions.

Table D–62 Summary of the Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year Water Leach Process at Rocky Flats

Accident Scenario	*Accident Frequency (per year)*	*MEI (LCF/yr)*		*Population (LCF/yr)*		*Worker (LCF/yr)*
		95% Met	*50% Met*	*95% Met*	*50% Met*	*50% Met*
Process Direct Oxide Reduction Salt Residues—Building 371						
Explosion	0.00005	3.80×10^{-15}	4.40×10^{-16}	5.40×10^{-11}	1.28×10^{-12}	2.56×10^{-15}
Criticality (Liquid)	0.0001	3.95×10^{-8}	5.50×10^{-9}	0.000349	0.0000126	1.28×10^{-8}
Fire (Room)	0.0005	2.93×10^{-7}	2.93×10^{-8}	0.00342	0.0000819	1.76×10^{-6}
Fire (Dock)	2.0×10^{-6}	4.32×10^{-11}	4.32×10^{-12}	5.04×10^{-7}	1.21×10^{-8}	2.59×10^{-10}
Spill (Room)	0.008	1.82×10^{-15}	2.11×10^{-16}	2.59×10^{-11}	6.14×10^{-13}	1.23×10^{-15}
Spill (Glovebox)	0.8	6.08×10^{-14}	7.04×10^{-15}	8.64×10^{-10}	2.05×10^{-11}	4.10×10^{-14}
Spill (Dock)	0.001	7.20×10^{-11}	7.20×10^{-12}	8.40×10^{-7}	2.01×10^{-8}	4.32×10^{-10}
Earthquake	0.000094	7.28×10^{-7}	7.28×10^{-8}	0.00849	0.000203	8.74×10^{-6}
Process Electrorefining and Molten Salt Extraction Salt Residues—Building 371						
Explosion	0.00005	3.80×10^{-15}	4.40×10^{-16}	5.40×10^{-11}	1.28×10^{-12}	2.56×10^{-15}
Criticality (Liquid)	0.0001	3.95×10^{-8}	5.50×10^{-9}	0.000349	0.0000126	1.28×10^{-8}
Fire (Room)	0.0005	2.93×10^{-7}	2.93×10^{-8}	0.00342	0.0000819	1.76×10^{-6}
Fire (Dock)	2.0×10^{-6}	4.32×10^{-11}	4.32×10^{-12}	5.04×10^{-7}	1.21×10^{-8}	2.59×10^{-10}
Spill (Room)	0.008	1.82×10^{-15}	2.11×10^{-16}	2.59×10^{-11}	6.14×10^{-13}	1.23×10^{-15}
Spill (Glovebox)	0.8	6.08×10^{-14}	7.04×10^{-15}	8.64×10^{-10}	2.05×10^{-11}	4.10×10^{-14}
Spill (Dock)	0.001	7.20×10^{-11}	7.20×10^{-12}	8.40×10^{-7}	2.01×10^{-8}	4.32×10^{-10}
Earthquake	0.000094	7.28×10^{-7}	7.28×10^{-8}	0.00849	0.000203	8.74×10^{-6}
Final Calcination—Building 707A						
Explosion	0.00005	7.00×10^{-10}	7.50×10^{-11}	0.000013	3.10×10^{-7}	6.80×10^{-9}
Fire (Room)	0.0005	2.31×10^{-7}	2.48×10^{-8}	0.00429	0.000102	2.24×10^{-6}
Fire (Dock)	2.0×10^{-6}	1.68×10^{-11}	1.80×10^{-12}	3.12×10^{-7}	7.44×10^{-9}	1.63×10^{-10}
Spill (Room)	0.008	3.04×10^{-16}	1.15×10^{-16}	1.44×10^{-11}	7.36×10^{-13}	1.54×10^{-16}
Spill (Glovebox)	0.8	3.04×10^{-14}	1.15×10^{-14}	1.44×10^{-9}	7.36×10^{-11}	1.54×10^{-14}
Spill (Dock)	0.001	1.40×10^{-11}	1.50×10^{-12}	2.60×10^{-7}	6.20×10^{-9}	1.36×10^{-10}
Earthquake	0.0008	4.88×10^{-6}	5.23×10^{-7}	0.0906	0.00216	0.0000948

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data DOR = direct oxide reduction

Table D–63 provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of preprocessing and packaging the direct oxide reduction salt residue at Rocky Flats and of processing the residue using the water leach technology at Los Alamos National Laboratory. **Table D–64** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with the preprocessing and packaging of the residues at Rocky Flats and the processing of the pyrochemical salt residues at Los Alamos National Laboratory. The risks associated with the preprocessing and packaging at Rocky Flats and the processing using water leach technology at Los Alamos National Laboratory are summarized in **Table D–65**.

Table D–63 Pyrochemical Salt Residues Accident Scenarios Parameters Water Leach Process at Los Alamos National Laboratory

Rocky Flats Preprocessing and Packaging of Direct Oxide Reduction Residue for Shipment to Los Alamos National Laboratory

Accident Scenario	*Frequency (per year)*	*Pyrochemical Salt Residues*	*HEPA Banks*	*Material at Risk (grams)*
Explosion	0.00005	2 drums [a]	0	4,000 g
Nuclear Criticality [b]	–	–	–	–
Fire:				
a. Room	0.0005	5-day supply [c]	2	6,560 g
b. Loading Dock	2.0×10^{-6}	4 drums [d]	0	6,000 g
Spill:				
a. Room	0.008	1 container at the maximum limit [e]	2	600 g
b. Glovebox	0.8	1 feed prep container	2	205 g
c. Loading Dock	0.001	1 drum [f]	0	3,000 g
Earthquake	0.0018	5-day supply [c]	0	6,560 g
Aircraft Crash	0.00003	Consequences enveloped by the earthquake.	–	–

Rocky Flats Preprocessing and Packaging of Direct Oxide Reduction Residues for Shipment to Los Alamos National Laboratory

Accident Scenario	*DR*	*ARF*	*RF*	*LPF*	*Release Point*
Explosion	1.0	0.001	0.001	1.0	Ground
Nuclear Criticality [b]	–	–	–	–	–
Fire:					
a. Room	1.0	0.006	0.01	0.1	Ground
b. Loading Dock	0.01	0.006	0.01	0.5	Ground
Spill:					
a. Room	1.0	0.00002	0.001	2.0×10^{-6}	Elevated
b. Glovebox	1.0	0.00002	0.001	2.0×10^{-6}	Elevated
c. Loading Dock	0.25	0.00008	0.001	0.1	Ground
Earthquake	1.0	0.002 [g]	0.3 [g]	0.1	Ground
Aircraft Crash [h]	–	–	–	–	–

Water Leach Processing of Direct Oxide Reduction Residues at Los Alamos National Laboratory

Accident Scenario	*Frequency (per year)*	*Material at Risk (grams)*
Explosion [j]	–	–
Nuclear Criticality	0.0001	1.0×10^{18} fissions
Fire	0.0005	1,000 g slurry 5,000 g powder
Spill	0.003	205 g
Earthquake	0.0005	1,000 g slurry 5,000 g powder
Aircraft Crash [k]	–	–

Accident Scenario	*DR*	*ARF×RF*	*LPF*	*Release Point*
Nuclear Criticality	–	–	–	Elevated
Fire:				
a. Powder	1.0	0.00006	0.011	Ground
b. Slurry	1.0	0.00006	0.011	Ground
Spill	1.0	0.00001	4.00×10^{-9}	Elevated

Accident Scenario	DR	ARF×RF	LPF	Release Point
Earthquake:				
a. Powder	1.0	0.000792	0.1	Ground
b. Slurry	1.0	7.00×10^{-6}	0.1	Ground

DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content.

[b] The wet nuclear criticality is not a viable accident scenario for the residue preprocessing and packaging process in Building707.

[c] 3-day supply of feed and 2-day supply of product.

[d] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.

[e] 5 containers per drum of feed.

[f] 1 drum at the maximum plutonium content level.

[g] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000792).

[h] Consequences enveloped by the earthquake.

[j] Neither of the explosions postulated in the Technical Area 55 Safety Analysis Report (LANL 1996) would breach the integrity of the gloveboxes proposed for the processing of the Rocky Flats residues.

[k] The Technical Area 55 Safety Analysis Report (LANL 1996) stated that an aircraft crash into Technical Area 55 is not a credible event.

Table D–64 Summary of the Accident Analysis Doses Water Leach Process at Los Alamos National Laboratory

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Rocky Flats Preprocessing and Packaging of Direct Oxide Reduction Salt Residues for Shipment to Los Alamos National Laboratory							
Explosion	0.004	Salt-M	0.064	0.0068	1,120	26.8	0.72
Fire (Room)	0.0394	Salt-M	0.63	0.0669	11,000	264	7.08
Fire (Dock)	0.0018	Salt-M	0.0288	0.00306	504	12.1	0.324
Spill (Room)	2.40×10^{-11}	Salt-M	5.04×10^{-11}	1.90×10^{-11}	2.30×10^{-6}	1.18×10^{-7}	2.88×10^{-11}
Spill (Glovebox)	8.20×10^{-12}	Salt-M	1.72×10^{-11}	6.48×10^{-12}	7.87×10^{-7}	4.02×10^{-8}	9.84×10^{-12}
Spill (Dock)	6.00×10^{-6}	Salt-M	0.000096	0.0000102	1.68	0.0402	0.00108
Earthquake	0.52	Salt-M	8.31	0.883	145,000	3,480	93.5
Water Leach Processing of Direct Oxide Reduction Salt Residues at Los Alamos National Laboratory							
Criticality	[a]	–	0.137	0.0220	98.8	15.7	0.0450
Fire	0.00396	Salt-O	0.150	0.0194	198	20.2	1.62
Spill	8.20×10^{-12}	Salt-O	2.54×10^{-10}	3.77×10^{-11}	2.95×10^{-7}	4.26×10^{-8}	2.30×10^{-11}
Earthquake	0.397	Salt-O	15.1	1.94	19,800	2,020	163

MEI = maximally exposed individual Met = meteorological data Salt-M = metal salt Salt-O = oxide salt

[a] 1.0×10^{18} fissions.

Table D–65 Summary of the Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year Water Leach Process at Los Alamos National Laboratory

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr)		Population (LCF/yr)		Worker (LCF/yr)
		95% Met	50% Met	95% Met	50% Met	50% Met
Rocky Flats Preprocessing and Packaging of Direct Oxide Reduction Salt Residues for Shipment to Los Alamos National Laboratory						
Explosion	0.00005	1.60×10^{-9}	1.70×10^{-10}	0.000028	6.70×10^{-7}	1.44×10^{-8}
Fire (Room)	0.0005	1.57×10^{-7}	1.67×10^{-8}	0.00276	0.0000659	1.42×10^{-6}
Fire (Dock)	2.00×10^{-6}	2.88×10^{-11}	3.06×10^{-12}	5.04×10^{-7}	1.21×10^{-8}	2.59×10^{-10}
Spill (Room)	0.008	2.02×10^{-16}	7.58×10^{-17}	9.22×10^{-12}	4.70×10^{-13}	9.22×10^{-17}
Spill (Glovebox)	0.8	6.89×10^{-15}	2.59×10^{-15}	3.15×10^{-10}	1.61×10^{-11}	3.15×10^{-15}
Spill (Dock)	0.001	4.80×10^{-11}	5.10×10^{-12}	8.40×10^{-7}	2.01×10^{-8}	4.32×10^{-10}
Earthquake	0.0018	7.48×10^{-6}	7.95×10^{-7}	0.131	0.00313	0.000135
Water Leach Processing of Direct Oxide Reduction Salt Residues at Los Alamos National Laboratory						
Criticality	0.0001	6.85×10^{-9}	1.10×10^{-9}	4.94×10^{-6}	7.85×10^{-7}	1.80×10^{-9}
Fire	0.0005	3.76×10^{-8}	4.85×10^{-9}	0.0000495	5.05×10^{-6}	3.25×10^{-7}
Spill	0.003	3.81×10^{-16}	5.66×10^{-17}	4.43×10^{-13}	6.40×10^{-14}	2.76×10^{-17}
Earthquake	0.0005	3.77×10^{-6}	4.86×10^{-7}	0.00496	0.000506	0.0000651

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

- **Salt Scrub Technology**—The salt scrub technology can be used to process all pyrochemical salt residues. Implementation of this technology requires processing of the residues in Rocky Flats Building 707, Modules A and B. The scrub alloy byproduct of the process will be sent to the Savannah River Site F-Canyon for final processing.

Table D–66 provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of pyrochemical salt processing with the salt scrub technology at Rocky Flats and the Savannah River Site. **Table D–67** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with the processing of pyrochemical salt residues. The risks associated with this processing technology are summarized in **Table D–68**. The processes at the Savannah River Site can be performed in either the F-Canyon and FB-Line or the H-Canyon and HB-Line. Data are presented in Table D–66, Table D–67, and Table D–68 for both options.

Table D–66 Pyrochemical Salt Residues Accident Scenarios Parameters Salt Scrub Process at Rocky Flats and the Savannah River Site

Accident Scenario	Frequency (per year)	Pyrochemical Salt Residues	HEPA Banks	Material at Risk (grams)
Salt Scrub at Rocky Flats				
Explosion	0.00005	2 drums [a]	0	4,000 g
Nuclear Criticality [b]	–	–	–	–
Fire:				
a. Room	0.0005	5-day supply [c]	2	7,403 g feed 4,693 g product [d]
b. Loading Dock	2.0×10^{-6}	4 drums [e]	0	6,000 g

Accident Scenario	*Frequency (per year)*	*Pyrochemical Salt Residues*	*HEPA Banks*	*Material at Risk (grams)*
Spill:				
a. Room	0.008	1 container at the maximum limit [f]	2	600 g
b. Glovebox	0.8	1 feed prep container	2	168 g
c. Loading Dock	0.001	1 drum [g]	0	3,000 g
Earthquake	0.0018	5-day supply [c]	0	7,403 g feed 4,693 g product [d]
Aircraft Crash	0.00003	Consequences enveloped by the earthquake.	–	–

Accident Scenario	*DR*	*ARF*	*RF*	*LPF*	*Release Point*
Explosion	1.0	0.001	0.001	1.0	Ground
Nuclear Criticality [b]	–	–	–	–	–
Fire:					
a. Room					
Feed	1.0	0.006	0.01	0.1	Ground
Product	0.01	0.006	0.01	0.1	Ground
b. Loading Dock	0.01	0.006	0.01	0.5	Ground
Spill:					
a. Room	1.0	0.00002	0.001	2.0×10^{-6}	Elevated
b. Glovebox	1.0	0.00002	0.001	2.0×10^{-6}	Elevated
c. Loading Dock	0.25	0.00008	0.001	0.1	Ground
Earthquake:					
a. Feed	1.0	0.002 [h]	0.3 [h]	0.1	Ground
b. Product	0.01	0.001 [j]	0.1 [j]	0.1	Ground
Aircraft Crash [k]	–	–	–	–	–

Purex/Plutonium Metal Recovery Process at the Savannah River Site F-Canyon

Accident Scenario	*Frequency (per year)*	*Material at Risk (grams)*
Explosion:		
a. Hydrogen	0.000015	8,000 g
b. Ion Exchange Column	0.0001	241 mg [l]
Nuclear Criticality [m]	0.0001	1.0×10^{19} fissions
Fire	0.00061	8,000 g
Spill [n]	–	–
Earthquake:	0.000125	
a. F-Canyon:		
Liquid		24,000 g
b. FB-Line:		
Powder		2,000 g
Molten Metal		2,000 g
Liquid		2,000 g

Accident Scenario	*DR*	*ARF×RF*	*LPF*	*Release Point*
Explosion:				
a. Hydrogen	1.0	0.001	0.005	Elevated
b. Ion Exchange Column	1.0	1.0	1.0	Elevated
Nuclear Criticality [m]	–	–	–	–
Fire	1.0	0.01	0.005	Elevated
Spill [n]	–	–	–	–

Accident Scenario	*DR*	*ARF×RF*	*LPF*	*Release Point*
Earthquake:				
a. F-Canyon:				
Liquid	1.0	0.000047	0.1	Ground
b. FB-Line:				
Powder	1.0	0.002	0.1	Ground
Molten Metal	1.0	0.0022	0.1	Ground
Liquid	1.0	0.000047	0.1	Ground

Purex Process/Plutonium Oxide Recovery at the Savannah River Site H-Canyon

Accident Scenario	*Frequency (per year)*	*Material at Risk (grams)*
Explosion:		
a. Hydrogen	0.000015	6,000 g
b. Ion Exchange Column	0.0001	241 mg [l]
Nuclear Criticality [m]	0.0001	1.0×10^{19} fissions
Fire	0.00061	6,000 g
Spill [n]	–	–
Earthquake:	0.000182	
a. H-Canyon		18,000 g
b. HB-Line:		
Powder		4,000 g
Liquid		4,000 g

Accident Scenario	*DR*	*ARF×RF*	*LPF*	*Release Point*
Explosion:				
a. Hydrogen	1.0	0.001	0.005	Elevated
b. Ion Exchange Column	1.0	1.0	1.0	Elevated
Nuclear Criticality [m]	–	–	–	–
Fire	1.0	0.01	0.005	Elevated
Spill [n]	–	–	–	–
Earthquake:				
a. H-Canyon:				
Liquid	1.0	0.000047	0.1	Ground
b. HB-Line:				
Powder	1.0	0.002	0.1	Ground
Liquid	1.0	0.000047	0.1	Ground

DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content.

[b] The wet nuclear criticality is not a viable accident scenario for the salt scrub and pyro-oxidizing processes in Building 707.

[c] 3-day supply of feed and 2-day supply of product.

[d] 97% (4,693 g) of the product is in alloy form and 3% (145 g) is in salt form. The 145 g in salt form was added to the feed supply.

[e] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.

[f] 5 containers per drum of feed.

[g] 1 drum at the maximum plutonium content level.

[h] Add 0.000192 to ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000792).

[j] Add 0.000192 to ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000292).

[k] Consequences enveloped by the earthquake.

[l] Respirable source term value in milligrams of plutonium released up the stack.

[m] Refer to Table D–28 for criticality accident source term.

[n] Powder spill is not a viable accident scenario for processing salt residue at the Savannah River Site.

Table D–67 Summary of the Accident Analysis Doses Salt Scrub Process at Rocky Flats and the Savannah River Site

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Rocky Flats Salt Scrub Process							
Explosion	0.004	Salt-M	0.064	0.0068	1,120	26.8	0.72
Fire (Room)	0.0447	Salt-M	0.715	0.076	12,500	299	8.05
Fire (Dock)	0.0018	Salt-M	0.0288	0.00306	504	12.1	0.324
Spill (Room)	2.40×10^{-11}	Salt-M	5.04×10^{-11}	1.90×10^{-11}	2.30×10^{-6}	1.18×10^{-7}	2.88×10^{-11}
Spill (Glovebox)	6.72×10^{-12}	Salt-M	1.41×10^{-11}	5.31×10^{-12}	6.45×10^{-7}	3.29×10^{-8}	8.06×10^{-12}
Spill (Dock)	6.00×10^{-6}	Salt-M	0.000096	0.0000102	1.68	0.0402	0.00108
Earthquake	0.588	Salt-M	9.40	0.999	165,000	3,940	106
Purex/Plutonium Metal Recovery Process at the Savannah River Site F-Canyon							
Explosion (Hydrogen)	0.04	Salt-M	0.0088	0.00328	480	40.0	0.0264
Explosion (Ion Exchange)	0.241	Salt-FB	0.00771	0.00265	386	36.2	0.0231
Criticality (Liquid)	[a]	–	0.011	0.0044	310	32.0	0.038
Fire	0.4	Salt-M	0.0880	0.0328	4,800	400	0.264
Earthquake	0.962	Salt-M	0.577	0.106	20,200	1,440	144
Purex Process/Plutonium Oxide Recovery at the Savannah River Site H-Canyon							
Explosion (Hydrogen)	0.03	Salt-M	0.0063	0.00189	330	28.8	0.0198
Explosion (Ion Exchange)	0.241	Salt-HB	0.00747	0.00205	354	34.7	0.0231
Criticality (Liquid)	[a]	–	0.009	0.003	290	29.0	0.038
Fire	0.3	Salt-M	0.0630	0.0189	3,300	288	0.198
Earthquake	0.903	Salt-M	0.407	0.0813	18,100	1,170	136

MEI = maximally exposed individual Met = meteorological data Salt-M = metal salt Salt-FB = FB-Line salt
Salt-HB = HB-Line salt
[a] 1.0×10^{19} fissions.

Table D–68 Summary of the Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year Salt Scrub Process at Rocky Flats and the Savannah River Site

Rocky Flats Salt Scrub Process						
Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr) 95% Met	MEI (LCF/yr) 50% Met	Population (LCF/yr) 95% Met	Population (LCF/yr) 50% Met	Worker (LCF/yr) 50% Met
Explosion	0.00005	1.60×10^{-9}	1.71×10^{-10}	0.000028	6.70×10^{-7}	1.44×10^{-8}
Fire (Room)	0.0005	1.79×10^{-7}	1.90×10^{-8}	0.00313	0.0000749	1.61×10^{-6}
Fire (Dock)	2.0×10^{-6}	2.88×10^{-11}	3.06×10^{-12}	5.04×10^{-7}	1.21×10^{-8}	2.59×10^{-10}
Spill (Room)	0.008	2.02×10^{-16}	7.58×10^{-17}	9.22×10^{-12}	4.70×10^{-13}	9.22×10^{-17}
Spill (Glovebox)	0.8	5.64×10^{-15}	2.12×10^{-15}	2.58×10^{-10}	1.32×10^{-11}	2.58×10^{-15}
Spill (Dock)	0.001	4.80×10^{-11}	5.10×10^{-12}	8.40×10^{-7}	2.01×10^{-8}	4.32×10^{-10}
Earthquake	0.0018	8.46×10^{-6}	8.99×10^{-7}	0.148	0.00354	0.000152

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr)		Population (LCF/yr)		Worker (LCF/yr)
		95% Met	50% Met	95% Met	50% Met	50% Met
Purex/Plutonium Metal Recovery Process at the Savannah River Site F-Canyon						
Explosion (Hydrogen)	0.000015	6.60×10^{-11}	2.46×10^{-11}	3.60×10^{-6}	3.00×10^{-7}	1.58×10^{-10}
Explosion (Ion Exchange)	0.0001	3.86×10^{-10}	1.33×10^{-10}	0.0000193	1.81×10^{-6}	9.25×10^{-10}
Criticality (Liquid)	0.0001	5.50×10^{-10}	2.20×10^{-10}	0.0000155	1.60×10^{-6}	1.52×10^{-9}
Fire	0.00061	2.68×10^{-8}	1.00×10^{-8}	0.00146	0.000122	6.44×10^{-8}
Earthquake	0.000125	3.61×10^{-8}	6.62×10^{-9}	0.00126	0.0000902	0.0000144
Purex Process/Plutonium Oxide Recovery at the Savannah River Site H-Canyon						
Explosion (Hydrogen)	0.000015	4.73×10^{-11}	1.42×10^{-11}	2.48×10^{-6}	2.16×10^{-7}	1.19×10^{-10}
Explosion (Ion Exchange)	0.0001	3.74×10^{-10}	1.02×10^{-10}	0.0000177	1.74×10^{-6}	9.25×10^{-10}
Criticality (Liquid)	0.0001	4.50×10^{-10}	1.50×10^{-10}	0.0000145	1.45×10^{-6}	1.52×10^{-9}
Fire	0.00061	1.92×10^{-8}	5.76×10^{-9}	0.00101	0.0000878	4.83×10^{-8}
Earthquake	0.000182	3.70×10^{-8}	7.40×10^{-9}	0.00164	0.000107	0.0000197

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.3 Combustible Residues:

D.3.4.3.1 No Action

The combustible residues processing technologies considered for this alternative are neutralization, thermal desorption/steam passivation, and direct repackaging. The neutralization and thermal desorption/steam passivation processes will be performed at Rocky Flats in Building 371, Room 3701. The direct repackaging process will be performed at Rocky Flats in Building 707, Modules D, E, and F.

Table D–69 provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of calcination/cementation processing technology of combustible residues at Rocky Flats. **Table D–70** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with the processing of combustible residues. The risks associated with these processing technologies are summarized in **Table D–71**.

Table D–69 Combustible Residues Accident Scenarios Parameters at Rocky Flats

Accident Scenario	Frequency (per year)	Combustible Residues	HEPA Banks	Material at Risk (grams)		
				Neutralization Process Building 371	Desorption and Passivation Process Building 371	Direct Repackaging Process Building 707
Explosion	0.00005	2 drums [a]	2/0 [b]	1,000 g	1,000 g	1,000 g
Nuclear Criticality [c]	–	–	–	–	–	–
Fire:						
a. Room	0.0005	5-day supply [d]	2	1,218 g	265 g	8,016 g
b. Loading Dock	2.0×10^{-6}	4 drums [a]	0	2,000 g	2,000 g	2,000 g
Spill:						
a. Room [e]	–	–		–	–	–
b. Glovebox	0.8	1 feed prep container	2	87 g	18.9 g	83.5 g
c. Loading Dock	0.001	1 drum [a]	0	500 g	500 g	500 g

Accident Scenario	Frequency (per year)	Combustible Residues	HEPA Banks	Material at Risk (grams)		
				Neutralization Process Building 371	Desorption and Passivation Process Building 371	Direct Repackaging Process Building 707
Earthquake:						
a. Building 371	0.000094	5-day supply [d]	0	1,218 g	265 g	N/A
b. Building 707	0.0018	5-day supply [d]	0	N/A	N/A	8,016 g
Aircraft Crash:						
a Building 371	0.00003	Consequences enveloped by the earthquake.	–	–	–	–
b. Building 707	0.00004	The aircraft will not penetrate the building wall.	–	–	–	–

Accident Scenario	DR	ARF	RF	LPF	Release Point
Explosion:					
a. Building 371	1.0	0.001	0.1	2.0×10^{-6}	Elevated
b. Building 707	1.0	0.001	0.1	1.0	Ground
Nuclear Criticality [c]	–	–	–	–	–
Fire:					
a. Room	1.0	0.0005	1.0	0.1	Ground
b. Loading Dock	1.0	0.0005	1.0	0.5	Ground
Spill:					
a. Glovebox	1.0	1.0×10^{-6} [f]	1.0 [f]	2.0×10^{-6}	Elevated
b. Loading Dock	0.25	1.0×10^{-6} [f]	1.0 [f]	0.1	Ground
Earthquake:					
a. Building 371	1.0	0.001 [g]	0.1 [g]	0.1	Ground
b. Building 707	1.0	0.001 [g]	0.1 [g]	0.1	Ground
Aircraft Crash:					
a. Building 371 [h]	–	–	–	–	–
b. Building 707 [j]	–	–	–	–	–

DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor N/A = not applicable

[a] 1 drum contains the maximum plutonium content level (500 g) (RFFO 1997).
[b] Building 371, 2 HEPA Banks; Building 707, 0 HEPA Banks.
[c] The wet nuclear criticality is not a viable accident scenario for the No Action Alternative technology assessment.
[d] 3-day supply of feed and 2-day supply of product.
[e] Materials are opened in a glovebox. No room spill is considered.
[f] The product of ARF×RF = 1.0×10^{-6}.
[g] Add 0.000192 to ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000292).
[h] The aircraft will not penetrate the building.
[j] Consequences enveloped by the earthquake.

Table D–70 Summary of the Accident Analysis Doses at Rocky Flats

Accident Scenario	Building Source Term		MEI (rem)		Population (person-rem)		Worker (rem)
	(grams)	Type	95% Met	50% Met	95% Met	50% Met	50% Met
Neutralization Process—Building 371							
Explosion	2.00×10^{-7}	Metal	6.00×10^{-7}	6.80×10^{-8}	0.0084	0.0002	5.00×10^{-7}
Fire (Room)	0.0609	Metal	0.219	0.0219	2,560	60.9	1.71
Fire (Dock)	0.5	Metal	1.80	0.18	21,000	500	14.0

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Spill (Glovebox)	1.74×10^{-10}	Metal	5.22×10^{-10}	5.92×10^{-11}	7.31×10^{-6}	1.74×10^{-7}	4.35×10^{-10}
Spill (Dock)	0.0000125	Metal	0.000045	4.50×10^{-6}	0.525	0.0125	0.00035
Earthquake	0.0356	Metal	0.128	0.0128	1,490	35.6	0.996
Desorption and Passivation Process—Building 371							
Explosion	2.00×10^{-7}	Metal	6.00×10^{-7}	6.80×10^{-8}	0.0084	0.0002	5.00×10^{-7}
Fire (Room)	0.0133	Metal	0.0477	0.00477	557	13.3	0.371
Fire (Dock)	0.5	Metal	1.80	0.18	21,000	500	14.0
Spill (Glovebox)	3.78×10^{-11}	Metal	1.13×10^{-10}	1.29×10^{-11}	1.59×10^{-6}	3.78×10^{-8}	9.45×10^{-11}
Spill (Dock)	0.0000125	Metal	0.000045	4.50×10^{-6}	0.525	0.0125	0.00035
Earthquake	0.00774	Metal	0.0279	0.00279	325	7.74	0.217
Direct Repackaging Process—Building 707							
Explosion	0.1	Metal	0.24	0.026	4,200	100	2.80
Fire (Room)	0.401	Metal	0.962	0.104	16,800	401	11.2
Fire (Dock)	0.5	Metal	1.20	0.13	21,000	500	14.0
Spill (Glovebox)	1.67×10^{-10}	Metal	5.34×10^{-11}	2.00×10^{-11}	2.51×10^{-6}	1.29×10^{-7}	3.17×10^{-11}
Spill (Dock)	0.0000125	Metal	0.00003	3.25×10^{-6}	0.525	0.0125	0.00035
Earthquake	0.234	Metal	0.562	0.0609	9,830	234	6.55

MEI = maximally exposed individual Met = meteorological data

Table D–71 Summary of the Accident Analysis Risks at Rocky Flats in Terms of Latent Cancer Fatalities per Year

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr) 95% Met	MEI (LCF/yr) 50% Met	Population (LCF/yr) 95% Met	Population (LCF/yr) 50% Met	Worker (LCF/yr) 50% Met
Neutralization Process—Building 371						
Explosion	0.00005	1.50×10^{-14}	1.70×10^{-15}	2.10×10^{-10}	5.00×10^{-12}	1.00×10^{-14}
Fire (Room)	0.0005	5.48×10^{-8}	5.48×10^{-9}	0.000639	0.0000152	3.41×10^{-7}
Fire (Dock)	2.0×10^{-6}	1.80×10^{-9}	1.80×10^{-10}	0.000021	5.00×10^{-7}	1.12×10^{-8}
Spill (Glovebox)	0.8	2.09×10^{-13}	2.37×10^{-14}	2.92×10^{-9}	6.96×10^{-11}	1.39×10^{-13}
Spill (Dock)	0.001	2.25×10^{-11}	2.25×10^{-12}	2.63×10^{-7}	6.25×10^{-9}	1.40×10^{-10}
Earthquake	0.000094	6.02×10^{-9}	6.02×10^{-10}	0.0000702	1.67×10^{-6}	3.74×10^{-8}
Desorption and Passivation Process—Building 371						
Explosion	0.00005	1.50×10^{-14}	1.70×10^{-15}	2.10×10^{-10}	5.00×10^{-12}	1.00×10^{-14}
Fire (Room)	0.0005	1.19×10^{-8}	1.19×10^{-9}	0.000139	3.31×10^{-6}	7.42×10^{-8}
Fire (Dock)	2.0×10^{-6}	1.80×10^{-9}	1.80×10^{-10}	0.0000210	5.00×10^{-7}	1.12×10^{-8}
Spill (Glovebox)	0.8	4.54×10^{-14}	5.14×10^{-15}	6.35×10^{-10}	1.51×10^{-11}	3.02×10^{-14}
Spill (Dock)	0.001	2.25×10^{-11}	2.25×10^{-12}	2.63×10^{-7}	6.25×10^{-9}	1.40×10^{-10}
Earthquake	0.000094	1.31×10^{-9}	1.31×10^{-10}	0.0000153	3.64×10^{-7}	8.15×10^{-9}

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr)		Population (LCF/yr)		Worker (LCF/yr)
		95% Met	50% Met	95% Met	50% Met	50% Met
Direct Repackaging Process—Building 707						
Explosion	0.00005	6.00×10^{-9}	6.50×10^{-10}	0.000105	2.50×10^{-6}	5.60×10^{-8}
Fire (Room)	0.0005	2.40×10^{-7}	2.61×10^{-8}	0.00421	0.0001	2.24×10^{-6}
Fire (Dock)	2.0×10^{-6}	1.20×10^{-9}	1.30×10^{-10}	0.000021	5.00×10^{-7}	1.12×10^{-8}
Spill (Glovebox)	0.8	2.14×10^{-14}	8.02×10^{-15}	1.00×10^{-9}	5.14×10^{-11}	1.02×10^{-14}
Spill (Dock)	0.001	1.50×10^{-11}	1.63×10^{-12}	2.63×10^{-7}	6.25×10^{-9}	1.40×10^{-10}
Earthquake	0.0018	5.06×10^{-7}	5.48×10^{-8}	0.00885	0.000211	4.72×10^{-6}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.3.2 Processing and Storage without Plutonium Separation

The combustible residues processing technologies considered for this alternative are blend down, catalytic chemical oxidation, fluidized bed incineration, and sonic wash. The blend down process, the catalytic chemical oxidation process, and the sonic wash process will be performed at Rocky Flats in Building 371, Room 3701. The fluidized bed incineration process will be performed at Rocky Flats in Building 776. Building 707 at Rocky Flats is under consideration as an alternate location for the blend down process. The accident analysis evaluates both the primary and alternate locations for the blend down process.

For analysis purposes, this EIS uses accident data (e.g., explosion, aircraft crash, HEPA banks available) from Building 707 (Modules A through H) as surrogate data for Building 776.

Similar accidents are applicable to all of these technologies. **Table D–72** provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of combustible processing technology at Rocky Flats. **Table D–73** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with the processing of combustible residues. The risks associated with these processing technologies are summarized in **Table D–74**.

Table D–72 Combustible Residues Accident Scenarios Parameters at Rocky Flats

Accident Scenario	Frequency (per year)	Combustible Residues	HEPA Banks	Material at Risk (grams)			
				Blend Down Process Building 371 or Building 707	Catalytic Chemical Oxidation Process Building 371	Fluidized Bed Incineration Process Building 776	Sonic Wash Process Building 371
Explosion	0.00005	2 drums	0/2 [a]	1,000 g [b]	1,000 g [b]	1,000 g [b]	1,000 g [b]
Nuclear Criticality	0.0001	Solution	–	N/A [c]	1.0×10^{19} fissions	N/A [c]	N/A [c]
Fire:							
a. Room	0.0005	5-day supply [b]	2	7,014 g	610 g	1,308 g	837 g feed + 471 g product [e]
b. Loading Dock	2.0×10^{-6}	4 drums	0	2,000 g [b]	2,000 g [b]	2,000 g [b]	2,000 g [b]
Spill:							
a. Room [f]	–	–	–	–	–	–	–
b. Glovebox	0.8	1 feed prep container	2	83.5 g	2 g	93.4 g	93.4 g
c. Loading Dock	0.001	1 drum	0	500 g [b]	500 g [b]	500 g [b]	500 g [b]

Accident Scenario	Frequency (per year)	Combustible Residues	HEPA Banks	Material at Risk (grams): Blend Down Process Building 371 or Building 707	Catalytic Chemical Oxidation Process Building 371	Fluidized Bed Incineration Process Building 776	Sonic Wash Process Building 371
Earthquake:							
a. Building 776	0.001	5-day supply [d]	0	N/A	N/A	1,308 g	N/A
b. Building 371	0.000094	5-day supply [d]	0	7,014 g	610 g	N/A	837 g feed + 471 g product [e]
c. Building 707	0.0018	5-day supply [d]	0	7,014 g	N/A	N/A	N/A
Aircraft Crash:							
a. Building 776	0.00003	Consequences enveloped by the earthquake.	–	N/A	N/A	–	N/A
b. Building 371	0.00004	The aircraft will not penetrate the building wall.	–	–	–	N/A	–
c. Building 707	0.00003	Consequences enveloped by the earthquake.	–	–	N/A	N/A	N/A

Accident Scenario	DR	ARF	RF	LPF	Release Point
Explosion:					
a. Buildings 707 and 776	1.0	0.001	0.1	1.0	Ground
b. Building 371	1.0	0.001	0.1	2.0×10^{-6}	Elevated
Nuclear Criticality [c, g]	–	–	–	–	Elevated
Fire:					
a. Room	1.0	0.0005	1.0	0.1	Ground
b. Loading Dock	1.0	0.0005	1.0	0.5	Ground
Spill:					
a. Glovebox	1.0	1.0×10^{-6} [h]	1.0 [h]	2.0×10^{-6}	Elevated
b. Loading Dock	0.25	1.0×10^{-6} [h]	1.0 [h]	0.1	Ground
Earthquake:					
Buildings 371, 707, and 776	1.0	0.001 [j]	0.1 [j]	0.1	Ground
Aircraft Crash:					
a. Buildings 707 and 776 [k]	–	–	–	–	–
b. Building 371 [l]	–	–	–	–	–

N/A = not applicable DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] Buildings 707 and 776, 0 HEPA Banks; Building 371, 2 HEPA Banks.
[b] 1 drum contains the maximum plutonium content level of 500 g (RFFO 1997).
[c] The wet nuclear criticality is not a viable accident scenario for the blend down, fluidized bed incineration, and sonic wash technology assessments.
[d] 3-day supply of feed and 2-day supply of product.
[e] 90% of the product is glass, 10% is powder. The effect of the vitrified product on the accident source term is negligible. The product powder is included with the feed supply accident source term.
[f] Materials are opened in a glovebox. No room spill is considered.
[g] Refer to Table D–28 for the Building 371 catalytic chemical oxidation criticality accident source term.
[h] The product of ARF×RF = 1.0×10^{-6}..
[j] Add 0.000192 to ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000292).
[k] Consequences enveloped by the earthquake.
[l] The aircraft will not penetrate the building walls.

Table D–73 Summary of the Accident Analysis Doses at Rocky Flats

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Blend Down Process—Building 371							
Explosion	2.00×10^{-7}	Metal	6.00×10^{-7}	6.80×10^{-8}	0.0084	0.0002	5.00×10^{-7}
Fire (Room)	0.351	Metal	1.26	0.126	14,700	351	9.82
Fire (Dock)	0.5	Metal	1.80	0.18	21,000	500	14.0

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Spill (Glovebox)	1.67×10^{-10}	Metal	5.01×10^{-10}	5.68×10^{-11}	7.01×10^{-6}	1.67×10^{-7}	4.18×10^{-10}
Spill (Dock)	0.0000125	Metal	0.000045	4.50×10^{-6}	0.525	0.0125	0.00035
Earthquake	0.205	Metal	0.737	0.0737	8,600	205	5.73
Blend Down Process—Building 707							
Explosion	0.100	Metal	0.240	0.0260	4,200	100	2.80
Fire (Room)	0.351	Metal	0.842	0.0912	14,700	351	9.82
Fire (Dock)	0.500	Metal	1.20	0.130	21,000	5.00	14.0
Spill (Glovebox)	1.67×10^{-10}	Metal	5.34×10^{-11}	2.00×10^{-11}	2.51×10^{-6}	1.29×10^{-7}	3.17×10^{-11}
Spill (Dock)	0.0000125	Metal	0.0000300	3.25×10^{-6}	0.525	0.0125	0.000350
Earthquake	0.205	Metal	0.492	0.0533	8,600	205	5.73
Catalytic Chemical Oxidation Process—Building 371							
Explosion	2.00×10^{-7}	Metal	6.00×10^{-7}	6.80×10^{-8}	0.0084	0.0002	5.00×10^{-7}
Nuclear Criticality	[a]	–	0.79	0.11	0.00698	252	0.321
Fire (Room)	0.0305	Metal	0.11	0.011	1,280	30.5	0.854
Fire (Dock)	0.5	Metal	1.80	0.18	21,000	500	14.0
Spill (Glovebox)	4.00×10^{-12}	Metal	1.20×10^{-11}	1.36×10^{-12}	1.68×10^{-7}	4.00×10^{-9}	1.00×10^{-11}
Spill (Dock)	0.0000125	Metal	0.000045	4.50×10^{-6}	0.525	0.0125	0.00035
Earthquake	0.0178	Metal	0.0641	0.00641	748	17.8	0.499
Fluidized Bed Incineration Process—Building 776							
Explosion	0.1	Metal	0.24	0.026	4,200	100	2.80
Fire (Room)	0.0654	Metal	0.157	0.017	2,750	65.4	1.83
Fire (Dock)	0.5	Metal	1.20	0.13	21,000	500	14.0
Spill (Glovebox)	1.87×10^{-10}	Metal	5.98×10^{-11}	2.24×10^{-11}	2.80×10^{-6}	1.44×10^{-7}	3.55×10^{-11}
Spill (Dock)	0.0000125	Metal	0.00003	3.25×10^{-6}	0.525	0.0125	0.00035
Earthquake	0.0382	Metal	0.0917	0.00993	1,600	38.2	1.07
Sonic Wash Process—Building 371							
Explosion	2.00×10^{-7}	Metal	6.00×10^{-7}	6.80×10^{-8}	0.0084	0.0002	5.00×10^{-7}
Fire (Room)	0.0419	Metal	0.151	0.0151	1,760	41.9	1.17
Fire (Dock)	0.5	Metal	1.80	0.18	21,000	500	14.0
Spill (Glovebox)	1.87×10^{-10}	Metal	5.60×10^{-10}	6.35×10^{-11}	7.85×10^{-6}	1.87×10^{-7}	4.67×10^{-10}
Spill (Dock)	0.0000125	Metal	0.000045	4.50×10^{-6}	0.525	0.0125	0.00035
Earthquake	0.0244	Metal	0.088	0.0088	1,030	24.4	0.684

MEI = maximally exposed individual Met = meteorological data

[a] 1.0×10^{19} fissions.

Table D–74 Summary of the Accident Analysis Risks at Rocky Flats in Terms of Latent Cancer Fatalities per Year

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr)		Population (LCF/yr)		Worker (LCF/yr)
		95% Met	50% Met	95% Met	50% Met	50% Met
Blend Down Process—Building 371						
Explosion	0.00005	1.50×10^{-14}	1.70×10^{-15}	2.10×10^{-10}	5.00×10^{-12}	1.00×10^{-14}
Fire (Room)	0.0005	3.16×10^{-7}	3.16×10^{-8}	0.00368	0.0000877	1.96×10^{-6}
Fire (Dock)	2.0×10^{-6}	1.80×10^{-9}	1.80×10^{-10}	0.000021	5.00×10^{-7}	1.12×10^{-8}
Spill (Glovebox)	0.8	2.00×10^{-13}	2.27×10^{-14}	2.81×10^{-9}	6.68×10^{-11}	1.34×10^{-13}
Spill (Dock)	0.001	2.25×10^{-11}	2.25×10^{-12}	2.63×10^{-7}	6.25×10^{-9}	1.40×10^{-10}
Earthquake	0.000094	3.47×10^{-8}	3.47×10^{-9}	0.000404	9.63×10^{-6}	2.16×10^{-7}
Blend Down Process—Building 707						
Explosion	0.00005	6.00×10^{-9}	6.50×10^{-10}	0.000105	2.50×10^{-6}	5.60×10^{-8}
Fire (Room)	0.0005	2.10×10^{-6}	2.28×10^{-8}	0.00368	0.0000877	1.96×10^{-6}
Fire (Dock)	2.0×10^{-6}	1.20×10^{-9}	1.30×10^{-10}	0.0000210	5.00×10^{-7}	1.12×10^{-8}
Spill (Glovebox)	0.8	2.14×10^{-14}	8.02×10^{-15}	1.00×10^{-9}	5.14×10^{-11}	1.02×10^{-14}
Spill (Dock)	0.001	1.50×10^{-11}	1.63×10^{-12}	2.63×10^{-7}	6.25×10^{-9}	1.40×10^{-10}
Earthquake	0.0018	4.42×10^{-7}	4.79×10^{-8}	0.00774	0.000184	4.13×10^{-6}
Catalytic Chemical Oxidation Process—Building 371						
Explosion	0.00005	1.50×10^{-14}	1.70×10^{-15}	2.10×10^{-10}	5.00×10^{-12}	1.00×10^{-14}
Nuclear Criticality	0.0001	3.95×10^{-8}	5.50×10^{-9}	3.49×10^{-10}	0.0000126	1.28×10^{-8}
Fire (Room)	0.0005	2.75×10^{-8}	2.75×10^{-9}	0.00032	7.63×10^{-6}	1.71×10^{-7}
Fire (Dock)	2.0×10^{-6}	1.80×10^{-9}	1.80×10^{-10}	0.000021	5.00×10^{-7}	1.12×10^{-8}
Spill (Glovebox)	0.8	4.80×10^{-15}	5.44×10^{-16}	6.72×10^{-11}	1.60×10^{-12}	3.20×10^{-15}
Spill (Dock)	0.001	2.25×10^{-11}	2.25×10^{-12}	2.63×10^{-7}	6.25×10^{-9}	1.40×10^{-10}
Earthquake	0.000094	3.01×10^{-9}	3.01×10^{-10}	0.0000352	8.37×10^{-7}	1.88×10^{-8}
Fluidized Bed Incineration Process—Building 776						
Explosion	0.00005	6.00×10^{-9}	6.50×10^{-10}	0.000105	2.50×10^{-6}	5.60×10^{-8}
Fire (Room)	0.0005	3.92×10^{-8}	4.25×10^{-9}	0.000687	0.0000164	3.66×10^{-7}
Fire (Dock)	2.0×10^{-6}	1.20×10^{-9}	1.30×10^{-10}	0.0000210	5.00×10^{-7}	1.12×10^{-8}
Spill (Glovebox)	0.8	2.39×10^{-14}	8.97×10^{-15}	1.12×10^{-9}	5.75×10^{-11}	1.14×10^{-14}
Spill (Dock)	0.001	1.50×10^{-11}	1.63×10^{-12}	2.63×10^{-7}	6.25×10^{-9}	1.40×10^{-10}
Earthquake	0.0018	4.58×10^{-8}	4.97×10^{-9}	0.000802	0.0000191	4.28×10^{-7}

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr)		Population (LCF/yr)		Worker (LCF/yr)
		95% Met	50% Met	95% Met	50% Met	50% Met
Sonic Wash Process—Building 371						
Explosion	0.00005	1.50×10^{-14}	1.70×10^{-15}	2.10×10^{-10}	5.00×10^{-12}	1.00×10^{-14}
Fire (Room)	0.0005	3.77×10^{-8}	3.77×10^{-9}	0.000439	0.0000105	2.34×10^{-7}
Fire (Dock)	2.0×10^{-6}	1.80×10^{-9}	1.80×10^{-10}	0.000021	5.00×10^{-7}	1.12×10^{-8}
Spill (Glovebox)	0.8	2.24×10^{-13}	2.54×10^{-14}	3.14×10^{-9}	7.47×10^{-11}	1.49×10^{-13}
Spill (Dock)	0.001	2.25×10^{-11}	2.25×10^{-12}	2.63×10^{-7}	6.25×10^{-9}	1.40×10^{-10}
Earthquake	0.000094	4.14×10^{-9}	4.14×10^{-10}	0.0000482	1.15×10^{-6}	2.57×10^{-8}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.3.3 Processing and Storage with Plutonium Separation

The combustible residues processing technology considered for this alternative is mediated electrochemical oxidation. Most of the mediated electrochemical oxidation process will be performed at Rocky Flats in Building 371, Room 3701. The final calcination in the process will be performed at Rocky Flats in Building 707A, Module J.

Similar accidents are applicable to the mediated electrochemical oxidation processes in both buildings. **Table D–75** provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of processing combustible residues using the mediated electrochemical oxidation technology at Rocky Flats. **Table D–76** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with the processing of combustible residues. The risks associated with this processing technology are summarized in **Table D–77**.

Table D–75 Combustible Residues Accident Scenarios Parameters at Rocky Flats

Accident Scenario	Frequency (per year)	Combustible Residues	HEPA Banks	Material at Risk (grams) MEO Process Building 371	Material at Risk (grams) MEO Process Building 707A [a]
Explosion (Acetylene)	0.00005	2 drums	2/0 [b]	1,000 g [c]	4,000 g
Explosion (Ion Exchange Column)	0.0001	Solution	2	0.245 mg [d]	N/A
Nuclear Criticality	0.0001	Solution	2	1.0×10^{19} fissions	N/A [e]
Fire:					
a. Room	0.0005	5-day supply [f]	2	2,626 g	3,000 g
b. Loading Dock	2.0×10^{-6}	4 drums	0	2,000 g [c]	4,000 g
Spill:					
a. Room [g]	–	–	–	–	–
b. Glovebox	0.8	1 feed prep container	2	93.8 g	1,000 g
c. Loading Dock	0.001	1 drum	0	500 g[c]	3,000 g
Earthquake:					
a. Building 371	0.000094	5-day supply [f]	0	2,626 g	N/A
b. Building 707A	0.0008	5-day supply [f]	0	N/A	3,000 g

Accident Scenario	Frequency (per year)	Combustible Residues	HEPA Banks	Material at Risk (grams) MEO Process Building 371	Material at Risk (grams) MEO Process Building 707A [a]
Aircraft Crash:					
a. Building 371	0.00004	The aircraft will not penetrate the building wall.	–	–	N/A
b. Building 707A	0.00001	Consequences enveloped by the earthquake.	–	N/A	–

Accident Scenario	DR	ARF	RF	LPF	Release Point
Explosion (Acetylene):					
a. Building 707A	1.0	0.001	0.1	1.0	Ground
b. Building 371	1.0	0.001	0.1	2.0×10^{-6}	Elevated
Explosion (Ion Exchange Column) [d]	1.0	1.0	1.0	1.0	Elevated
Nuclear Criticality [e, h]	–	–	–	–	Elevated
Fire:					
a. Room	1.0	0.0005	1.0	0.1	Ground
b. Loading Dock	1.0	0.0005	1.0	0.5	Ground
Spill:					
a. Glovebox	1.0	1.0×10^{-6} [j]	1.0 [j]	2.0×10^{-6}	Elevated
b. Loading Dock	0.25	1.0×10^{-6} [j]	1.0 [j]	0.1	Ground
Earthquake:					
Buildings 371 and 707A	1.0	0.001 [k]	0.1 [k]	0.1	Ground
Aircraft Crash:					
a. Building 707A [l]	–	–	–	–	–
b. Building 371 [m]	–	–	–	–	–

MEO = mediated electrochemical oxidation N/A = not applicable DR = damage ratio ARF = airborne release fraction
RF = respirable fraction LPF = leak path factor

a 1,000-g product drums are transported from Building 371 to Building 707A for processing.
b Building 707A, 0 HEPA Banks; Building 371, 2 HEPA Banks.1.0×10^{-6}.
c 1 drum contains the maximum plutonium content level (500 g) (RFFO 1997).
d Respirable source term value in milligrams of plutonium released up the stack.
e The wet nuclear criticality is not a viable accident scenario for the mediated electrochemical oxidation process in Building 707A.
f 3-day supply of feed and 2-day supply of product.
g Materials are opened in a glovebox. No room spill is considered.
h Refer to Table D–28 for Building 371 mediated electrochemical oxidation criticality accident source term.
j The product of ARF×RF = 1.0×10^{-6}
k Add 0.000192 to ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000292).
l Consequences enveloped by the earthquake.
m The aircraft will not penetrate the building walls.

Table D–76 Summary of the Accident Analysis Doses at Rocky Flats

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Mediated Electrochemical Oxidation Process—Building 371							
Explosion (Acetylene)	2.00×10^{-7}	Metal	6.00×10^{-7}	6.80×10^{-8}	0.0084	0.0002	5.00×10^{-7}
Explosion (Ion Exchange Column)	0.000245	Metal	0.000735	0.0000833	10.3	0.245	0.000613
Criticality (Liquid)	[a]	–	0.79	0.11	6,980	25.2	0.321

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Fire (Room)	0.131	Metal	0.473	0.0473	5,510	131	3.68
Fire (Dock)	0.5	Metal	1.80	0.18	21,000	500	14.0
Spill (Glovebox)	1.88×10^{-10}	Metal	5.63×10^{-10}	6.38×10^{-11}	7.88×10^{-6}	1.88×10^{-7}	4.69×10^{-10}
Spill (Dock)	0.0000125	Metal	0.000045	4.50×10^{-6}	0.525	0.0125	0.00035
Earthquake	0.0767	Metal	0.276	0.0276	3,220	76.7	2.15
Mediated Electrochemical Oxidation Process—Building 707A							
Explosion (Acetylene)	0.4	Oxide	0.48	0.052	10,000	240	8.40
Fire (Room)	0.15	Oxide	0.18	0.0195	3,750	90.0	3.15
Fire (Dock)	1.00	Oxide	1.20	0.13	25,000	600	21.0
Spill (Glovebox)	2.00×10^{-9}	Oxide	3.20×10^{-10}	1.20×10^{-10}	0.0000174	9.00×10^{-7}	2.80×10^{-10}
Spill (Dock)	0.000075	Oxide	0.00009	9.75×10^{-6}	1.88	0.045	0.00158
Earthquake	0.0876	Oxide	0.15	0.0114	2,190	52.6	1.84

MEI = maximally exposed individual Met = meteorological data

[a] 1.0×10^{19} fissions.

Table D–77 Summary of the Accident Analysis Risks at Rocky Flats in Terms of Latent Cancer Fatalities per Year

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr) 95% Met	MEI (LCF/yr) 50% Met	Population (LCF/yr) 95% Met	Population (LCF/yr) 50% Met	Worker (LCF/yr) 50% Met
Mediated Electrochemical Oxidation Process—Building 371						
Explosion (Acetylene)	0.00005	1.50×10^{-14}	1.70×10^{-15}	2.10×10^{-10}	5.00×10^{-12}	1.00×10^{-14}
Explosion (Ion Exchange Column)	0.0001	3.68×10^{-11}	4.17×10^{-12}	5.15×10^{-7}	1.23×10^{-9}	2.45×10^{-11}
Criticality (Liquid)	0.0001	3.95×10^{-8}	5.50×10^{-9}	0.000349	1.26×10^{-6}	1.28×10^{-8}
Fire (Room)	0.0005	1.18×10^{-7}	1.18×10^{-8}	0.00138	0.0000328	7.35×10^{-7}
Fire (Dock)	2.0×10^{-6}	1.80×10^{-9}	1.80×10^{-10}	0.000021	5.00×10^{-7}	1.12×10^{-8}
Spill (Glovebox)	0.8	2.25×10^{-13}	2.55×10^{-14}	3.15×10^{-9}	7.50×10^{-11}	1.50×10^{-13}
Spill (Dock)	0.001	2.25×10^{-11}	2.25×10^{-12}	2.63×10^{-7}	6.25×10^{-9}	1.40×10^{-10}
Earthquake	0.000094	1.30×10^{-8}	1.30×10^{-9}	0.000151	3.60×10^{-6}	8.07×10^{-8}
Mediated Electrochemical Oxidation Process—Building 707A						
Explosion (Acetylene)	0.00005	1.20×10^{-8}	1.30×10^{-9}	0.00025	6.00×10^{-6}	1.68×10^{-7}
Fire (Room)	0.0005	4.50×10^{-8}	4.88×10^{-9}	0.000938	0.0000225	6.30×10^{-7}
Fire (Dock)	2.0×10^{-6}	1.20×10^{-9}	1.30×10^{-10}	0.0000250	6.00×10^{-7}	3.36×10^{-8}
Spill (Glovebox)	0.8	1.28×10^{-13}	4.80×10^{-14}	6.96×10^{-9}	3.60×10^{-10}	8.96×10^{-14}
Spill (Dock)	0.001	4.50×10^{-11}	4.88×10^{-12}	9.38×10^{-7}	2.25×10^{-8}	6.30×10^{-10}
Earthquake	0.0008	4.20×10^{-8}	4.56×10^{-9}	0.000876	0.000021	5.89×10^{-7}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.4 Fluoride Residues

D.3.4.4.1 No Action

The fluoride residues processing technology considered for this alternative is the acid dissolution/plutonium oxide recovery process. Most of the acid dissolution/plutonium oxide recovery process will be performed at Rocky Flats in Building 371, Room 3701. The final calcination will be performed at Rocky Flats in Building 707A, Module J.

Similar accidents are applicable to both buildings. **Table D–78** provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of using the acid dissolution/plutonium oxide recovery process. **Table D–79** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with this processing technology at Rocky Flats. The risks associated with this processing technology at Rocky Flats are summarized in **Table D–80**.

Table D–78 Fluoride Residues Accident Scenarios Parameters
Acid Dissolution/Plutonium Oxide Recovery Process at Rocky Flats

Accident Scenario	*Frequency (per year)*	*Fluoride Residues*	*HEPA Banks*	*Material at Risk (grams)* — *Acid Dissolution/Plutonium Oxide Recovery Process*	
				Building 371	*Building 707A* [a]
Explosion	0.00005	2 drums	2/0 [b]	4,000 g [c]	2,000 g
Nuclear Criticality	0.0001	Solution	2	1.0×10^{19} fissions	N/A [d]
Fire:					
a. Room	0.0005	5-day supply [e]	2	5,600 g	8,000 g
b. Loading Dock	2.0×10^{-6}	4 drums	0	6,000 g [f]	4,000 g
Spill:					
a. Room	0.008	1 container at the maximum limit [g]	2	3,000 g	N/A [g]
b. Glovebox	0.8	1 feed prep container	2	200 g	1,000 g
c. Loading Dock	0.001	1 drum	0	3,000 g [h]	1,000 g
Earthquake:					
a. Building 371	0.000094	5-day supply [e]	0	5,600 g	N/A
b. Building 707A	0.0008	5-day supply [e]	0	N/A	8,000 g
Aircraft Crash:					
a. Building 371	0.00004	The aircraft will not penetrate the building wall.	–	–	N/A
b. Building 707A	0.00001	Consequences enveloped by the earthquake.	–	N/A	–

Accident Scenario	*DR*	*ARF*	*RF*	*LPF*	*Release Point*
Explosion:					
a. Building 707A	1.0	0.001	0.01	1.0	Ground
b. Building 371	1.0	0.001	0.01	2.0×10^{-6}	Elevated
Nuclear Criticality [d,j]	–	–	–	–	Elevated
Fire:					
a. Room	1.0	0.001	0.001	0.1	Ground
b. Loading Dock	0.01	0.001	0.001	0.5	Ground

Accident Scenario	DR	ARF	RF	LPF	Release Point
Spill:					
a. Room [k]	1.0	0.00002	0.01	2.0×10^{-6}	Elevated
b. Glovebox	1.0	0.00002	0.01	2.0×10^{-6}	Elevated
c. Loading Dock	0.25	0.00008	0.5	0.1	Ground
Earthquake:					
Buildings 371 and 707A	1.0	0.002 [l]	0.3 [l]	0.1	Ground
Aircraft Crash:					
a. Building 707A [m]	–	–	–	–	–
b. Building 371 [n]	–	–	–	–	–

N/A = not applicable DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] 1,000-g product drums are transported from Building 371 to Building 707A for processing (1 drum per batch).
[b] Building 707A, 0 HEPA Banks; Building 371, 2 HEPA Banks.
[c] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content.
[d] The wet nuclear criticality is not a viable accident scenario for the process in Building 707A.
[e] 3-day supply of feed and 2-day supply of product.
[f] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.
[g] 1 container per drum of feed.
[h] 1 drum at the maximum plutonium content level.
[j] Refer to Table D–28 for Building 371 criticality accident source term.
[k] Materials are opened in a glovebox in Building 707A. No room spill is considered.
[l] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000792).
[m] Consequences enveloped by the earthquake.
[n] The aircraft will not penetrate the building walls.

Table D–79 Summary of the Accident Analysis Doses Acid Dissolution/Plutonium Oxide Recovery Process at Rocky Flats

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Acid Dissolution/Plutonium Oxide Recovery Process—Building 371							
Explosion	8.00×10^{-8}	Metal	2.40×10^{-7}	2.72×10^{-8}	0.00336	0.00008	2.00×10^{-7}
Criticality (Liquid)	[a]	–	0.79	0.11	6,980	252	0.321
Fire (Room)	0.00056	Metal	0.00202	0.000202	23.5	0.56	0.0157
Fire (Dock)	0.00003	Metal	0.000108	0.0000108	1.26	0.03	0.00084
Spill (Room)	1.20×10^{-9}	Metal	3.60×10^{-9}	4.08×10^{-10}	0.0000504	1.20×10^{-6}	3.00×10^{-9}
Spill (Glovebox)	8.00×10^{-11}	Metal	2.40×10^{-10}	2.72×10^{-11}	3.36×10^{-6}	8.00×10^{-8}	2.00×10^{-10}
Spill (Dock)	0.003	Metal	0.0108	0.00108	126	3.00	0.084
Earthquake	0.444	Metal	1.60	0.16	18,600	444	12.4
Acid Dissolution/Plutonium Oxide Recovery Process—Building 707A							
Explosion	0.02	Oxide	0.024	0.0026	500	12.0	0.42
Fire (Room)	0.0008	Oxide	0.00096	0.000104	0.200	0.48	0.0168
Fire (Dock)	0.00002	Oxide	0.000024	2.60×10^{-6}	0.500	0.012	0.00042

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Spill (Glovebox)	4.00×10^{-10}	Oxide	6.40×10^{-11}	2.40×10^{-11}	3.48×10^{-6}	1.80×10^{-7}	5.60×10^{-11}
Spill (Dock)	0.001	Oxide	0.0012	0.00013	25.0	0.6	0.021
Earthquake	0.634	Oxide	0.76	0.0824	15,800	380	13.3

MEI = maximally exposed individual Met = meteorological data
[a] 1.0×10^{19} fissions.

Table D–80 Summary of the Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year Acid Dissolution/Plutonium Oxide Recovery Process at Rocky Flats

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr) 95% Met	MEI (LCF/yr) 50% Met	Population (LCF/yr) 95% Met	Population (LCF/yr) 50% Met	Worker (LCF/yr) 50% Met
Acid Dissolution/Plutonium Oxide Recovery Process—Building 371						
Explosion	0.00005	6.00×10^{-15}	6.80×10^{-16}	8.40×10^{-11}	2.00×10^{-12}	4.00×10^{-15}
Criticality (Liquid)	0.0001	3.95×10^{-8}	5.50×10^{-9}	0.000349	0.0000126	1.28×10^{-8}
Fire (Room)	0.0005	5.04×10^{-10}	5.04×10^{-11}	5.88×10^{-6}	1.40×10^{-7}	3.14×10^{-9}
Fire (Dock)	2.0×10^{-6}	1.08×10^{-13}	1.08×10^{-14}	1.26×10^{-9}	3.00×10^{-11}	6.72×10^{-13}
Spill (Room)	0.008	1.44×10^{-14}	1.63×10^{-15}	2.02×10^{-10}	4.80×10^{-12}	9.60×10^{-15}
Spill (Glovebox)	0.8	9.60×10^{-14}	1.09×10^{-14}	1.34×10^{-9}	3.20×10^{-11}	6.40×10^{-14}
Spill (Dock)	0.001	5.40×10^{-9}	5.40×10^{-10}	0.000063	1.50×10^{-6}	3.36×10^{-8}
Earthquake	0.000094	7.50×10^{-8}	7.50×10^{-9}	0.000876	0.0000208	4.67×10^{-7}
Acid Dissolution/Plutonium Oxide Recovery Process—Building 707A						
Explosion	0.00005	6.00×10^{-10}	6.50×10^{-11}	0.0000125	3.00×10^{-7}	8.40×10^{-9}
Fire (Room)	0.0005	2.40×10^{-10}	2.60×10^{-11}	5.00×10^{-6}	1.20×10^{-7}	3.36×10^{-9}
Fire (Dock)	2.0×10^{-6}	2.40×10^{-14}	2.60×10^{-15}	5.00×10^{-10}	1.20×10^{-11}	3.36×10^{-13}
Spill (Glovebox)	0.8	2.56×10^{-14}	9.60×10^{-15}	1.39×10^{-9}	7.20×10^{-11}	1.79×10^{-14}
Spill (Dock)	0.001	6.00×10^{-10}	6.50×10^{-11}	0.0000125	3.00×10^{-7}	8.40×10^{-9}
Earthquake	0.0008	3.04×10^{-7}	3.29×10^{-8}	0.00634	0.000152	4.26×10^{-6}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.4.2 Processing and Storage without Plutonium Separation

The fluoride residues processing technology considered for this alternative is blending down. The blend down process will be performed at Rocky Flats in Building 707, Module E. Building 371 is under consideration as an alternate location for the blend down process. The accident analysis evaluates both the primary and alternate locations for the blend down process. **Table D–81** provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of fluoride processing technology at Rocky Flats.

Table D–82 summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with the processing of fluoride residues. The risks associated with this processing technology are summarized in **Table D–83**.

Table D–81 Fluoride Residues Accident Scenarios Parameters Blend Down Process at Rocky Flats

Accident Scenario	*Frequency (per year)*	*Fluoride Residues*	*HEPA Banks*	*Material at Risk (grams)*
Explosion	0.00005	2 drums [a]	0/2 [b]	4,000 g
Nuclear Criticality [c]	–	–	–	–
Fire:				
a. Room	0.0005	5-day supply [d]	2	1,738 g
b. Loading Dock	2.0×10^{-6}	4 drums [e]	0	6,000 g
Spill:				
a. Room	0.008	1 container at the limit [f]	2	600 g
b. Glovebox	0.8	1 feed prep container	2	18.1 g
c. Loading Dock	0.001	1 drum [g]	0	3,000 g
Earthquake:				
a. Building 707	0.0018	5-day supply [d]	0	1,738 g
b. Building 371	0.000094	5-day supply [d]	0	1,738 g
Aircraft Crash:				
a. Building 707	0.00003	Consequences enveloped by the earthquake.	–	–
b. Building 371	0.00004	The aircraft will not penetrate the building walls.	–	–

Accident Scenario	*DR*	*ARF*	*RF*	*LPF*	*Release Point*
Explosion:					
a. Building 707	1.0	0.001	0.01	1.0	Ground
b. Building 371	1.0	0.001	0.01	2.0×10^{-6}	Elevated
Nuclear Criticality [c]	–	–	–	–	–
Fire:					
a. Room	1.0	0.001	0.001	0.1	Ground
b. Loading Dock	0.01	0.001	0.001	0.5	Ground
Spill:					
a. Room	1.0	0.00002	0.01	2.0×10^{-6}	Elevated
b. Glovebox	1.0	0.00002	0.01	2.0×10^{-6}	Elevated
c. Loading Dock	0.25	0.00008	0.5	0.1	Ground
Earthquake	1.0	0.002 [h]	0.3 [h]	0.10	Ground
Aircraft Crash					
a. Building 707 [j]	–	–	–	–	–
b. Building 371 [k]	–	–	–	–	–

DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content.

[b] Building 371, 2 HEPA Banks; Building 707, 0 HEPA Banks.

[c] The wet nuclear criticality is not a viable accident scenario for the blend down technology assessment.

[d] 3-day supply of feed and 2-day supply of product.

[e] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.

[f] 5 containers per drum of feed.

[g] 1 drum at the maximum plutonium content level.

[h] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000792).

[j] Enveloped by the earthquake.

[k] The aircraft will not penetrate the building walls.

Table D–82 Summary of the Accident Analysis Doses Blend Down Process at Rocky Flats

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Building 707							
Explosion	0.04	Metal	0.096	0.0104	1,680	40.0	1.12
Fire (Room)	0.000174	Metal	0.000417	0.0000452	7.30	0.174	0.00487
Fire (Dock)	0.00003	Metal	0.000072	7.80×10^{-6}	1.26	0.03	0.00084
Spill (Room)	2.40×10^{-10}	Metal	7.68×10^{-11}	2.88×10^{-11}	3.60×10^{-6}	1.85×10^{-7}	4.56×10^{-11}
Spill (Glovebox)	7.24×10^{-12}	Metal	2.32×10^{-12}	8.69×10^{-13}	1.09×10^{-7}	5.57×10^{-9}	1.38×10^{-12}
Spill (Dock)	0.003	Metal	0.0072	0.00078	126	3.00	0.084
Earthquake	0.138	Metal	0.330	0.0358	5,780	138	3.85
Building 371							
Explosion	8.00×10^{-8}	Metal	2.40×10^{-7}	2.72×10^{-8}	0.00336	0.0000800	2.00×10^{-7}
Fire (Room)	0.000174	Metal	0.000626	0.0000626	7.30	0.174	0.00487
Fire (Dock)	0.0000300	Metal	0.000108	0.0000108	1.26	0.0300	0.000840
Spill (Room)	2.40×10^{-10}	Metal	7.20×10^{-10}	8.16×10^{-11}	0.0000101	2.40×10^{-7}	6.00×10^{-10}
Spill (Glovebox)	7.24×10^{-12}	Metal	2.17×10^{-11}	2.46×10^{-12}	3.04×10^{-7}	7.24×10^{-9}	1.81×10^{-11}
Spill (Dock)	0.00300	Metal	0.0108	0.00108	126	3.00	0.0840
Earthquake	0.138	Metal	0.496	0.0496	5,780	138	3.85

MEI = maximally exposed individual Met = meteorological data

Table D–83 Summary of the Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year Blend Down Process at Rocky Flats

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr) 95% Met	MEI (LCF/yr) 50% Met	Population (LCF/yr) 95% Met	Population (LCF/yr) 50% Met	Worker (LCF/yr) 50% Met
Building 707						
Explosion	0.00005	2.40×10^{-9}	2.60×10^{-10}	0.000042	1.00×10^{-6}	2.24×10^{-8}
Fire (Room)	0.0005	1.04×10^{-10}	1.13×10^{-11}	1.82×10^{-6}	4.35×10^{-8}	9.73×10^{-10}
Fire (Dock)	2.0×10^{-6}	7.20×10^{-14}	7.80×10^{-15}	1.26×10^{-9}	3.00×10^{-11}	6.72×10^{-13}
Spill (Room)	0.008	3.07×10^{-16}	1.15×10^{-16}	1.44×10^{-11}	7.39×10^{-13}	1.46×10^{-16}
Spill (Glovebox)	0.80	9.27×10^{-16}	3.48×10^{-16}	4.34×10^{-11}	2.23×10^{-12}	4.40×10^{-16}
Spill (Dock)	0.001	3.60×10^{-9}	3.90×10^{-10}	0.000063	1.50×10^{-6}	3.36×10^{-8}
Earthquake	0.0018	2.97×10^{-7}	3.22×10^{-8}	0.0052	0.000124	2.78×10^{-6}
Building 371						
Explosion	0.00005	6.00×10^{-15}	6.80×10^{-16}	8.40×10^{-11}	2.00×10^{-12}	4.00×10^{-15}
Fire (Room)	0.0005	1.56×10^{-10}	1.56×10^{-11}	1.82×10^{-6}	4.35×10^{-8}	9.73×10^{-10}
Fire (Dock)	2.0×10^{-6}	1.08×10^{-13}	1.08×10^{-14}	1.26×10^{-9}	3.00×10^{-11}	6.72×10^{-13}
Spill (Room)	0.008	2.88×10^{-15}	3.26×10^{-16}	4.03×10^{-11}	9.60×10^{-13}	1.92×10^{-15}
Spill (Glovebox)	0.8	8.69×10^{-15}	9.85×10^{-16}	1.22×10^{-10}	2.90×10^{-12}	5.79×10^{-15}
Spill (Dock)	0.001	5.40×10^{-9}	5.40×10^{-10}	0.0000630	1.50×10^{-6}	3.36×10^{-8}
Earthquake	0.000094	2.33×10^{-8}	2.33×10^{-9}	0.000272	6.47×10^{-6}	1.45×10^{-7}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.4.3 Processing with Plutonium Separation

The fluoride residues processing technologies considered for this alternative are the acid dissolution/plutonium oxide recovery process performed at Rocky Flats and the Purex/plutonium metal (or oxide) recovery process performed at the Savannah River Site. At Rocky Flats, most of the acid dissolution/plutonium oxide recovery process will be performed in Building 371, Room 3701. The final calcination will be performed in Building 707A, Module J. For processing at the Savannah River Site, the packaging of the fluoride residues at Rocky Flats will be performed in Building 371, Room 3701. The Purex/plutonium metal (or oxide) recovery process will be performed in canyon facilities at the Savannah River Site.

Similar accidents are applicable to both processing technologies. **Table D–84** provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of the acid dissolution/plutonium oxide recovery processing technology at Rocky Flats. **Table D–85** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with this processing technology at Rocky Flats. The risks associated with this processing technology at Rocky Flats are summarized in **Table D–86**.

Table D–84 Fluoride Residues Accident Scenarios Parameters
Acid Dissolution/Plutonium Oxide Recovery Process at Rocky Flats

Accident Scenario	*Frequency (per year)*	*Fluoride Residues*	*HEPA Banks*	*Material at Risk (grams)* — *Acid Dissolution/Plutonium Oxide Recovery Process* — *Building 371*	*Building 707A* [a]
Explosion	0.00005	2 drums	2/0 [b]	4,000 g [c]	2,000 g
Nuclear Criticality	0.0001	Solution	2	1.0×10^{19} fissions	N/A [d]
Fire:					
a. Room	0.0005	5-day supply [e]	2	5,600 g	8,000 g
b. Loading Dock	2.0×10^{-6}	4 drums	0	6,000 g [f]	4,000 g
Spill:					
a. Room	0.008	1 container at the maximum limit [g]	2	3,000 g	N/A [h]
b. Glovebox	0.80	1 feed prep container	2	200 g	1,000 g
c. Loading Dock	0.001	1 drum	0	3,000 g [j]	1,000 g
Earthquake:					
a. Building 371	0.000094	5-day supply [e]	0	5,600 g	N/A
b. Building 707A	0.0008	5-day supply [e]	0	N/A	8,000 g
Aircraft Crash:					
a. Building 371	0.00004	The aircraft will not penetrate the building wall. Consequences enveloped by the earthquake.	–	–	N/A
b. Building 707A	0.00001		–	N/A	–

Accident Scenario	*DR*	*ARF*	*RF*	*LPF*	*Release Point*
Explosion:					
a. Building 707A	1.0	0.001	0.01	1.0	Ground
b. Building 371	1.0	0.001	0.01	2.0×10^{-6}	Elevated
Nuclear Criticality [d, k]	–	–	–	–	Elevated
Fire:					
a. Room	1.0	0.001	0.001	0.10	Ground
b. Loading Dock	0.01	0.001	0.001	0.50	Ground

Accident Scenario	DR	ARF	RF	LPF	Release Point
Spill:					
a. Room [h]	1.0	0.00002	0.01	2.0×10^{-6}	Elevated
b. Glovebox	1.0	0.00002	0.01	2.0×10^{-6}	Elevated
c. Loading Dock	0.25	0.00008	0.50	0.10	Ground
Earthquake:					
Buildings 371 and 707A	1.0	0.002 [l]	0.30 [l]	0.10	Ground
Aircraft Crash:					
a. Building 707A [m]	–	–	–	–	–
b. Building 371 [n]	–	–	–	–	–

N/A = not applicable DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] 1,000-g product drums are transported from Building 371 to Building 707A for processing.
[b] Building 707A, 0 HEPA Banks; Building 371, 2 HEPA Banks.
[c] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content.
[d] The wet nuclear criticality is not a viable accident scenario for the process in Building 707A.
[e] 3-day supply of feed and 2-day supply of product.
[f] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.
[g] 1 container per drum of feed.
[h] Materials are opened in a glovebox in Building 707A. No room spill is considered.
[j] 1 drum at the maximum plutonium content level.
[k] Refer to Table D–28 for Building 371 criticality accident source term.
[l] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000792).
[m] Consequences enveloped by the earthquake.
[n] The aircraft will not penetrate the building walls.

Table D–85 Summary of the Accident Analysis Doses Acid Dissolution/Plutonium Oxide Recovery Process at Rocky Flats

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Acid Dissolution/Plutonium Oxide Recovery Process—Building 371							
Explosion	8.00×10^{-8}	Metal	2.40×10^{-7}	2.72×10^{-8}	0.00336	0.00008	2.00×10^{-7}
Criticality (Liquid)	[a]	–	0.790	0.110	6,980	252	0.321
Fire (Room)	0.00056	Metal	0.00202	0.000202	23.5	0.560	0.0157
Fire (Dock)	0.00003	Metal	0.000108	0.0000108	1.26	0.03	0.00084
Spill (Room)	1.20×10^{-9}	Metal	3.60×10^{-9}	4.08×10^{-10}	0.0000504	1.20×10^{-6}	3.00×10^{-9}
Spill (Glovebox)	8.00×10^{-11}	Metal	2.40×10^{-10}	2.72×10^{-11}	3.36×10^{-6}	8.00×10^{-8}	2.00×10^{-10}
Spill (Dock)	0.003	Metal	0.0108	0.00108	126	3.00	0.084
Earthquake	0.444	Metal	1.60	0.160	18,600	444	12.4
Acid Dissolution/Plutonium Oxide Recovery Process—Building 707A							
Explosion	0.02	Oxide	0.024	0.0026	500	12.0	0.420
Fire (Room)	0.0008	Oxide	0.00096	0.000104	20.0	0.480	0.0168
Fire (Dock)	0.00002	Oxide	0.000024	2.60×10^{-6}	0.500	0.012	0.00042
Spill (Glovebox)	4.00×10^{-10}	Oxide	6.40×10^{-11}	2.40×10^{-11}	3.48×10^{-6}	1.80×10^{-7}	5.60×10^{-11}
Spill (Dock)	0.001	Oxide	0.0012	0.00013	25.0	0.600	0.021
Earthquake	0.634	Oxide	0.760	0.0824	15,800	380	13.3

MEI = maximally exposed individual Met = meteorological data

[a] 1.0×10^{19} fissions.

Table D–86 Summary of the Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year Acid Dissolution/Plutonium Oxide Recovery Process at Rocky Flats

Accident Scenario	*Accident Frequency (per year)*	*MEI (LCF/yr)*		*Population (LCF/yr)*		*Worker (LCF/yr)*
		95% Met	*50% Met*	*95% Met*	*50% Met*	*50% Met*
Acid Dissolution/Plutonium Oxide Recovery Process—Building 371						
Explosion	0.00005	6.00×10^{-15}	6.80×10^{-16}	8.40×10^{-11}	2.00×10^{-12}	4.00×10^{-15}
Criticality (Liquid)	0.0001	3.95×10^{-8}	5.50×10^{-9}	0.000349	0.0000126	1.28×10^{-8}
Fire (Room)	0.0005	5.04×10^{-10}	5.04×10^{-11}	5.88×10^{-6}	1.40×10^{-7}	3.14×10^{-9}
Fire (Dock)	2.0×10^{-6}	1.08×10^{-13}	1.08×10^{-14}	1.26×10^{-9}	3.00×10^{-11}	6.72×10^{-13}
Spill (Room)	0.008	1.44×10^{-14}	1.63×10^{-15}	2.02×10^{-10}	4.80×10^{-12}	9.60×10^{-15}
Spill (Glovebox)	0.80	9.60×10^{-14}	1.09×10^{-14}	1.34×10^{-9}	3.20×10^{-11}	6.40×10^{-14}
Spill (Dock)	0.001	5.40×10^{-9}	5.40×10^{-10}	0.000063	1.50×10^{-6}	3.36×10^{-8}
Earthquake	0.000094	7.50×10^{-8}	7.50×10^{-9}	0.000876	0.0000208	4.67×10^{-7}
Acid Dissolution/Plutonium Oxide Recovery Process—Building 707A						
Explosion	0.00005	6.00×10^{-10}	6.50×10^{-11}	0.0000125	3.00×10^{-7}	8.40×10^{-9}
Fire (Room)	0.0005	2.40×10^{-10}	2.60×10^{-11}	5.00×10^{-6}	1.20×10^{-7}	3.36×10^{-9}
Fire (Dock)	2.0×10^{-6}	2.40×10^{-14}	2.60×10^{-15}	5.00×10^{-10}	1.20×10^{-11}	3.36×10^{-13}
Spill (Glovebox)	0.80	2.56×10^{-14}	9.60×10^{-15}	1.39×10^{-9}	7.20×10^{-11}	1.79×10^{-14}
Spill (Dock)	0.001	6.00×10^{-10}	6.50×10^{-11}	0.0000125	3.00×10^{-7}	8.40×10^{-9}
Earthquake	0.0008	3.04×10^{-7}	3.29×10^{-8}	0.00634	0.000152	4.26×10^{-6}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

Table D–87 provides the applicable accident scenarios, assumptions, and parameters used in determining the impacts of packaging the fluoride residue at Rocky Flats and of processing the residue using the Purex/plutonium metal recovery process at the Savannah River Site. **Table D–88** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with packaging the residues at Rocky Flats and processing the residues at the Savannah River Site. The risks associated with the packaging at Rocky Flats and the Purex/plutonium metal recovery process at the Savannah River Site are summarized in **Table D–89**. The processes at the Savannah River Site could be performed either in the F-Canyon and FB-Line or in the H-Canyon and HB-Line. Data are presented in Table D–87, Table D–88, and Table D–89 for both options.

Table D–87 Fluoride Residues Accident Scenarios Parameters Purex/Plutonium Metal Recovery Process at the Savannah River Site

Accident Scenario	*Frequency (per year)*	*Fluoride Residues*	*HEPA Banks*	*Material at Risk (grams)*
Rocky Flats Packaging of Residue for Shipment to the Savannah River Site				
Explosion	0.00005	2 drums [a]	2	4,000 g
Nuclear Criticality [b]	–	–	–	–
Fire:				
a. Room	0.0005	5-day supply [c]	2	15,750 g
b. Loading Dock	2.0×10^{-6}	4 drums [d]	0	6,000 g

Accident Scenario	*Frequency (per year)*	*Fluoride Residues*	*HEPA Banks*	*Material at Risk (grams)*
Spill:				
a. Room	0.008	1 container at the maximum limit [e]	2	3,000 g
b. Glovebox	0.80	1 feed prep container	2	375 g
c. Loading Dock	0.001	1 drum [f]	0	3,000 g
Earthquake	0.000094	5-day supply [b]	0	15,750 g
Aircraft Crash	0.00004	The aircraft will not penetrate the building wall.	–	–

Accident Scenario	*DR*	*ARF*	*RF*	*LPF*	*Release Point*
Explosion	1.0	0.001	0.01	2.0×10^{-6}	Elevated
Nuclear Criticality [b]	–	–	–	–	–
Fire:					
a. Room	1.0	0.001	0.001	0.010	Ground
b. Loading Dock	0.01	0.001	0.001	0.50	Ground
Spill:					
a. Room	1.0	0.00002	0.01	2.0×10^{-6}	Elevated
b. Glovebox	1.0	0.00002	0.01	2.0×10^{-6}	Elevated
c. Loading Dock	0.25	0.00008	0.50	0.10	Ground
Earthquake	1.0	0.002 [g]	0.30 [g]	0.10	Ground
Aircraft Crash [h]	–	–	–	–	–

Purex/Plutonium Metal Recovery Process at the Savannah River Site F-Canyon

Accident Scenario	*Frequency (per year)*	*Material at Risk (grams)*
Explosion:		
a. Hydrogen	0.000015	4,000 g
b. Ion Exchange Column	0.0001	120.5 mg [j]
Nuclear Criticality [k]	0.0001	1.0×10^{19} fissions
Fire	0.00061	4,000 g
Spill [l]	–	–
Earthquake:	0.000125	
a. F-Canyon		
Liquid		12,000 g
b. FB-Line		
Powder		1,000 g
Molten Metal		1,000 g
Liquid		1,000 g

Accident Scenario	*DR*	*ARF×RF*	*LPF*	*Release Point*
Explosion				
a. Hydrogen	1.0	0.001	0.005	Elevated
b. Ion Exchange Column	1.0	1.0	1.0	Elevated
Nuclear Criticality [k]	–	–	–	–
Fire	1.0	0.01	0.005	Elevated
Spill [l]	–	–	–	–

Accident Scenario	*DR*	*ARF×RF*	*LPF*	*Release Point*
Earthquake:				
a. F-Canyon				
Liquid	1.0	0.000047	0.10	Ground
b. FB-Line				
Powder	1.0	0.002	0.10	Ground
Molten Metal	1.0	0.0022	0.10	Ground
Liquid	1.0	0.000047	0.10	Ground

Purex/Plutonium Oxide Recovery Process at the Savannah River Site H-Canyon

Accident Scenario	*Frequency (per year)*	*Material at Risk (grams)*
Explosion:		
a. Hydrogen	0.000015	1,000 g
b. Ion Exchange Column	0.0001	241 mg [j, m]
Nuclear Criticality [k]	0.0001	1.0×10^{19} fissions
Fire	0.00061	3,000 g
Spill [j]	–	–
Earthquake:	0.000182	
a. H-Canyon		54,000 g
b. HB-Line		
Powder		4,000 g [m]
Liquid		4,000 g [m]

Accident Scenario	*DR*	*ARF×RF*	*LPF*	*Release Point*
Explosion:				
a. Hydrogen	1.0	0.001	0.005	Elevated
b. Ion Exchange Column	1.0	1.0	1.0	Elevated
Nuclear Criticality [k]	–	–	–	–
Fire	1.0	0.01	0.005	Elevated
Spill [j]	–	–	–	–
Earthquake:				
a. H-Canyon				
Liquid	1.0	0.000047	0.10	Ground
b. HB-Line				
Powder	1.0	0.002	0.010	Ground
Liquid	1.0	0.000047	1.0	Ground

DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content.

[b] The wet nuclear criticality is not a viable accident scenario for the residue packaging process in Building 371.

[c] 3-day supply of feed and 2-day supply of product.

[d] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.

[e] 1 container per drum of feed.

[f] 1 drum at the maximum plutonium content level.

[g] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000792).

[h] The aircraft will not penetrate the building walls.

[j] Respirable source term value in milligrams of plutonium released up the stack.

[k] Refer to Table D–28 for criticality accident source term.

[l] Powder spill is not a viable accident scenario for processing fluoride residue at the Savannah River Site.

[m] Duty cycle = 12.5%.

Table D–88 Summary of the Accident Analysis Doses Purex/Plutonium Metal Recovery Process at the Savannah River Site

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Rocky Flats Packaging of Residue for Shipment to the Savannah River Site							
Explosion	8.00×10^{-8}	Metal	2.40×10^{-7}	2.72×10^{-8}	0.00336	0.00008	2.00×10^{-7}
Fire (Room)	0.00158	Metal	0.00567	0.000567	66.2	1.58	0.0441
Fire (Dock)	0.00003	Metal	0.000108	0.0000108	1.26	0.03	0.00084
Spill (Room)	1.20×10^{-9}	Metal	3.60×10^{-9}	4.08×10^{-10}	0.0000504	1.20×10^{-6}	3.00×10^{-9}
Spill (Glovebox)	1.50×10^{-10}	Metal	4.50×10^{-10}	5.10×10^{-11}	6.30×10^{-6}	1.50×10^{-7}	3.75×10^{-10}
Spill (Dock)	0.003	Metal	0.0108	0.00108	126	3.00	0.084
Earthquake	1.25	Metal	4.49	0.449	52,400	1,250	34.9
Purex/Plutonium Metal Recovery Process at the Savannah River Site F-Canyon							
Explosion (Hydrogen)	0.02	Metal	0.00068	0.00024	36.0	3.20	0.002
Explosion (Ion Exchange Column)	0.121	Metal-FB	0.00374	0.00133	193	18.1	0.0112
Criticality (Liquid)	[a]	–	0.011	0.0044	310	32.0	0.038
Fire	0.200	Metal	0.0068	0.0024	360	32.0	0.02
Earthquake	0.481	Metal	0.0443	0.00818	1,590	111	10.6
Purex/Plutonium Oxide Recovery Process at the Savannah River Site H-Canyon							
Explosion (Hydrogen)	0.005	Metal	0.00016	0.000048	8.00	0.750	0.0005
Explosion (Ion Exchange Column)	0.241	Metal-HB	0.00699	0.00212	342	34.0	0.0224
Criticality (Liquid)	[a]	–	0.009	0.003	290	29.0	0.038
Fire	0.150	Metal	0.0048	0.00144	240	22.5	0.015
Earthquake	1.07	Metal	0.074	0.015	3,330	215	23.6

MEI = maximally exposed individual Met = meteorological data

[a] 1.0×10^{19} fissions.

Table D–89 Summary of the Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year Purex/Plutonium Metal Recovery Process at the Savannah River Site

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr) 95% Met	MEI (LCF/yr) 50% Met	Population (LCF/yr) 95% Met	Population (LCF/yr) 50% Met	Worker (LCF/yr) 50% Met
Rocky Flats Packaging of Residue for Shipment to the Savannah River Site						
Explosion	0.00005	6.00×10^{-15}	6.80×10^{-16}	8.40×10^{-11}	2.00×10^{-12}	4.00×10^{-15}
Fire (Room)	0.0005	1.42×10^{-9}	1.42×10^{-10}	0.0000165	3.94×10^{-7}	8.82×10^{-9}
Fire (Dock)	2.0×10^{-6}	1.08×10^{-13}	1.08×10^{-14}	1.26×10^{-9}	3.00×10^{-11}	6.72×10^{-13}
Spill (Room)	0.008	1.44×10^{-14}	1.63×10^{-15}	2.02×10^{-10}	4.80×10^{-12}	9.60×10^{-15}
Spill (Glovebox)	0.80	1.80×10^{-13}	2.04×10^{-14}	2.52×10^{-9}	6.00×10^{-11}	1.20×10^{-13}
Spill (Dock)	0.001	5.40×10^{-9}	5.40×10^{-10}	0.000063	1.50×10^{-6}	3.36×10^{-8}
Earthquake	0.000094	2.11×10^{-7}	2.11×10^{-8}	0.00246	0.0000586	2.63×10^{-6}

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr)		Population (LCF/yr)		Worker (LCF/yr)
		95% Met	50% Met	95% Met	50% Met	50% Met
Purex/Plutonium Metal Recovery Process at the Savannah River Site F-Canyon						
Explosion (Hydrogen)	0.000015	5.10×10^{-12}	1.80×10^{-12}	2.70×10^{-7}	2.40×10^{-8}	1.20×10^{-11}
Explosion (Ion Exchange Column)	0.000100	1.87×10^{-10}	6.63×10^{-11}	9.64×10^{-6}	9.04×10^{-7}	4.48×10^{-10}
Criticality (Liquid)	0.0001	5.50×10^{-10}	2.20×10^{-10}	0.0000155	1.60×10^{-6}	1.52×10^{-9}
Fire	0.00061	2.07×10^{-9}	7.32×10^{-10}	0.00011	9.76×10^{-6}	4.88×10^{-9}
Earthquake	0.000125	2.77×10^{-9}	5.11×10^{-10}	0.0000992	6.92×10^{-6}	5.29×10^{-7}
Purex Process/Plutonium Oxide Recovery at the Savannah River Site H-Canyon						
Explosion (Hydrogen)	0.000015	1.20×10^{-12}	3.60×10^{-13}	6.00×10^{-8}	5.63×10^{-9}	3.00×10^{-12}
Explosion (Ion Exchange Column)	0.0001	4.37×10^{-11}	1.33×10^{-11}	2.14×10^{-6}	2.12×10^{-7}	1.12×10^{-10}
Criticality (Liquid)	0.0001	4.50×10^{-10}	1.50×10^{-10}	0.0000145	1.45×10^{-6}	1.52×10^{-9}
Fire	0.00061	1.46×10^{-9}	4.39×10^{-10}	0.0000732	6.86×10^{-6}	3.66×10^{-9}
Earthquake	0.000182	2.24×10^{-9}	4.54×10^{-10}	0.0001	6.48×10^{-6}	1.14×10^{-6}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.5 Filter Media Residues

D.3.4.5.1 No Action

The filter media residues processing technology considered for this alternative is neutralize/dry. This process will be conducted within glovebox lines in Building 371, Room 3701, at Rocky Flats.

Table D–90 provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of using the neutralize/dry processing technology for filter media residues. **Table D–91** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with using the neutralize/dry processing technology for filter media residues. The risks associated with this processing technology are summarized in **Table D–92**.

Table D–90 Filter Media Residues Accident Scenarios Parameters Neutralize/Dry Process at Rocky Flats

Accident Scenario	Frequency (per year)	Filter Media Residues	HEPA Banks	Material at Risk (grams)
Explosion	0.00005	2 drums [a]	2	4,000 g
Nuclear Criticality	–	–	–	–
Fire:				
a. Room	0.0005	5-day supply [b]	2	2,968 g
b. Loading Dock	2.0×10^{-6}	4 drums [c]	0	6,000 g
Spill:				
a. Room [d]	–	–	–	–
b. Glovebox	0.80	1 feed prep container	2	212 g
c. Loading Dock	0.001	1 drum [e]	0	3,000 g
Earthquake	0.000094	5-day supply [b]	0	2,968 g
Aircraft Crash	0.00004	Consequences enveloped by the earthquake.	–	–

Accident Scenario	*DR*	*ARF*	*RF*	*LPF*	*Release Point*
Explosion	1.0	0.001	0.01	2.0×10^{-6}	Elevated
Nuclear Criticality [f]	–	–	–	–	–
Fire:					
a. Room	1.0	0.006	0.01	0.10	Ground
b. Loading Dock	0.01	0.006	0.01	0.50	Ground
Spill:					
a. Glovebox	1.0	1.0×10^{-6} [g]	1.0 [g]	2.0×10^{-6}	Elevated
b. Loading Dock	0.25	1.0×10^{-6} [g]	1.0 [g]	0.10	Ground
Earthquake	1.0	0.002 [h]	0.30 [h]	0.10	Ground
Aircraft Crash [j]	–	–	–	–	–

DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content

[b] 3-day supply of feed and 2-day supply of product.

[c] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.

[d] Materials are opened in a glovebox. No room spill is considered.

[e] 1 drum at the maximum plutonium content level.

[f] The wet nuclear criticality is not a viable accident scenario for the neutralize/dry process in Building 371.

[g] The product of ARF×RF = 1.0×10^{-6}.

[h] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000792).

[j] Consequences enveloped by the earthquake.

Table D–91 Summary of the Accident Analysis Doses Neutralize/Dry Process at Rocky Flats

Accident Scenario	*Building Source Term*		*MEI (rem)*		*Population (person-rem)*		*Worker (rem)*
	(grams)	*Type*	*95% Met*	*50% Met*	*95% Met*	*50% Met*	*50% Met*
Explosion	8.00×10^{-8}	Metal	2.40×10^{-7}	2.72×10^{-8}	0.00336	0.00008	2.00×10^{-7}
Fire (Room)	0.0178	Metal	0.0641	0.00641	748	17.8	0.499
Fire (Dock)	0.0018	Metal	0.00648	0.000648	75.6	1.80	0.0504
Spill (Glovebox)	4.24×10^{-10}	Metal	1.27×10^{-9}	1.44×10^{-10}	0.0000178	4.24×10^{-7}	1.06×10^{-9}
Spill (Dock)	0.000075	Metal	0.00027	0.000027	3.15	0.075	0.0021
Earthquake	0.235	Metal	0.846	0.0846	9,870	235	6.58

MEI = maximally exposed individual Met = meteorological data

Table D–92 Summary of the Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year Neutralize/Dry Process at Rocky Flats

Accident Scenario	*Accident Frequency (per year)*	*MEI (LCF/yr)*		*Population (LCF/yr)*		*Worker (LCF/yr)*
		95% Met	*50% Met*	*95% Met*	*50% Met*	*50% Met*
Explosion	0.00005	6.00×10^{-15}	6.80×10^{-16}	8.40×10^{-11}	2.00×10^{-12}	4.00×10^{-15}
Fire (Room)	0.0005	1.60×10^{-8}	1.60×10^{-9}	0.000187	4.45×10^{-6}	9.97×10^{-8}
Fire (Dock)	2.0×10^{-6}	6.48×10^{-12}	6.48×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Glovebox)	0.80	5.09×10^{-13}	5.77×10^{-14}	7.12×10^{-9}	1.70×10^{-10}	3.39×10^{-13}
Spill (Dock)	0.001	1.35×10^{-10}	1.35×10^{-11}	1.58×10^{-6}	3.75×10^{-8}	8.40×10^{-10}
Earthquake	0.000094	3.98×10^{-8}	3.98×10^{-9}	0.000464	0.000011	2.47×10^{-7}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.5.2 Processing and Storage without Plutonium Separation

The filter media residues processing technologies considered for this alternative include vitrification, blend down, fluidized bed incineration, and sonic wash. The vitrification process will be performed at Rocky Flats in Building 707, Modules D, E, and F. The blend down process and the sonic wash process will be performed at Rocky Flats in Building 371, Room 3701. The fluidized bed incineration process will be performed at Rocky Flats in Building 776. Building 707 is under consideration as an alternate location for the blend down process. The accident analysis evaluates both the primary and alternate locations for the blend down process.

The accident data (e.g., explosion, aircraft crash, HEPA banks available) for Building 707 have been used for Building 776.

Similar accidents are applicable to all of these technologies. **Table D–93** provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of processing filter media residues using the processing technologies at Rocky Flats. **Table D–94** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with the processing of filter media residues. The risks associated with these processing technologies are summarized in **Table D–95**.

Table D–93 Filter Media Residues Accident Scenarios Parameters Vitrification, Blend Down, Fluidized Bed Incineration, and Sonic Wash Processes at Rocky Flats

				Material at Risk (grams)			
Accident Scenario	*Frequency (per year)*	*Filter Media Residues*	*HEPA Banks*	*Vitrification Process* [a]	*Blend Down Process* [b]	*Fluidized Bed Incineration Process* [c]	*Sonic Wash Process* [d]
Explosion	0.00005	2 drums [e]	0/2 [f]	4,000 g	4,000 g	4,000 g	4,000 g
Nuclear Criticality [g]	–	–	–	–	–	–	–
Fire:							
a. Room	0.0005	5-day supply [h]	2	4,810 g feed + 3,206 g product [j]	7,014 [a]	2,996 g	1,908 g feed + 1,074 g product [k]
b. Loading Dock	2.0×10^{-6}	4 drums [l]	0	6,000 g	6,000 g	6,000 g	6,000 g powder
Spill:							
a. Room [m]	–	–	–	–	–	–	–
b. Glovebox	0.80	1 feed prep container	2	83.5 g	83.5 g	214 g	214 g
c. Loading Dock	0.001	1 drum [n]	0	3,000 g	3,000 g	3,000 g	3,000 g
Earthquake:							
a. Building 707	0.0018	5-day supply [h]	0	4,810 g feed + 3,206 g product [j]	7,014 g	N/A	N/A
b. Building 776	0.001	5-day supply [h]	0	N/A	N/A	2,996 g	N/A
c. Building 371	0.000094	5-day supply [h]	0	N/A	7,014 g	N/A	1,908 g feed + 1,074 g product [k]
Aircraft Crash:							
a. Building 707	0.00003	Consequences enveloped by the earthquake.	–	–	–	N/A	N/A
b. Building 776	0.00003	Consequences enveloped by the earthquake.	–	N/A	N/A	–	N/A
c. Building 371	0.00004	The aircraft will not penetrate the building wall.	–	N/A	–	N/A	–

Accident Scenario	*DR*	*ARF*	*RF*	*LPF*	*Release Point*
Explosion:					
a. Building 707	1.0	0.001	0.01	1.0	Ground
b. Building 776	1.0	0.001	0.01	1.0	Ground
c. Building 371	1.0	0.001	0.01	2.0×10^{-6}	Elevated

Accident Scenario	*DR*	*ARF*	*RF*	*LPF*	*Release Point*
Nuclear Criticality [g]	–	–	–	–	–
Fire:					
a. Room	1.0	0.006	0.01	0.01	Ground
b. Loading Dock	0.01	0.006	0.01	05.0	Ground
Spill:					
a. Glovebox	1.0	1.0×10^{-6} [p]	1.0 [p]	2.0×10^{-6}	Elevated
b. Loading Dock	0.25	1.0×10^{-6} [p]	1.0 [p]	0.10	Ground
Earthquake:					
a. Building 707	1.0	0.002 [q]	0.30 [q]	0.10	Ground
b. Building 776	1.0	0.002 [q]	0.30 [q]	0.10	Ground
c. Building 371	1.0	0.002 [q]	0.30 [q]	0.10	Ground
Aircraft Crash:					
a. Building 707 [r]	–	–	–	–	–
b. Building 776 [r]	–	–	–	–	–
b. Building 371 [s]	–	–	–	–	–

N/A = not applicable DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] Building 707, Modules D, E, and F.
[b] Building 371, Room 3701, or Building 707.
[c] Building 776.
[d] Building 371, Room 3701.
[e] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content.
[f] Buildings 707 and 776, 0 HEPA Banks; Building 371, 2 HEPA Banks.
[g] The wet nuclear criticality is not a viable accident scenario for the vitrification, blend down, fluidized bed incineration, and sonic wash technology assessments.
[h] 3-day supply of feed and 2-day supply of product.
[j] The product is glass. The effect of the vitrified product on the accident source term is negligible.
[k] 90% of the product is glass, 10% is powder. The effect of the vitrified product on the accident source term is negligible. The powder product is included in the feed accident source term.
[l] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.
[m] Materials are opened in a glovebox. No room spill is considered.
[n] 1 drum at the maximum plutonium content level.
[p] The product of ARF×RF = 1.0×10^{-6}.
[q] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000792).
[r] Consequences enveloped by the earthquake.
[s] The aircraft will not penetrate the building walls.

Table D–94 Summary of the Filter Media Residues Accident Analysis Doses Vitrification, Blend Down, Fluidized Bed Incineration, and Sonic Wash Processes at Rocky Flats

	Building Source Term		*MEI (rem)*		*Population (person-rem)*		*Worker (rem)*
Accident Scenario	*(grams)*	*Type*	*95% Met*	*50% Met*	*95% Met*	*50% Met*	*50% Met*
Vitrification Process							
Explosion	0.04	Metal	0.096	0.0104	1,680	40.0	1.12
Fire (Room)	0.0289	Metal	0.0693	0.0075	121	28.9	0.808
Fire (Dock)	0.0018	Metal	0.00432	0.000468	75.6	1.80	0.0504
Spill (Glovebox)	1.67×10^{-10}	Metal	5.34×10^{-11}	2.00×10^{-11}	2.51×10^{-6}	1.29×10^{-7}	3.17×10^{-11}
Spill (Dock)	0.000075	Metal	0.000180	1.95×10^{-6}	3.15	0.075	0.00210
Earthquake	0.381	Metal	0.914	0.0990	16,000	381	10.7
Blend Down Process—Building 371							
Explosion	8.00×10^{-8}	Metal	2.40×10^{-7}	2.72×10^{-8}	0.00336	0.00008	2.00×10^{-7}
Fire (Room)	0.0421	Metal	0.152	0.0152	1,770	42.1	1.18
Fire (Dock)	0.00180	Metal	0.00648	0.000648	75.6	1.80	0.0504
Spill (Glovebox)	1.67×10^{-10}	Metal	5.01×10^{-10}	5.68×10^{-11}	7.01×10^{-6}	1.67×10^{-7}	4.18×10^{-10}
Spill (Dock)	0.000075	Metal	0.00027	0.000027	3.15	0.075	0.00210

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Earthquake	0.556	Metal	2.00	0.200	23,300	556	15.6
Blend Down Process—Building 707							
Explosion	0.0400	Metal	0.0960	0.0104	1,680	40.0	1.12
Fire (Room)	0.0421	Metal	0.101	0.0109	1,770	42.1	1.18
Fire (Dock)	0.00180	Metal	0.00432	0.000468	75.6	1.80	0.0504
Spill (Glovebox)	1.67×10^{-10}	Metal	5.34×10^{-11}	2.00×10^{-11}	2.51×10^{-6}	1.29×10^{-7}	3.17×10^{-11}
Spill (Dock)	0.0000750	Metal	0.000180	0.0000195	3.15	0.0750	0.00210
Earthquake	0.556	Metal	1.33	0.144	23,300	556	15.6
Fluidized Bed Incineration Process							
Explosion	0.04	Metal	0.096	0.0104	1,680	40.0	1.12
Fire (Room)	0.018	Metal	0.0431	0.00467	755	18.0	0.503
Fire (Dock)	0.00180	Metal	0.00432	0.000468	75.6	1.80	0.0504
Spill (Glovebox)	4.28×10^{-10}	Metal	1.37×10^{-10}	5.14×10^{-11}	6.42×10^{-6}	3.30×10^{-7}	8.13×10^{-11}
Spill (Dock)	0.000075	Metal	0.00018	0.0000195	3.15	0.075	0.00210
Earthquake	0.237	Metal	0.569	0.0617	9,970	237	6.64
Sonic Wash Process							
Explosion	8.00×10^{-8}	Metal	2.40×10^{-7}	2.72×10^{-8}	0.00336	0.00008	2.00×10^{-7}
Fire (Room)	0.0114	Metal	0.0412	0.00412	481	11.4	0.321
Fire (Dock)	0.00180	Metal	0.00648	0.000648	75.6	1.80	0.0504
Spill (Glovebox)	4.28×10^{-10}	Metal	1.28×10^{-9}	1.46×10^{-10}	0.000018	4.28×10^{-7}	1.07×10^{-9}
Spill (Dock)	0.000075	Metal	0.00027	0.000027	3.15	0.075	0.00210
Earthquake	0.151	Metal	0.544	0.0544	6,350	151	4.23

MEI = maximally exposed individual Met = meteorological data

Table D–95 Summary of the Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year Vitrification, Blend Down, Fluidized Bed Incineration, and Sonic Wash at Rocky Flats

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr) 95% Met	MEI (LCF/yr) 50% Met	Population (LCF/yr) 95% Met	Population (LCF/yr) 50% Met	Worker (LCF/yr) 50% Met
Vitrification Process						
Explosion	0.00005	2.40×10^{-9}	2.60×10^{-10}	0.000042	1.00×10^{-6}	2.24×10^{-8}
Fire (Room)	0.0005	1.73×10^{-8}	1.88×10^{-9}	0.000303	7.22×10^{-6}	1.62×10^{-7}
Fire (Dock)	2.0×10^{-6}	4.32×10^{-12}	4.68×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Glovebox)	0.80	2.14×10^{-14}	8.02×10^{-15}	1.00×10^{-9}	5.14×10^{-11}	1.02×10^{-14}
Spill (Dock)	0.0010	9.00×10^{-11}	9.75×10^{-12}	1.58×10^{-6}	3.75×10^{-8}	8.40×10^{-10}
Earthquake	0.0018	8.23×10^{-7}	8.91×10^{-8}	0.0144	0.000343	7.68×10^{-6}
Blend Down Process—Building 371						
Explosion	0.00005	6.00×10^{-15}	6.80×10^{-16}	8.40×10^{-11}	2.00×10^{-12}	4.00×10^{-15}
Fire (Room)	0.0005	3.79×10^{-8}	3.79×10^{-9}	0.000442	0.0000105	2.36×10^{-7}
Fire (Dock)	2.0×10^{-6}	6.48×10^{-12}	6.48×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Glovebox)	0.80	2.00×10^{-13}	2.27×10^{-14}	2.81×10^{-9}	6.68×10^{-11}	1.34×10^{-13}
Spill (Dock)	0.0010	1.35×10^{-10}	1.35×10^{-11}	1.58×10^{-6}	3.75×10^{-8}	8.40×10^{-10}
Earthquake	0.000094	9.40×10^{-8}	9.40×10^{-9}	0.00110	0.0000261	5.85×10^{-7}

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr)		Population (LCF/yr)		Worker (LCF/yr)
		95% Met	50% Met	95% Met	50% Met	50% Met
Blend Down Process—Building 707						
Explosion	0.00005	2.40×10^{-9}	2.60×10^{-10}	0.0000420	1.00×10^{-6}	2.24×10^{-8}
Fire (Room)	0.0005	2.53×10^{-8}	2.74×10^{-9}	0.000442	0.0000105	2.36×10^{-7}
Fire (Dock)	2.0×10^{-6}	4.32×10^{-12}	4.68×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Glovebox)	0.8	2.14×10^{-14}	8.02×10^{-15}	1.00×10^{-9}	5.14×10^{-11}	1.02×10^{-14}
Spill (Dock)	0.001	9.00×10^{-11}	9.75×10^{-12}	1.58×10^{-6}	3.75×10^{-8}	8.40×10^{-10}
Earthquake	0.0018	1.20×10^{-6}	1.30×10^{-7}	0.0210	0.000500	0.0000112
Fluidized Bed Incineration Process						
Explosion	0.00005	2.40×10^{-9}	2.60×10^{-10}	0.000042	1.00×10^{-6}	2.24×10^{-8}
Fire (Room)	0.0005	1.08×10^{-8}	1.17×10^{-9}	0.000189	4.49×10^{-6}	1.01×10^{-7}
Fire (Dock)	2.0×10^{-6}	4.32×10^{-12}	4.68×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Glovebox)	0.80	5.48×10^{-14}	2.05×10^{-14}	2.57×10^{-9}	1.32×10^{-10}	2.60×10^{-14}
Spill (Dock)	0.0010	9.00×10^{-11}	9.75×10^{-12}	1.58×10^{-6}	3.75×10^{-8}	8.40×10^{-10}
Earthquake	0.0018	2.85×10^{-7}	3.08×10^{-8}	0.00498	0.000119	2.66×10^{-6}
Sonic Wash Process						
Explosion	0.00005	6.00×10^{-15}	6.80×10^{-16}	8.40×10^{-11}	2.00×10^{-12}	4.00×10^{-15}
Fire (Room)	0.0005	1.03×10^{-8}	1.03×10^{-9}	0.00012	2.86×10^{-6}	6.41×10^{-8}
Fire (Dock)	2.0×10^{-6}	6.48×10^{-12}	6.48×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Glovebox)	0.80	5.14×10^{-13}	5.82×10^{-14}	7.19×10^{-9}	1.71×10^{-10}	3.42×10^{-13}
Spill (Dock)	0.0010	1.35×10^{-10}	1.35×10^{-11}	1.58×10^{-6}	3.75×10^{-8}	8.40×10^{-10}
Earthquake	0.000094	2.56×10^{-8}	2.56×10^{-9}	0.000298	0.0000710	1.59×10^{-7}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.5.3 Processing and Storage with Plutonium Separation

The filter media residues processing technology considered for this alternative is mediated electrochemical oxidation. Most of the mediated electrochemical oxidation process will be performed at Rocky Flats in Building 371, Room 3701. The final calcination in the process will be performed at Rocky Flats in Building 707A, Module J.

Similar accidents are applicable to the mediated electrochemical oxidation processes in both buildings. **Table D–96** provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of processing filter media residues using the mediated electrochemical oxidation technology at Rocky Flats. **Table D–97** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with the processing of filter media residues. The risks associated with this processing technology are summarized in **Table D–98**.

Table D–96 Filter Media Residues Accident Scenarios Parameters Mediated Electrochemical Oxidation at Rocky Flats

Accident Scenario	Frequency (per year)	Filter Media Residues	HEPA Banks	Material at Risk (grams) MEO Process: Building 371	Material at Risk (grams) MEO Process: Building 707A [a]
Explosion (Acetylene)	0.00005	2 drums [b]	2/0 [c]	4,000 g powder	2,000 g
Explosion (Ion Exchange Column)	0.0001	Solution	2	0.245 mg [d]	N/A
Nuclear Criticality [e]	0.0001	Solution	2	1.0×10^{19} fissions	N/A [f]
Fire:					
a. Room	0.0005	5-day supply [g]	2	5,572 g	6,000 g
b. Loading Dock	2.0×10^{-6}	4 drums [h]	0	6,000 g	4,000 g
Spill:					
a. Room [j]	–	–	–	–	–
b. Glovebox	0.80	1 feed prep container	2	200 g	1,000 g
c. Loading Dock	0.0010	1 drum [k]	0	3,000 g	1,000 g
Earthquake:					
a. Building 371	0.000094	5-day supply [g]	0	5,572 g	N/A
b. Building 707A	0.0008	5-day supply [g]	0	N/A	6,000 g
Aircraft Crash:					
a. Building 371	0.00004	The aircraft will not penetrate the building wall.	–	–	N/A
b. Building 707A	0.00001	Consequences enveloped by the earthquake.	–	N/A	–

Accident Scenario	DR	ARF	RF	LPF	Release Point
Explosion (Acetylene):					
a. Building 707A	1.0	0.001	0.01	1.0	Ground
b. Building 371	1.0	0.001	0.01	2.0×10^{-6}	Elevated
Explosion (Ion Exchange Column) [l]	1.0	1.0	1.0	1.0	Elevated
Nuclear Criticality [e, f]	–	–	–	–	Elevated
Fire:					
a. Room	1.0	0.0060	0.01	0.10	Ground
b. Loading Dock	0.01	0.0060	0.01	0.50	Ground
Spill:					
a. Glovebox	1.0	1.0×10^{-6} [m]	1.0 [m]	2.0×10^{-6}	Elevated
b. Loading Dock	0.25	1.0×10^{-6} [m]	1.0 [m]	0.10	Ground
Earthquake:					
Buildings 371 and 707A	1.0	0.002 [d]	0.30 [d]	0.10	Ground
Aircraft Crash:					
a. Building 707A [n]	–	–	–	–	–
b. Building 371 [p]	–	–	–	–	–

MEO = mediated electrochemical oxidation N/A = not applicable DR = damage ratio ARF = airborne release fraction
RF = respirable fraction LPF = leak path factor

[a] 1,000-g product container transported from Building 371 to Building 707A for processing.
[b] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content.
[c] Building 707A, 0 HEPA Banks; Building 371, 2 HEPA Banks.
[d] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000792).
[e] Refer to Table D–28 for Building 371 mediated electrochemical oxidation criticality accident source term.
[f] The wet nuclear criticality is not a viable accident scenario for the mediated electrochemical oxidation process in Building 707A.
[g] 3-day supply of feed and 2-day supply of product.
[h] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.
[j] Materials are opened in a glovebox. No room spill is considered.
[k] 1 drum at the maximum plutonium content level.
[l] Respirable source term value in milligrams of plutonium released up the stack.
[m] The product of ARF×RF = 1.0×10^{-6}.
[n] Consequences enveloped by the earthquake.
[p] The aircraft will not penetrate the building walls.

Table D–97 Summary of the Accident Analysis Doses Mediated Electrochemical Oxidation at Rocky Flats

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Mediated Electrochemical Oxidation Process—Building 371							
Explosion (Acetylene)	8.00×10^{-8}	Metal	2.40×10^{-7}	2.72×10^{-8}	0.00336	0.00008	2.00×10^{-7}
Explosion (Ion Exchange Column)	0.000245	Metal	0.000735	0.0000833	10.3	0.245	0.000613
Criticality (Liquid)	[a]	–	0.790	0.110	6,980	252	0.321
Fire (Room)	0.0334	Metal	0.120	0.012	1,400	33.4	0.936
Fire (Dock)	0.0018	Metal	0.00648	0.000648	75.6	1.80	0.0504
Spill (Glovebox)	4.00×10^{-10}	Metal	1.20×10^{-9}	1.36×10^{-10}	0.0000168	4.00×10^{-7}	1.00×10^{-9}
Spill (Dock)	0.000075	Metal	0.00027	0.000027	3.15	0.075	0.0021
Earthquake	0.441	Metal	1.59	0.159	18,500	441	12.4
Mediated Electrochemical Oxidation Process—Building 707A							
Explosion (Acetylene)	0.02	Oxide	0.024	0.0026	500	12.0	0.420
Fire (Room)	0.036	Oxide	0.0432	0.00468	900	21.6	0.756
Fire (Dock)	0.0012	Oxide	0.00144	0.000156	30.0	0.720	0.0252
Spill (Glovebox)	2.00×10^{-9}	Oxide	3.20×10^{-10}	1.20×10^{-10}	0.0000174	9.00×10^{-7}	2.80×10^{-10}
Spill (Dock)	0.000025	Oxide	0.00003	3.25×10^{-6}	0.625	0.015	0.000525
Earthquake	0.475	Oxide	0.570	0.0618	11,900	285	9.98

MEI = maximally exposed individual Met = meteorological data

[a] 1.0×10^{19} fissions.

Table D–98 Summary of the Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year Mediated Electrochemical Oxidation at Rocky Flats

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr) 95% Met	MEI (LCF/yr) 50% Met	Population (LCF/yr) 95% Met	Population (LCF/yr) 50% Met	Worker (LCF/yr) 50% Met
Mediated Electrochemical Oxidation Process—Building 371						
Explosion (Acetylene)	0.00005	6.00×10^{-15}	6.80×10^{-16}	8.40×10^{-11}	2.00×10^{-12}	4.00×10^{-15}
Explosion (Ion Exchange Column)	0.0001	3.68×10^{-11}	4.17×10^{-12}	5.15×10^{-7}	1.23×10^{-8}	2.45×10^{-11}
Criticality (Liquid)	0.0001	3.95×10^{-8}	5.50×10^{-9}	0.000349	0.0000126	1.28×10^{-8}
Fire (Room)	0.0005	3.01×10^{-8}	3.01×10^{-9}	0.000351	8.36×10^{-6}	1.87×10^{-7}
Fire (Dock)	2.0×10^{-6}	6.48×10^{-12}	6.48×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Glovebox)	0.80	4.80×10^{-13}	5.44×10^{-14}	6.72×10^{-9}	1.60×10^{-10}	3.20×10^{-13}
Spill (Dock)	0.001	1.35×10^{-10}	1.35×10^{-11}	1.58×10^{-6}	3.75×10^{-8}	8.40×10^{-10}
Earthquake	0.000094	7.47×10^{-8}	7.47×10^{-9}	0.000871	0.0000207	4.65×10^{-7}

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr)		Population (LCF/yr)		Worker (LCF/yr)
		95% Met	50% Met	95% Met	50% Met	50% Met
Mediated Electrochemical Oxidation Process—Building 707A						
Explosion (Acetylene)	0.00005	6.00×10^{-10}	6.50×10^{-11}	0.0000125	3.00×10^{-7}	8.40×10^{-9}
Fire (Room)	0.0005	1.08×10^{-8}	1.17×10^{-9}	0.000225	5.40×10^{-6}	1.51×10^{-7}
Fire (Dock)	2.0×10^{-6}	1.44×10^{-12}	1.56×10^{-13}	3.00×10^{-8}	7.20×10^{-10}	2.02×10^{-11}
Spill (Glovebox)	0.80	1.28×10^{-13}	4.80×10^{-14}	6.96×10^{-9}	3.60×10^{-10}	8.96×10^{-14}
Spill (Dock)	0.001	1.50×10^{-11}	1.63×10^{-12}	3.13×10^{-7}	7.50×10^{-9}	2.10×10^{-10}
Earthquake	0.0008	2.28×10^{-7}	2.47×10^{-8}	0.00475	0.000114	3.19×10^{-6}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.6 Sludge Residues

D.3.4.6.1 No Action

The sludge residues processing technology considered for this alternative is filter/dry. The processing of the sludge residues will be conducted within glovebox lines at Rocky Flats in Building 371, Room 3701.

Table D–99 provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of the filter/dry processing of sludge residues at Rocky Flats. **Table D–100** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with the processing of sludge residues at Rocky Flats. The risks associated with this processing technology are summarized in **Table D–101**.

Table D–99 Sludge Residues Accident Scenarios Parameters—Filter/Dry at Rocky Flats

Accident Scenario	Frequency (per year)	Sludge Residues	HEPA Banks	Material at Risk (grams)
Explosion	0.00005	2 drums [a]	0	4,000 g
Nuclear Criticality	–	–	–	–
Fire:				
a. Room	0.0005	5-day supply [b]	2	1,218 g
b. Loading Dock	2.0×10^{-6}	4 drums [c]	0	6,000 g
Spill:				
a. Room	0.008	1 container at the maximum limit [d]	2	600 g
b. Glovebox	0.8	1 feed prep container	2	87 g
c. Loading Dock	0.001	1 drum [e]	0	3,000 g
Earthquake	0.000094	5-day supply [b]	0	1,218 g
Aircraft Crash	0.00004	Consequences enveloped by the earthquake.	–	–

Accident Scenario	DR	ARF	RF	LPF	Release Point
Explosion	1.0	0.001	0.10	2.0×10^{-6}	Elevated
Nuclear Criticality [f]	–	–	–	–	–
Fire:					
a. Room	1.0	0.006	0.01	0.1	Ground
b. Loading Dock	0.01	0.006	0.01	0.5	Ground

Accident Scenario	DR	ARF	RF	LPF	Release Point
Spill:					
a. Room	1.0	0.00002	0.5	2.0×10^{-6}	Elevated
b. Glovebox	1.0	0.00002	0.5	2.0×10^{-6}	Elevated
c. Loading Dock	0.25	0.00008	0.5	0.1	Ground
Earthquake	1.0	0.002 [g]	0.3 [g]	0.1	Ground
Aircraft Crash [h]	–	–	–	–	–

DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content

[b] 3-day supply of feed and 2-day supply of product.

[c] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.

[d] 5 containers per drum of feed.

[e] 1 drum at the maximum plutonium content level.

[f] The wet nuclear criticality is not a viable accident scenario for the filter/dry process in Building 371.

[g] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000792).

[h] Consequences enveloped by the earthquake.

Table D–100 Summary of the Sludge Residues Accident Analysis Doses—Filter/Dry at Rocky Flats

	Building Source Term		MEI (rem)		Population (person-rem)		Worker (rem)
Accident Scenario	(grams)	Type	95% Met	50% Met	95% Met	50% Met	50% Met
Explosion	8.00×10^{-7}	Metal	2.40×10^{-6}	2.72×10^{-7}	0.0336	0.0008	2.00×10^{-6}
Fire (Room)	0.00731	Metal	0.0263	0.00263	307	7.31	0.205
Fire (Dock)	0.0018	Metal	0.00648	0.000648	75.6	1.80	0.0504
Spill (Room)	1.20×10^{-8}	Metal	3.60×10^{-8}	4.08×10^{-9}	0.000504	0.000012	3.00×10^{-8}
Spill (Glovebox)	1.74×10^{-9}	Metal	5.22×10^{-9}	5.92×10^{-10}	0.0000731	1.74×10^{-6}	4.35×10^{-9}
Spill (Dock)	0.003	Metal	0.0108	0.00108	126	3.00	0.084
Earthquake	0.0965	Metal	0.347	0.0347	4,050	96.5	2.70

MEI = maximally exposed individual Met = meteorological data

Table D–101 Summary of the Sludge Residues Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year—Filter/Dry at Rocky Flats

	Accident Frequency	MEI (LCF/yr)		Population (LCF/yr)		Worker (LCF/yr)
Accident Scenario	(per year)	95% Met	50% Met	95% Met	50% Met	50% Met
Explosion	0.00005	6.00×10^{-14}	6.80×10^{-15}	8.40×10^{-10}	2.00×10^{-11}	4.00×10^{-14}
Fire (Room)	0.0005	6.58×10^{-9}	6.58×10^{-10}	0.0000767	1.83×10^{-6}	4.09×10^{-8}
Fire (Dock)	2.0×10^{-6}	6.48×10^{-12}	6.48×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Room)	0.008	1.44×10^{-13}	1.63×10^{-14}	2.02×10^{-9}	4.80×10^{-11}	9.60×10^{-14}
Spill (Glovebox)	0.80	2.09×10^{-12}	2.37×10^{-13}	2.92×10^{-8}	6.96×10^{-10}	1.39×10^{-12}
Spill (Dock)	0.001	5.40×10^{-9}	5.40×10^{-10}	0.000063	1.50×10^{-6}	3.36×10^{-8}
Earthquake	0.000094	1.63×10^{-8}	1.63×10^{-9}	0.00019	4.53×10^{-6}	1.02×10^{-7}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.6.2 Processing and Storage without Plutonium Separation

The sludge residues processing technologies considered for this alternative are vitrification and blend down. The vitrification process will be performed at Rocky Flats in Building 707, Modules D, E, and F. The blend down process will be performed at Rocky Flats in Building 707, Module E. Building 371 is under consideration as an alternate location for the blend down process. The accident analysis evaluates both the primary and alternate locations for the blend down process. Similar accidents are applicable to both these technologies. **Table D–102** provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of sludge processing technologies at Rocky Flats. **Table D–103** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with the processing of sludge residues. The risks associated with these processing technologies are summarized in **Table D–104**.

Table D–102 Sludge Residues Accident Scenarios Parameters Vitrification Process and Blend Down Process at Rocky Flats

Accident Scenario	*Frequency (per year)*	*Sludge Residues*	*HEPA Banks*	*Material at Risk (grams)*	
				Vitrification Process [a]	*Blend Down Process* [b]
Explosion	0.00005	2 drums [c]	2/0 [d]	4,000 g	4,000 g
Nuclear Criticality [e]	–	–	–	–	–
Fire:					
a. Room	0.0005	5-day supply [f]	2	4,810 g feed + 3,206 g product [g]	8,016 g
b. Loading Dock	2.0×10^{-6}	4 drums [h]	0	6,000 g	6,000 g
Spill:					
a. Room	0.008	1 container at the maximum limit [j]	2	600 g	600 g
b. Glovebox	0.8	1 feed prep container	2	83.5 g	83.5 g
c. Loading Dock	0.001	1 drum [k]	0	3,000 g	3,000 g
Earthquake:					
a. Building 707	0.0018	5-day supply [f]	0	4,810 g feed + 3,206 g product [g]	8,016 g
b. Building 371	0.000094	5-day supply [f]	0	N/A	8,016 g
Aircraft Crash:					
a. Building 707	0.00003	Consequences enveloped by the earthquake.	–	–	–
b. Building 371	0.00004	The aircraft will not penetrate the building walls.	–	–	–

Accident Scenario	*DR*	*ARF*	*RF*	*LPF*	*Release Point*
Explosion:					
a. Building 707	1	0.001	0.1	1	Ground
b. Building 371	1	0.001	0.1	2.0×10^{-6}	Elevated
Nuclear Criticality [e]	–	–	–	–	–
Fire:					
a. Room	1.0	0.006	0.01	0.0105.0	Ground
b. Loading Dock	0.01	0.006	0.01		Ground
Spill:					
a. Room	1.0	0.00002	0.50	2.0×10^{-6}	Elevated
b. Glovebox	1.0	0.00002	0.050	2.0×10^{-6}	Elevated
c. Loading Dock	0.25	0.00008	5.0	0.10	Ground
Earthquake	1.0	0.002 [l]	0.30 [l]	0.10	Ground
Aircraft Crash					
a. Building 707 [m]	–	–	–	–	–
b. Building 371 [n]	–	–	–	–	–

DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] Building 707, Modules D, E, and F, or Building 707.

[b] Building 707, Module E.

[c] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content.

[d] Building 371, 2 HEPA Banks; Building 707, 0 HEPA Banks.

[e] The wet nuclear criticality is not a viable accident scenario for the vitrification and blend down technology assessments.
[f] 3-day supply of feed and 2-day supply of product.
[g] The product is glass. The effect of the vitrified product on the accident source term is negligible.
[h] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.
[j] 5 containers per drum of feed.
[k] 1 drum at the maximum plutonium content level.
[l] Add 0.000192 to all (ARF×RF) values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000792).
[m] Consequences enveloped by the earthquake.
[n] The aircraft will not penetrate the building walls.

Table D–103 Summary of the Sludge Residues Accident Analysis Doses Vitrification Process and Blend Down Process at Rocky Flats

	Building Source Term		*MEI (rem)*		*Population (person-rem)*		*Worker (rem)*
Accident Scenario	*(grams)*	*Type*	*95% Met*	*50% Met*	*95% Met*	*50% Met*	*50% Met*
Vitrification Process							
Explosion	0.400	Metal	0.960	0.104	16,800	400	11.2
Fire (Room)	0.0289	Metal	0.0693	0.0075	1,210	28.9	0.808
Fire (Dock)	0.0018	Metal	0.00432	0.000468	75.6	1.80	0.0504
Spill (Room)	1.20×10^{-8}	Metal	3.84×10^{-9}	1.44×10^{-9}	0.00018	9.24×10^{-6}	2.28×10^{-9}
Spill (Glovebox)	1.67×10^{-9}	Metal	5.34×10^{-10}	2.00×10^{-10}	0.0000251	1.29×10^{-6}	3.17×10^{-10}
Spill (Dock)	0.003	Metal	0.0072	0.00078	126	3.00	0.084
Earthquake	0.381	Metal	0.914	0.099	16,000	381	10.7
Blend Down Process—Building 707							
Explosion	0.400	Metal	0.960	0.104	16,800	400	11.2
Fire (Room)	0.0481	Metal	0.115	0.0125	2,020	48.1	1.35
Fire (Dock)	0.0018	Metal	0.00432	0.000468	75.6	1.80	0.0504
Spill (Room)	1.20×10^{-8}	Metal	3.84×10^{-9}	1.44×10^{-9}	0.00018	9.24×10^{-6}	2.28×10^{-9}
Spill (Glovebox)	1.67×10^{-9}	Metal	5.34×10^{-10}	2.00×10^{-10}	0.0000251	1.29×10^{-6}	3.17×10^{-10}
Spill (Dock)	0.003	Metal	0.0072	0.00078	126	3.00	0.084
Earthquake	0.635	Metal	1.52	0.165	26,700	635	17.8
Blend Down Process—Building 371							
Explosion	8.00×10^{-7}	Metal	2.40×10^{-6}	2.72×10^{-7}	0.0336	0.000800	2.00×10^{-6}
Fire (Room)	0.0481	Metal	0.173	0.0173	2,020	48.1	1.35
Fire (Dock)	0.00180	Metal	0.00648	0.000648	75.6	1.80	0.0504
Spill (Room)	1.20×10^{-8}	Metal	3.60×10^{-8}	4.08×10^{-9}	0.000504	0.0000120	3.00×10^{-8}
Spill (Glovebox)	1.67×10^{-9}	Metal	5.01×10^{-9}	5.68×10^{-10}	0.0000701	1.67×10^{-6}	4.18×10^{-9}
Spill (Dock)	0.00300	Metal	0.0108	0.00108	126	3.00	0.0840
Earthquake	0.635	Metal	2.29	0.229	26,700	635	17.8

MEI = maximally exposed individual Met = meteorological data

Table D–104 Summary of the Sludge Residues Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year—Vitrification Process and Blend Down Process at Rocky Flats

Accident Scenario	*Accident Frequency (per year)*	*MEI (LCF/yr)*		*Population (LCF/yr)*		*Worker (LCF/yr)*
		95% Met	*50% Met*	*95% Met*	*50% Met*	*50% Met*
Vitrification Process						
Explosion	0.00005	2.40×10^{-8}	2.60×10^{-9}	0.00042	0.00001	2.24×10^{-7}
Fire (Room)	0.0005	1.73×10^{-8}	1.88×10^{-9}	0.000303	7.22×10^{-6}	1.62×10^{-7}
Fire (Dock)	2.0×10^{-6}	4.32×10^{-12}	4.68×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Room)	0.008	1.54×10^{-14}	5.76×10^{-15}	7.20×10^{-10}	3.70×10^{-11}	7.30×10^{-15}
Spill (Glovebox)	0.80	2.14×10^{-13}	8.02×10^{-14}	1.00×10^{-8}	5.14×10^{-10}	1.02×10^{-13}
Spill (Dock)	0.001	3.60×10^{-9}	3.90×10^{-10}	0.000063	1.50×10^{-6}	3.36×10^{-8}
Earthquake	0.0018	8.23×10^{-7}	8.91×10^{-8}	0.0144	0.000343	7.68×10^{-6}
Blend Down Process—Building 707						
Explosion	0.00005	2.40×10^{-8}	2.60×10^{-9}	0.00042	0.00001	2.24×10^{-7}
Fire (Room)	0.0005	2.89×10^{-8}	3.13×10^{-9}	0.000505	0.000012	2.69×10^{-7}
Fire (Dock)	2.0×10^{-6}	4.32×10^{-12}	4.68×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Room)	0.008	1.54×10^{-14}	5.76×10^{-15}	7.20×10^{-10}	3.70×10^{-11}	7.30×10^{-15}
Spill (Glovebox)	0.80	2.14×10^{-13}	8.02×10^{-14}	1.00×10^{-8}	5.14×10^{-10}	1.02×10^{-13}
Spill (Dock)	0.001	3.60×10^{-9}	3.90×10^{-10}	0.000063	1.50×10^{-6}	3.36×10^{-8}
Earthquake	0.0018	1.37×10^{-6}	1.49×10^{-7}	0.024	0.000571	0.0000128
Blend Down Process—Building 371						
Explosion	0.00005	6.00×10^{-14}	6.80×10^{-15}	8.40×10^{-10}	2.00×10^{-11}	4.00×10^{-14}
Fire (Room)	0.0005	4.33×10^{-8}	4.33×10^{-9}	0.000505	0.0000120	2.69×10^{-7}
Fire (Dock)	2.0×10^{-6}	6.48×10^{-12}	6.48×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Room)	0.008	1.44×10^{-13}	1.63×10^{-14}	2.02×10^{-9}	4.80×10^{-11}	9.60×10^{-14}
Spill (Glovebox)	0.8	2.00×10^{-12}	2.27×10^{-13}	2.81×10^{-8}	6.68×10^{-10}	1.34×10^{-12}
Spill (Dock)	0.001	5.40×10^{-9}	5.40×10^{-10}	0.0000630	1.50×10^{-6}	3.36×10^{-8}
Earthquake	0.000094	1.07×10^{-7}	1.07×10^{-8}	0.00125	0.0000298	6.68×10^{-7}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.6.3 Processing and Storage with Plutonium Separation

The sludge residues processing technology considered for this alternative is the acid dissolution/plutonium oxide recovery process. Most of the process will be performed at Rocky Flats in Building 371, Room 3701. The final calcination will be performed at Rocky Flats in Building 707A, Module J.

Similar accidents are applicable to the process in both buildings. **Table D–105** provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of the sludge processing technology at Rocky Flats. **Table D–106** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with the processing of sludge residues. The risks associated with the acid dissolution/plutonium oxide recovery process are summarized in **Table D–107**.

Table D–105 Sludge Residues Accident Scenarios Parameters Acid Dissolution/Plutonium Oxide Recovery Process at Rocky Flats

Accident Scenario	*Frequency (per year)*	*Sludge Residues*	*HEPA Banks*	*Material at Risk (grams)* — *Acid Dissolution/Plutonium Oxide Recovery Process*	
				Building 371	*Building 707A* [a]
Explosion	0.00005	2 drums	2/0 [b]	4,000 g [c]	2,000 g
Nuclear Criticality	0.0001	Solution	2	1.0×10^{19} fissions	N/A [d]
Fire:					
a. Room	0.0005	5-day supply [e]	2	560 g	8,000 g
b. Loading Dock	2.0×10^{-6}	4 drums	0	6,000 g [f]	4,000 g
Spill:					
a. Room	0.008	1 container at the maximum limit [g]	2	600 g	N/A [h]
b. Glovebox	0.8	1 feed prep container	2	20 g	1,000 g
c. Loading Dock	0.001	1 drum	0	3,000 [j]	1,000 g
Earthquake:					
a. Building 371	0.000094	5-day supply [e]	0	560 g	N/A
b. Building 707A	0.0008	5-day supply [e]	0	N/A	8,000 g
Aircraft Crash:					
a. Building 371	0.00004	The aircraft will not penetrate the building wall.	–	–	N/A
b. Building 707A	0.00001	Consequences enveloped by the earthquake.	–	N/A	–

Accident Scenario	*DR*	*ARF*	*RF*	*LPF*	*Release Point*
Explosion:					
a. Building 707A	1.0	0.001	0.010	1.0	Ground
b. Building 371	1.0	0.001	1.0	2.0×10^{-6}	Elevated
Nuclear Criticality [d, k]	–	–	–	–	Elevated
Fire:					
a. Room	1.0	0.006	0.01	0.010	Ground
b. Loading Dock	0.01	0.006	0.01	5.0	Ground
Spill:					
a. Room [h]	1.0	0.00002	0.50	2.0×10^{-6}	Elevated
b. Glovebox	1.0	0.00002	0.50	2.0×10^{-6}	Elevated
c. Loading Dock	0.25	0.00008	0.50	0.10	Ground
Earthquake:					
Buildings 371 and 707A	1.0	0.002 [l]	0.30 [l]	0.10	Ground
Aircraft Crash:					
a. Building 707A [m]	–	–	–	–	–
b. Building 371 [n]	–	–	–	–	–

N/A = not applicable DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] 1,000-g product containers are transported from Building 371 to Building 707A for processing.

[b] Building 707A, 0 HEPA Banks; Building 371, 2 HEPA Banks.

[c] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content.
[d] The wet nuclear criticality is not a viable accident scenario for the process in Building 707A.
[e] 3-day supply of feed and 2-day supply of product.
[f] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.
[g] 5 containers per drum of feed.
[h] Materials are opened in a glovebox in Building 707A. No room spill is considered.
[j] 1 drum at the maximum plutonium content level.
[k] Refer to Table D–28 for Building 371 criticality accident source term.
[l] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000792).
[m] Consequences enveloped by the earthquake.
[n] The aircraft will not penetrate the building walls.

Table D–106 Summary of the Sludge Residues Accident Analysis Doses Acid Dissolution/Plutonium Oxide Recovery Process at Rocky Flats

Accident Scenario	*Building Source Term*		*MEI (rem)*		*Population (person-rem)*		*Worker (rem)*
	(grams)	*Type*	*95% Met*	*50% Met*	*95% Met*	*50% Met*	*50% Met*
Acid Dissolution/Plutonium Oxide Recovery Process—Building 371							
Explosion	8.00×10^{-7}	Oxide	1.20×10^{-6}	1.36×10^{-7}	0.02	0.00048	1.44×10^{-6}
Criticality (Liquid)	[a]	–	0.790	0.110	6,980	252	0.321
Fire (Room)	0.00336	Metal	0.0121	0.00121	141	3.36	0.0941
Fire (Dock)	0.0018	Metal	0.00648	0.000648	75.6	1.80	0.0504
Spill (Room)	1.20×10^{-8}	Oxide	2.16×10^{-8}	2.16×10^{-9}	0.0003	7.20×10^{-6}	2.52×10^{-7}
Spill (Glovebox)	4.00×10^{-10}	Oxide	6.00×10^{-10}	6.80×10^{-11}	0.00001	2.40×10^{-7}	7.20×10^{-10}
Spill (Dock)	0.003	Oxide	0.0054	0.00054	75.0	1.80	0.063
Earthquake	0.0444	Oxide	0.0798	0.00798	1,110	26.6	0.931
Acid Dissolution/Plutonium Oxide Recovery Process—Building 707A							
Explosion	0.200	Oxide	0.240	0.026	5,000	120	4.20
Fire (Room)	0.048	Oxide	0.0576	0.00624	1,200	28.8	1.01
Fire (Dock)	0.0012	Oxide	0.00144	0.000156	30.0	0.720	0.0252
Spill (Glovebox)	2.00×10^{-8}	Oxide	3.20×10^{-9}	1.20×10^{-9}	0.000174	9.00×10^{-6}	2.80×10^{-9}
Spill (Dock)	0.001	Oxide	0.0012	0.00013	25.0	0.600	0.021
Earthquake	0.634	Oxide	0.760	0.0824	15,800	380	13.3

MEI = maximally exposed individual Met = meteorological data

Table D–107 Summary of the Sludge Residues Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year—Acid Dissolution/Plutonium Oxide Recovery Process at Rocky Flats

Accident Scenario	*Accident Frequency (per year)*	*MEI (LCF/yr)*		*Population (LCF/yr)*		*Worker (LCF/yr)*
		95% Met	*50% Met*	*95% Met*	*50% Met*	*50% Met*
Acid Dissolution/Plutonium Oxide Recovery Process—Building 371						
Explosion	0.00005	3.00×10^{-14}	3.40×10^{-15}	5.00×10^{-10}	1.20×10^{-11}	2.88×10^{-14}
Criticality (Liquid)	0.0001	3.95×10^{-8}	5.50×10^{-9}	0.000349	0.0000126	1.28×10^{-8}
Fire (Room)	0.0005	3.02×10^{-9}	3.02×10^{-10}	0.0000353	8.40×10^{-7}	1.88×10^{-8}
Fire (Dock)	2.0×10^{-6}	6.48×10^{-12}	6.48×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Room)	0.008	8.64×10^{-14}	8.64×10^{-15}	1.20×10^{-9}	2.88×10^{-11}	8.06×10^{-13}
Spill (Glovebox)	0.80	2.40×10^{-13}	2.72×10^{-14}	4.00×10^{-9}	9.60×10^{-11}	2.30×10^{-13}
Spill (Dock)	0.001	2.70×10^{-9}	2.70×10^{-10}	0.0000375	9.00×10^{-7}	2.52×10^{-8}
Earthquake	0.000094	3.75×10^{-9}	3.75×10^{-10}	0.0000521	1.25×10^{-6}	3.50×10^{-8}
Acid Dissolution/Plutonium Oxide Recovery Process—Building 707A						
Explosion	0.00005	6.00×10^{-9}	6.50×10^{-10}	0.000125	3.00×10^{-6}	8.40×10^{-8}
Fire (Room)	0.0005	1.44×10^{-8}	1.56×10^{-9}	0.0003	7.20×10^{-6}	2.02×10^{-7}
Fire (Dock)	2.0×10^{-6}	1.44×10^{-12}	1.56×10^{-13}	3.00×10^{-8}	7.20×10^{-10}	2.02×10^{-11}
Spill (Glovebox)	0.80	1.28×10^{-12}	4.80×10^{-13}	6.96×10^{-8}	3.60×10^{-9}	8.96×10^{-13}
Spill (Dock)	0.001	6.00×10^{-10}	6.50×10^{-11}	0.0000125	3.00×10^{-7}	8.40×10^{-9}
Earthquake	0.0008	3.04×10^{-7}	3.29×10^{-8}	0.00634	0.000152	4.26×10^{-6}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.7 Glass Residues

D.3.4.7.1 No Action

The glass residues processing technology considered for this alternative is neutralize/dry. This process will be conducted within glovebox lines at Rocky Flats in Building 371, Room 3701.

Table D–108 provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of the neutralize/dry processing of glass residues. **Table D–109** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with this processing of glass residues. The risks associated with this processing technology are summarized in **Table D–110**.

Table D–108 Glass Residues Accident Scenarios Parameters—Neutralize/Dry at Rocky Flats

Accident Scenario	*Frequency (per year)*	*Glass Residues*	*HEPA Banks*	*Material at Risk (grams)*
Explosion	0.00005	2 drums [a]	0	4,000 g
Nuclear Criticality	–	–	–	–
Fire:				
a. Room	0.0005	5-day supply [b]	2	2,646 g
b. Loading Dock	2.0×10^{-6}	4 drums [c]	0	6,000 g

Accident Scenario	Frequency (per year)	Glass Residues	HEPA Banks	Material at Risk (grams)
Spill:				
a. Room [d]	–	–	–	–
b. Glovebox	0.80	1 feed prep container	2	189 g
c. Loading Dock	0.001	1 drum [e]	0	3,000 g
Earthquake	0.000094	5-day supply [b]	0	2,646 g
Aircraft Crash	0.00004	Consequences enveloped by the earthquake.	–	–

Accident Scenario	DR	ARF	RF	LPF	Release Point
Explosion	1.0	0.001	0.10	2.0×10^{-6}	Elevated
Nuclear Criticality [f]	–	–	–	–	–
Fire:					
a. Room	1.0	0.006	0.01	0.10	Ground
b. Loading Dock	0.01	0.006	0.01	0.50	Ground
Spill:					
a. Glovebox	1.0	1.0×10^{-6} [g]	1.0 [g]	2.0×10^{-6}	Elevated
b. Loading Dock	0.25	1.0×10^{-6} [g]	1.0 [g]	0.10	Ground
Earthquake	1.0	0.002 [h]	0.30 [h]	0.10	Ground
Aircraft Crash [j]	–	–	–	–	–

DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content.

[b] 3-day supply of feed and 2-day supply of product.

[c] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.

[d] Materials are opened in a glovebox. No room spill is considered.

[e] 1 drum at the maximum plutonium content level.

[f] The wet nuclear criticality is not a viable accident scenario for the neutralize/dry process in Building 371.

[g] The product of ARF×RF = 1.0×10^{-6}.

[h] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000792).

[j] Consequences enveloped by the earthquake.

Table D–109 Summary of the Glass Residues Accident Analysis Doses Neutralize/Dry at Rocky Flats

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Explosion	8.00×10^{-7}	Metal		2.72×10^{-7}	0.0336	0.0008	2.00×10^{-6}
Fire (Room)	0.0159	Metal	0.0572	0.00572	667	15.9	0.445
Fire (Dock)	0.0018	Metal	0.00648	0.000648	75.6	1.80	0.0504
Spill (Glovebox)	3.78×10^{-10}	Metal	1.13×10^{-9}	1.29×10^{-10}	0.0000159	3.78×10^{-7}	9.45×10^{-10}
Spill (Dock)	0.000075	Metal	0.00027	0.000027	3.15	0.075	0.0021
Earthquake	0.210	Metal	0.754	0.0754	8,800	210	5.87

MEI = maximally exposed individual Met = meteorological data

Table D–110 Summary of the Glass Residues Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year—Neutralize/Dry at Rocky Flats

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr)		Population (LCF/yr)		Worker (LCF/yr)
		95% Met	50% Met	95% Met	50% Met	50% Met
Explosion	0.00005	6.00×10^{-14}	6.80×10^{-15}	8.40×10^{-10}	2.00×10^{-11}	4.00×10^{-14}
Fire (Room)	0.0005	1.43×10^{-8}	1.43×10^{-9}	0.000167	3.97×10^{-6}	8.89×10^{-8}
Fire (Dock)	2.0×10^{-6}	6.48×10^{-12}	6.48×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Glovebox)	0.80	4.54×10^{-13}	5.14×10^{-14}	6.35×10^{-9}	1.51×10^{-10}	3.02×10^{-13}
Spill (Dock)	0.001	1.35×10^{-10}	1.35×10^{-11}	1.58×10^{-6}	3.75×10^{-8}	8.40×10^{-10}
Earthquake	0.000094	3.55×10^{-8}	3.55×10^{-9}	0.000414	9.85×10^{-6}	2.21×10^{-7}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.7.2 Processing and Storage without Plutonium Separation

The glass residues processing technologies considered for this alternative are vitrification, blend down, and sonic wash. The vitrification process will be performed at Rocky Flats in Building 707, Modules D, E, and F. The blend down and sonic wash processes will be performed at Rocky Flats in Building 371, Room 3701. Building 707 is under consideration as an alternate location for the blend down process. The accident analysis evaluates both the primary and alternate locations for the blend down process.

Similar accidents are applicable to all of these technologies. **Table D–111** provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of glass residues processing at Rocky Flats. **Table D–112** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with the processing of glass residues. The risks associated with these processing technologies are summarized in **Table D–113**.

Table D–111 Glass Residues Accident Scenarios Parameters Vitrification Process, Blend Down Process, and Sonic Wash Process at Rocky Flats

Accident Scenario	Frequency (per year)	Glass Residues	HEPA Banks	Material at Risk (grams)		
				Vitrification Process [a]	Blend Down Process [b]	Sonic Wash Process [c]
Explosion	0.00005	2 drums [d]	0/2 [e]	4,000 g	4,000 g	4,000 g
Nuclear criticality [f]	–	–	–	–	–	–
Fire:						
a. Room	0.0005	5-day supply [g]	2	4,810 g feed + 3,206 g product [h]	7,014 g powder	1,588 g feed + 1,058 g product [h]
b. Loading Dock	2.0×10^{-6}	4 drums [j]	0	6,000 g	6,000 g	6,000 g
Spill:						
a. Room [k]	–	–	–	–	–	–
b. Glovebox	0.80	1 feed prep container	2	83.5 g	83.5 g	189 g
c. Loading Dock	0.001	1 drum [l]	0	3,000 g	3,000 g	3,000 g
Earthquake:						
a. Building 707	0.0018	5-day supply [g]	0	4,810 g feed + 3,206 g product [h]	7,014 g	N/A
b. Building 371	0.000094	5-day supply [g]	0	N/A	7,014 g	1,588 g feed + 1,058 g product [h]

Accident Scenario	Frequency (per year)	Glass Residues	HEPA Banks	Material at Risk (grams)		
				Vitrification Process [a]	Blend Down Process [b]	Sonic Wash Process [c]
Aircraft Crash:						
a. Building 707	0.00003	Consequences enveloped by the earthquake.	–	–	–	N/A
b. Building 371	0.00004	The aircraft will not penetrate the building wall.	–	N/A	–	–

Accident Scenario	DR	ARF	RF	LPF	Release Point
Explosion:					
a. Building 707	1.0	0.001	0.1	1.0	Ground
b. Building 371	1.0	0.001	0.1	2.0×10^{-6}	Elevated
Nuclear criticality [f]	–	–	–	–	–
Fire:					
a. Room	1.0	0.006	0.01	0.1	Ground
b. Loading Dock	0.01	0.006	0.01	0.5	Ground
Spill:					
a. Glovebox	1.0	1.0×10^{-6} [m]	1.0 [m]	2.0×10^{-6}	Elevated
b. Loading Dock	0.25	1.0×10^{-6} [m]	1.0 [m]	0.10	Ground
Earthquake:					
a. Building 707	1.0	0.002 [n]	0.30 [n]	0.1	Ground
b. Building 371	1.0	0.002 [n]	0.30 [n]	0.1	Ground
Aircraft Crash:					
a. Building 707 [p]	–	–	–	–	–
b. Building 371 [q]	–	–	–	–	–

N/A = not applicable DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] Building 707, Modules D, E, and F.
[b] Building 371, Room 3701, or Building 707.
[c] Building 371, Room 3701.
[d] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content.
[e] Building 707, 0 HEPA Banks; Building 371, 2 HEPA Banks.
[f] The wet nuclear criticality is not a viable accident scenario for the vitrification, blend down, and sonic wash technology assessments.
[g] 3-day supply of feed and 2-day supply of product.
[h] The product is glass. The effect of the vitrified product on the accident source term is negligible.
[j] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.
[k] Materials are opened in a glovebox. No room spill is considered.
[l] 1 drum at the maximum plutonium content level.
[m] The product of ARF×RF = 1.0×10^{-6}.
[n] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000792).
[p] Consequences enveloped by the earthquake.
[q] The aircraft will not penetrate the building walls.

Table D–112 Summary of the Glass Residues Accident Analysis Doses Vitrification Process, Blend Down Process, Sonic Wash Process at Rocky Flats

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Vitrification Process							
Explosion	0.400	Metal	0.960	0.104	16,800	400	11.2
Fire (Room)	0.0289	Metal	0.0693	0.00750	1,210	28.9	0.808
Fire (Dock)	0.0018	Metal	0.00432	0.000468	75.6	1.80	0.0504
Spill (Glovebox)	1.67×10^{-10}	Metal	5.34×10^{-11}	2.00×10^{-11}	2.51×10^{-6}	1.29×10^{-7}	3.17×10^{-11}
Spill (Dock)	0.000075	Metal	0.00018	0.0000195	3.15	0.075	0.0021
Earthquake	0.381	Metal	0.914	0.099	16,000	381	10.7

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Blend Down Process—Building 371							
Explosion	8.00×10^{-7}	Metal	2.40×10^{-6}	2.72×10^{-7}	0.0336	0.0008	2.00×10^{-6}
Fire (Room)	0.0421	Metal	0.152	0.0152	1,770	42.1	1.18
Fire (Dock)	0.0018	Metal	0.00648	0.000648	75.6	1.80	0.0504
Spill (Glovebox)	1.67×10^{-10}	Metal	5.01×10^{-10}	5.68×10^{-11}	7.01×10^{-6}	1.67×10^{-7}	4.18×10^{-10}
Spill (Dock)	0.000075	Metal	0.00027	0.000027	3.15	0.075	0.0021
Earthquake	0.556	Metal	2.00	0.200	23,300	556	15.6
Blend Down Process—Building 707							
Explosion	0.400	Metal	0.960	0.104	16,800	400	11.2
Fire (Room)	0.0421	Metal	0.101	0.0109	1,770	42.1	1.18
Fire (Dock)	0.00180	Metal	0.00432	0.000468	75.6	1.80	0.0504
Spill (Glovebox)	1.67×10^{-10}	Metal	5.34×10^{-11}	2.00×10^{-11}	2.51×10^{-6}	1.29×10^{-7}	3.17×10^{-11}
Spill (Dock)	0.000750	Metal	0.000180	0.0000195	3.15	0.0750	0.00210
Earthquake	0.556	Metal	1.33	0.144	23,300	556	15.6
Sonic Wash Process							
Explosion	8.00×10^{-7}	Metal	2.40×10^{-6}	2.72×10^{-7}	0.0336	0.0008	2.00×10^{-6}
Fire (Room)	0.00953	Metal	0.0343	0.00343	400	9.53	0.267
Fire (Dock)	0.0018	Metal	0.00648	0.000648	75.6	1.80	0.0504
Spill (Glovebox)	3.78×10^{-10}	Metal	1.13×10^{-9}	1.29×10^{-10}	0.0000159	3.78×10^{-7}	9.45×10^{-10}
Spill (Dock)	0.000075	Metal	0.00027	0.000027	3.15	0.075	0.00210
Earthquake	0.126	Metal	0.453	0.0453	5,280	126	3.52

MEI = maximally exposed individual Met = meteorological data

Table D–113 Summary of the Glass Residues Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year—Vitrification Process, Blend Down Process, Sonic Wash Process at Rocky Flats

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr) 95% Met	MEI (LCF/yr) 50% Met	Population (LCF/yr) 95% Met	Population (LCF/yr) 50% Met	Worker (LCF/yr) 50% Met
Vitrification Process						
Explosion	0.00005	2.40×10^{-8}	2.60×10^{-9}	0.00042	0.00001	2.24×10^{-7}
Fire (Room)	0.0005	1.73×10^{-8}	1.88×10^{-9}	0.000303	7.21×10^{-6}	1.62×10^{-7}
Fire (Dock)	2.0×10^{-6}	4.32×10^{-12}	4.68×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Glovebox)	0.80	2.14×10^{-14}	8.02×10^{-15}	1.00×10^{-9}	5.14×10^{-11}	1.02×10^{-14}
Spill (Dock)	0.001	9.00×10^{-11}	9.75×10^{-12}	1.58×10^{-6}	3.75×10^{-8}	8.40×10^{-10}
Earthquake	0.0018	8.23×10^{-7}	8.91×10^{-8}	0.0144	0.000343	7.68×10^{-6}
Blend Down Process—Building 371						
Explosion	0.00005	6.00×10^{-14}	6.80×10^{-15}	8.40×10^{-10}	2.00×10^{-11}	4.00×10^{-14}
Fire (Room)	0.0005	3.79×10^{-8}	3.79×10^{-9}	0.000442	0.0000105	2.36×10^{-7}
Fire (Dock)	2.0×10^{-6}	6.48×10^{-12}	6.48×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr)		Population (LCF/yr)		Worker (LCF/yr)
		95% Met	50% Met	95% Met	50% Met	50% Met
Spill (Glovebox)	0.80	2.00×10^{-13}	2.27×10^{-14}	2.81×10^{-9}	6.68×10^{-11}	1.34×10^{-13}
Spill (Dock)	0.001	1.35×10^{-10}	1.35×10^{-11}	1.58×10^{-6}	3.75×10^{-8}	8.40×10^{-10}
Earthquake	0.000094	9.40×10^{-8}	9.40×10^{-9}	0.0011	0.0000261	5.85×10^{-7}
Blend Down Process—Building 707						
Explosion	0.00005	2.40×10^{-8}	2.60×10^{-9}	0.000420	0.0000100	2.24×10^{-7}
Fire (Room)	0.0005	2.53×10^{-8}	2.74×10^{-9}	0.000442	0.0000105	2.36×10^{-7}
Fire (Dock)	2.0×10^{-6}	4.32×10^{-12}	4.68×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Glovebox)	0.8	2.14×10^{-14}	8.02×10^{-15}	1.00×10^{-9}	5.14×10^{-11}	1.02×10^{-14}
Spill (Dock)	0.001	9.00×10^{-11}	9.75×10^{-12}	1.58×10^{-6}	3.75×10^{-8}	8.40×10^{-14}
Earthquake	0.0018	1.20×10^{-6}	1.30×10^{-7}	0.0210	0.000500	0.0000112
Sonic Wash Process						
Explosion	0.00005	6.00×10^{-14}	6.80×10^{-15}	8.40×10^{-10}	2.00×10^{-11}	4.00×10^{-14}
Fire (Room)	0.0005	8.58×10^{-9}	8.58×10^{-10}	0.0001	2.38×10^{-6}	5.34×10^{-8}
Fire (Dock)	2.0×10^{-6}	6.48×10^{-12}	6.48×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Glovebox)	0.80	4.54×10^{-13}	5.14×10^{-14}	6.35×10^{-9}	1.51×10^{-10}	3.02×10^{-13}
Spill (Dock)	0.001	1.35×10^{-10}	1.35×10^{-11}	1.58×10^{-6}	3.75×10^{-8}	8.40×10^{-10}
Earthquake	0.000094	2.13×10^{-8}	2.13×10^{-9}	0.000248	5.91×10^{-6}	1.32×10^{-7}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.7.3 Processing and Storage with Plutonium Separation

The glass residues processing technology considered for this alternative is mediated electrochemical oxidation. Most of the mediated electrochemical oxidation process will be performed at Rocky Flats in Building 371, Room 3701. The final calcination in the process will be performed at Rocky Flats in Building 707A, Module J.

Similar accidents are applicable to the mediated electrochemical oxidation processes in both buildings. **Table D–114** provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of processing glass residues using the mediated electrochemical oxidation technology at Rocky Flats. **Table D–115** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with the processing of glass residues. The risks associated with this processing technology are summarized in **Table D–116**.

Table D–114 Glass Residues Accident Scenarios Parameters Mediated Electrochemical Oxidation at Rocky Flats

Accident Scenario	Frequency (per year)	Glass Residues	HEPA Banks	Material at Risk (grams) MEO Process Building 371	Material at Risk (grams) MEO Process Building 707A
Explosion (Acetylene)	0.00005	2 drums	2/0 [a]	4,000 g [b]	1,960 g [c]
Explosion (Ion Exchange Column)	0.0001	Solution	2	0.245 mg [d]	N/A
Nuclear Criticality	0.0001	Solution	2	1.0×10^{19} fissions	N/A [e]
Fire:					
a. Room	0.0005	5-day supply [f]	2	5,180 g	14,700 g
b. Loading Dock	2.0×10^{-6}	4 drums	0	6,000 g [g]	3,920 g [c]
Spill:					
a. Room [h]	–	–	–	–	–
b. Glovebox	0.80	1 feed prep container	2	200 g	980 g
c. Loading Dock	0.001	1 drum	0	3,000 g [j]	980 g [c]
Earthquake:					
a. Building 371	0.000094	5-day supply [f]	0	5,180 g	N/A
b. Building 707A	0.0008	5-day supply [f]	0	N/A	14,700 g
Aircraft Crash:					
a. Building 371	0.00004	The aircraft will not penetrate the building wall.	–	–	N/A
b. Building 707A	0.00001	Consequences enveloped by the earthquake.	–	N/A	–

Accident Scenario	DR	ARF	RF	LPF	Release Point
Explosion (Acetylene):					
a. Building 707A	1.0	0.001	0.1	1.0	Ground
b. Building 371	1.0	0.001	0.1	2.0×10^{-6}	Elevated
Explosion (Ion Exchange Column) [d]	1.0	1.0	1.0	1.0	Elevated
Nuclear Criticality [e, k]	–	–	–	–	Elevated
Fire:					
a. Room	1.0	0.006	0.01	0.10	Ground
b. Loading Dock	0.01	0.006	0.01	0.50	Ground
Spill:					
a. Glovebox	1.0	1.0×10^{-6} [l]	1.0 [l]	2.0×10^{-6}	Elevated
b. Loading Dock	0.25	1.0×10^{-6} [l]	1.0 [l]	0.10	Ground
Earthquake:					
Buildings 371 and 707A	1.0	0.002 [m]	0.30 [m]	0.10	Ground
Aircraft Crash:					
a. Building 707A [n]	–	–	–	–	–
b. Building 371 [p]	–	–	–	–	–

N/A = not applicable DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] Building 707A, 0 HEPA Banks; Building 371, 2 HEPA Banks.
[b] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content.
[c] 980-g product containers are transported from Building 371 to Building 707A for processing.
[d] Respirable source term value in milligrams of plutonium released up the stack.
[e] The wet nuclear criticality is not a viable accident scenario for the mediated electrochemical oxidation process in Building 707A.
[f] 3-day supply of feed and 2-day supply of product.
[g] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.
[h] Materials are opened in a glovebox. No room spill is considered.
[j] 1 drum at the maximum plutonium content level.
[k] Refer to Table D–28 for Building 371 mediated electrochemical oxidation criticality accident source term.
[l] The product of ARF×RF = 1.0×10^{-6}.
[m] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000792).
[n] Consequences enveloped by the earthquake.
[p] The aircraft will not penetrate the building walls.

Table D–115 Summary of the Glass Residues Accident Analysis Doses Mediated Electrochemical Oxidation at Rocky Flats

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Mediated Electrochemical Oxidation Process—Building 371							
Explosion (Acetylene)	8.00×10^{-7}	Metal	2.40×10^{-6}	2.72×10^{-7}	0.0336	0.0008	2.00×10^{-6}
Explosion (Ion Exchange Column)	0.000245	Metal	0.000735	0.0000833	10.3	0.245	0.000613
Criticality (Liquid)	[a]	–	0.790	0.110	6,980	252	0.321
Fire (Room)	0.0311	Metal	0.112	0.0112	1,310	31.1	0.870
Fire (Dock)	0.0018	Metal	0.00648	0.000648	75.6	1.80	0.0504
Spill (Glovebox)	4.00×10^{-10}	Metal	1.20×10^{-9}	1.36×10^{-10}	0.0000168	4.00×10^{-7}	1.00×10^{-9}
Spill (Dock)	0.000075	Metal	0.00027	0.000027	3.15	0.075	0.0021
Earthquake	0.410	Metal	1.48	0.148	17,200	410	11.5
Mediated Electrochemical Oxidation Process—Building 707A							
Explosion (Acetylene)	0.196	Oxide	0.235	0.0255	4,900	118	4.12
Fire (Room)	0.0882	Oxide	0.106	0.0115	2,210	52.9	1.85
Fire (Dock)	0.00118	Oxide	0.00141	0.000153	29.4	0.706	0.0247
Spill (Glovebox)	1.96×10^{-9}	Oxide	3.14×10^{-10}	1.18×10^{-10}	0.0000171	8.82×10^{-7}	2.74×10^{-10}
Spill (Dock)	0.0000245	Oxide	0.0000294	3.19×10^{-6}	0.613	0.0147	0.000515
Earthquake	1.16	Oxide	1.40	0.151	29,100	699	24.4

MEI = maximally exposed individual Met = meteorological data
[a] 1.0×10^{19} fissions.

Table D–116 Summary of the Glass Residues Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year—Mediated Electrochemical Oxidation at Rocky Flats

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr) 95% Met	MEI (LCF/yr) 50% Met	Population (LCF/yr) 95% Met	Population (LCF/yr) 50% Met	Worker (LCF/yr) 50% Met
Mediated Electrochemical Oxidation Process—Building 371						
Explosion (Acetylene)	0.00005	6.00×10^{-14}	6.80×10^{-15}	8.40×10^{-10}	2.00×10^{-11}	4.00×10^{-14}
Explosion (Ion Exchange Column)	0.0001	3.68×10^{-11}	4.17×10^{-12}	5.15×10^{-7}	1.23×10^{-8}	2.45×10^{-11}
Criticality (Liquid)	0.0001	3.95×10^{-8}	5.50×10^{-9}	0.000349	0.0000126	1.28×10^{-8}
Fire (Room)	0.0005	2.80×10^{-8}	2.80×10^{-9}	0.000326	7.77×10^{-6}	1.74×10^{-7}
Fire (Dock)	2.0×10^{-6}	6.48×10^{-12}	6.48×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Glovebox)	0.80	4.80×10^{-13}	5.44×10^{-14}	6.72×10^{-9}	1.60×10^{-10}	3.20×10^{-13}

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr)		Population (LCF/yr)		Worker (LCF/yr)
		95% Met	50% Met	95% Met	50% Met	50% Met
Spill (Dock)	0.001	1.35×10^{-10}	1.35×10^{-11}	1.58×10^{-6}	3.75×10^{-8}	8.40×10^{-10}
Earthquake	0.000094	6.94×10^{-8}	6.94×10^{-9}	0.00081	0.0000193	4.32×10^{-7}
Mediated Electrochemical Oxidation Process—Building 707A						
Explosion (Acetylene)	0.00005	5.88×10^{-9}	6.37×10^{-10}	0.000123	2.94×10^{-6}	8.23×10^{-8}
Fire (Room)	0.0005	2.65×10^{-8}	2.87×10^{-9}	0.000551	0.0000132	3.70×10^{-7}
Fire (Dock)	2.0×10^{-6}	1.41×10^{-12}	1.53×10^{-13}	2.94×10^{-8}	7.06×10^{-10}	1.98×10^{-11}
Spill (Glovebox)	0.80	1.25×10^{-13}	4.70×10^{-14}	6.82×10^{-9}	3.53×10^{-10}	8.78×10^{-14}
Spill (Dock)	0.001	1.47×10^{-11}	1.59×10^{-12}	3.06×10^{-7}	7.35×10^{-9}	2.06×10^{-10}
Earthquake	0.0008	5.59×10^{-7}	6.05×10^{-8}	0.0116	0.000279	0.0000156

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.8 Graphite Residues

D.3.4.8.1 No Action

The graphite residues processing technology considered for this alternative is direct repackaging. Preparation of direct repackaging of residues will be conducted within glovebox lines in Modules D, E, and F in Building 707 at Rocky Flats.

Table D–117 provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of direct repackaging of graphite residues at Rocky Flats. **Table D–118** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with the repackaging of graphite residues at Rocky Flats. The risks associated with this processing technology are summarized in **Table D–119**.

Table D–117 Graphite Residues Accident Scenarios Parameters—Direct Repackaging at Rocky Flats

Accident Scenario	Frequency (per year)	Graphite Residues	HEPA Banks	Material at Risk (grams)
Explosion	0.00005	2 drums [a]	0	4,000 g
Nuclear Criticality	–	–	–	–
Fire:				
a. Room	0.0005	5-day supply [b]	2	8,016 g
b. Loading Dock	2.0×10^{-6}	4 drums [c]	0	6,000 g
Spill:				
a. Room	0.008	1 container at the maximum limit [d]	2	600 g
b. Glovebox	0.80	1 feed prep container	2	83.5 g
c. Loading Dock	0.001	1 drum [e]	0	3,000 g
Earthquake	0.0018	5-day supply [b]	0	8,016 g
Aircraft Crash	0.00003	Consequences enveloped by the earthquake.	–	–

Accident Scenario	DR	ARF	RF	LPF	Release Point
Explosion	1.0	0.001	0.10	1.0	Ground
Nuclear Criticality [f]	–	–	–	–	–
Fire:					
a. Room	1.0	0.006	0.01	0.10	Ground
b. Loading Dock	0.01	0.006	0.01	0.50	Ground
Spill:					
a. Room	1.0	0.00002	0.50	2.0×10^{-6}	Elevated
b. Glovebox	1.0	0.00002	0.50	2.0×10^{-6}	Elevated
c. Loading Dock	0.25	0.00008	0.50	0.10	Ground
Earthquake	1.0	0.002 [g]	0.30 [g]	0.10	Ground
Aircraft Crash [h]	–	–	–	–	–

DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content

[b] 3-day supply of feed and 2-day supply of product.

[c] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.

[d] 5 containers per drum of feed.

[e] 1 drum at the maximum plutonium content level.

[f] The wet nuclear criticality is not a viable accident scenario for the direct repackaging process in Building 707..

[g] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000792).

[h] Consequences enveloped by the earthquake

Table D–118 Summary of the Graphite Residues Accident Analysis Doses Direct Repackaging at Rocky Flats

Accident Scenario	Building Source Term		MEI (rem)		Population (person-rem)		Worker (rem)
	(grams)	Type	95% Met	50% Met	95% Met	50% Met	50% Met
Explosion	0.400	Metal	0.960	0.104	16,800	400	11.2
Fire (Room)	0.0481	Metal	0.115	0.0125	2,020	48.1	1.35
Fire (Dock)	0.0018	Metal	0.00432	0.000468	75.6	1.80	0.0504
Spill (Room)	1.20×10^{-8}	Metal	3.84×10^{-9}	1.44×10^{-9}	0.00018	9.24×10^{-6}	2.28×10^{-9}
Spill (Glovebox)	1.67×10^{-9}	Metal	5.34×10^{-10}	2.00×10^{-10}	0.0000251	1.29×10^{-6}	3.17×10^{-10}
Spill (Dock)	0.003	Metal	0.0072	0.00078	126	3.00	0.084
Earthquake	0.635	Metal	1.52	0.165	26,700	635	17.8

MEI = maximally exposed individual Met = meteorological data

Table D–119 Summary of the Graphite Residues Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year—Direct Repackaging at Rocky Flats

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr)		Population (LCF/yr)		Worker (LCF/yr)
		95% Met	50% Met	95% Met	50% Met	50% Met
Explosion	0.00005	2.40×10^{-8}	2.60×10^{-9}	0.00042	0.00001	2.24×10^{-7}
Fire (Room)	0.0005	2.89×10^{-8}	3.13×10^{-9}	0.000505	1.20×10^{-6}	2.69×10^{-7}
Fire (Dock)	2.0×10^{-6}	4.32×10^{-12}	4.68×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Room)	0.008	1.54×10^{-14}	5.76×10^{-15}	7.20×10^{-10}	3.70×10^{-11}	7.30×10^{-15}
Spill (Glovebox)	0.80	2.14×10^{-13}	8.02×10^{-14}	1.00×10^{-8}	5.14×10^{-10}	1.02×10^{-13}
Spill (Dock)	0.001	3.60×10^{-9}	3.90×10^{-10}	0.000063	1.50×10^{-6}	3.36×10^{-8}
Earthquake	0.0018	1.37×10^{-6}	1.49×10^{-7}	0.024	0.000571	0.0000128

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.8.2 Processing and Storage without Plutonium Separation

The graphite residues processing technologies considered for this alternative are vitrification, blend down, and cementation. The vitrification process will be performed at Rocky Flats in Building 707, Modules D, E, and F. The blend down process will be performed at Rocky Flats in Building 707, Module E. Building 371 is under consideration as an alternate location for the blend down process. The accident analysis evaluates both the primary and alternate locations for the blend down process. The cementation process will be performed at Rocky Flats in Building 371, Room 3701. Building 707 is under consideration as an alternate location for the cementation process. The accident analysis evaluates both the primary and alternate locations for the cementation process.

Similar accidents are applicable to all of these technologies. **Table D–120** provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of graphite residues processing at Rocky Flats. **Table D–121** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with the processing of graphite residues. The risks associated with these processing technologies are summarized in **Table D–122**.

Table D–120 Graphite Residues Accident Scenarios Parameters Vitrification Process, Blend Down Process, and Cementation Process at Rocky Flats

Accident Scenario	*Frequency (per year)*	*Graphite Residues*	*HEPA Banks*	*Material at Risk (grams)*		
				Vitrification Process [a]	*Blend Down Process* [b]	*Cementation Process* [c]
Explosion	0.00005	2 drums [d]	0/2 [e]	4,000 g	4,000 g	4,000 g
Nuclear Criticality [f]	–	–	–	–	–	–
Fire:						
a. Room	0.0005	5-day supply [g]	2	4,810 g feed + 3,206 g product [h]	8,016 g	3,507 g feed + 2,338 g product [j]
b. Loading Dock	2.0×10^{-6}	4 drums [k]	0	6,000 g	6,000 g	6,000 g
Spill:						
a. Room	0.008	1 container at the maximum limit [l]	2	600 g	600 g	600 g
b. Glovebox	0.8	1 feed prep container	2	83.5 g	83.5g	83.5g
c. Loading Dock	0.001	1 drum [m]	0	3,000 g	3,000 g	3,000 g
Earthquake:						
a. Building 707	0.0018	5-day supply [g]	0	4,810 g feed + 3,206 g product [h]	8,016 g	3,507 g feed + 2,338 g product [j]
b. Building 371	0.000094	5-day supply [g]	0	N/A	8,016 g	3,507 g feed + 2,338 g product [j]
Aircraft Crash:						
a. Building 707	0.00003	Consequences enveloped by the earthquake.	–	–	–	–
b. Building 371	0.00004	The aircraft will not penetrate the building wall.	–	N/A	–	–

Accident Scenario	*DR*	*ARF*	*RF*	*LPF*	*Release Point*
Explosion:					
a. Building 707	1.0	0.001	0.10	1.0	Ground
b. Building 371	1.0	0.001	0.10	2.0×10^{-6}	Elevated
Nuclear Criticality [f]	–	–	–	–	–
Fire:					
a. Room	1.0	0.006	0.01	0.10	Ground
b. Loading Dock	0.01	0.006	0.01	0.50	Ground
Spill:					
a. Room	1.0	0.00002	0.50	2.0×10^{-6}	Elevated
b. Glovebox	1.0	0.00002	0.50	2.0×10^{-6}	Elevated
c. Loading Dock	0.25	0.00008	0.50	0.10	Ground

Accident Scenario	DR	ARF	RF	LPF	Release Point
Earthquake:					
Buildings 371 and 707	1.0	0.002 [n]	0.30 [n]	0.10	Ground
Aircraft Crash:					
a. Building 707 [p]	–	–	–	–	–
b. Building 371 [q]	–	–	–	–	–

N/A = not applicable DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] Building 707, Modules D, E, and F.
[b] Building 707, Module E, or Building 371.
[c] Building 371, Room 3701, or Building 707.
[d] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content.
[e] Building 707, 0 HEPA Banks; Building 371, 2 HEPA Banks.
[f] The wet nuclear criticality is not a viable accident scenario for the vitrification, blend down, and sonic wash technology assessments.
[g] 3-day supply of feed and 2-day supply of product.
[h] The product is glass. The effect of the vitrified product on the accident source term is negligible.
[j] The product is concrete. The effect of the residue immobilized in the concrete on the accident source term is negligible.
[k] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.
[l] 5 containers per drum of feed.
[m] 1 drum at the maximum plutonium content level.
[n] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000792).
[p] Consequences enveloped by the earthquake.
[q] The aircraft will not penetrate the building walls.

Table D–121 Summary of the Graphite Residues Accident Analysis Doses Vitrification Process, Blend Down Process, and Cementation Process at Rocky Flats

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Vitrification Process							
Explosion	0.400	Metal	0.960	0.104	16,800	400	11.2
Fire (Room)	0.0289	Metal	0.0693	0.0075	1,210	28.9	0.808
Fire (Dock)	0.00180	Metal	0.00432	0.000468	75.6	1.80	0.0504
Spill (Room)	1.20×10^{-8}	Metal	3.84×10^{-9}	1.44×10^{-9}	0.00018	9.24×10^{-6}	2.28×10^{-9}
Spill (Glovebox)	1.67×10^{-9}	Metal	5.34×10^{-10}	2.00×10^{-10}	0.0000251	1.29×10^{-6}	3.17×10^{-10}
Spill (Dock)	0.003	Metal	0.0072	0.00078	126	3.00	0.084
Earthquake	0.381	Metal	0.914	0.099	16,000	381	10.7
Blend Down Process—Building 707							
Explosion	0.400	Metal	0.960	0.104	16,800	400	11.2
Fire (Room)	0.0481	Metal	0.115	0.0125	2,020	48.1	1.35
Fire (Dock)	0.0018	Metal	0.00432	0.000468	75.6	1.80	0.0504
Spill (Room)	1.20×10^{-8}	Metal	3.84×10^{-9}	1.44×10^{-9}	0.00018	9.24×10^{-6}	2.28×10^{-9}
Spill (Glovebox)	1.67×10^{-9}	Metal	5.34×10^{-10}	2.00×10^{-10}	0.0000251	1.29×10^{-6}	3.17×10^{-10}
Spill (Dock)	0.003	Metal	0.0072	0.00078	126	3.00	0.084
Earthquake	0.635	Metal	1.52	0.165	26,700	635	17.8

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Blend Down Process—Building 371							
Explosion	8.00×10^{-7}	Metal	2.40×10^{-6}	2.72×10^{-7}	0.0336	0.000800	2.00×10^{-6}
Fire (Room)	0.0481	Metal	0.173	0.0173	2,020	48.1	1.35
Fire (Dock)	0.00180	Metal	0.00648	0.000648	75.6	1.80	0.0504
Spill (Room)	1.20×10^{-8}	Metal	3.60×10^{-8}	4.08×10^{-9}	0.000504	0.0000120	3.00×10^{-8}
Spill (Glovebox)	1.67×10^{-9}	Metal	5.01×10^{-9}	5.68×10^{-10}	0.0000701	1.67×10^{-6}	4.18×10^{-9}
Spill (Dock)	0.00300	Metal	0.0108	0.00108	126	3.00	0.0840
Earthquake	0.635	Metal	2.29	0.229	26,700	635	17.8
Cementation Process—Building 371							
Explosion	8.00×10^{-7}	Metal	2.40×10^{-6}	2.72×10^{-7}	0.0336	0.0008	2.00×10^{-6}
Fire (Room)	0.021	Metal	0.0758	0.00758	884	21.0	0.589
Fire (Dock)	0.0018	Metal	0.00648	0.000648	75.6	1.08	0.0504
Spill (Room)	1.20×10^{-8}	Metal	3.60×10^{-8}	4.08×10^{-9}	0.000504	0.000012	3.00×10^{-8}
Spill (Glovebox)	1.67×10^{-9}	Metal	5.01×10^{-9}	5.68×10^{-10}	0.0000701	1.67×10^{-6}	4.18×10^{-9}
Spill (Dock)	0.003	Metal	0.0108	0.00108	126	3.00	0.084
Earthquake	0.278	Metal	1.00	0.100	11,700	278	7.78
Cementation Process—Building 707							
Explosion	0.400	Metal	0.960	0.104	16,800	400	11.2
Fire (Room)	0.0210	Metal	0.0505	0.00547	884	21.0	0.589
Fire (Dock)	0.00180	Metal	0.00432	0.000468	75.6	1.80	0.0504
Spill (Room)	1.20×10^{-8}	Metal	3.84×10^{-9}	1.44×10^{-9}	0.000180	9.24×10^{-6}	2.28×10^{-9}
Spill (Glovebox)	1.67×10^{-9}	Metal	5.34×10^{-10}	2.00×10^{-10}	0.0000251	1.29×10^{-6}	3.17×10^{-10}
Spill (Dock)	0.00300	Metal	0.00720	0.000780	126	3.00	0.0840
Earthquake	0.278	Metal	0.667	0.0722	11,700	278	7.78

MEI = maximally exposed individual Met = meteorological data

Table D–122 Summary of the Graphite Residues Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year—Vitrification Process, Blend Down Process, and Cementation Process at Rocky Flats

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr) 95% Met	MEI (LCF/yr) 50% Met	Population (LCF/yr) 95% Met	Population (LCF/yr) 50% Met	Worker (LCF/yr) 50% Met
Vitrification Process						
Explosion	0.00005	2.40×10^{-8}	2.60×10^{-9}	0.00042	0.00001	2.24×10^{-7}
Fire (Room)	0.0005	1.73×10^{-8}	1.88×10^{-9}	0.000303	7.22×10^{-6}	1.62×10^{-7}
Fire (Dock)	2.00×10^{-6}	4.32×10^{-12}	4.68×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Room)	0.008	1.54×10^{-14}	5.76×10^{-15}	7.20×10^{-10}	3.70×10^{-11}	7.30×10^{-15}

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr)		Population (LCF/yr)		Worker (LCF/yr)
		95% Met	50% Met	95% Met	50% Met	50% Met
Spill (Glovebox)	0.800	2.14×10^{-13}	8.02×10^{-14}	1.00×10^{-8}	5.14×10^{-10}	1.02×10^{-13}
Spill (Dock)	0.001	3.60×10^{-9}	3.90×10^{-10}	0.000063	1.50×10^{-6}	3.36×10^{-8}
Earthquake	0.0018	8.23×10^{-7}	8.91×10^{-8}	0.0144	0.000343	7.68×10^{-6}
Blend Down Process—Building 707						
Explosion	0.00005	2.40×10^{-8}	2.60×10^{-9}	0.00042	0.00001	2.24×10^{-7}
Fire (Room)	0.0005	2.89×10^{-8}	3.13×10^{-9}	0.000505	0.000012	2.69×10^{-7}
Fire (Dock)	2.00×10^{-6}	4.32×10^{-12}	4.68×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Room)	0.008	1.54×10^{-14}	5.76×10^{-15}	7.20×10^{-10}	3.70×10^{-11}	7.30×10^{-15}
Spill (Glovebox)	0.800	2.14×10^{-13}	8.02×10^{-14}	1.00×10^{-8}	5.14×10^{-10}	1.02×10^{-13}
Spill (Dock)	0.001	3.60×10^{-9}	3.90×10^{-10}	0.000063	1.50×10^{-6}	3.36×10^{-8}
Earthquake	0.0018	1.37×10^{-6}	1.49×10^{-7}	0.024	0.000571	0.0000128
Blend Down Process—Building 371						
Explosion	0.00005	6.00×10^{-14}	6.80×10^{-15}	8.40×10^{-10}	2.00×10^{-11}	4.00×10^{-14}
Fire (Room)	0.0005	4.33×10^{-8}	4.33×10^{-9}	0.000505	0.0000120	2.69×10^{-7}
Fire (Dock)	2.00×10^{-6}	6.48×10^{-12}	6.48×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Room)	0.008	1.44×10^{-13}	1.63×10^{-14}	2.02×10^{-9}	4.80×10^{-11}	9.60×10^{-14}
Spill (Glovebox)	0.8	2.00×10^{-12}	2.27×10^{-13}	2.81×10^{-8}	6.68×10^{-10}	1.34×10^{-12}
Spill (Dock)	0.001	5.40×10^{-9}	5.40×10^{-10}	0.0000630	1.50×10^{-6}	3.36×10^{-8}
Earthquake	0.000094	1.07×10^{-7}	1.07×10^{-8}	0.00125	0.0000298	6.68×10^{-7}
Cementation Process—Building 371						
Explosion	0.00005	6.00×10^{-14}	6.80×10^{-15}	8.40×10^{-10}	2.00×10^{-11}	4.00×10^{-14}
Fire (Room)	0.0005	1.89×10^{-8}	1.89×10^{-9}	0.000221	5.26×10^{-6}	1.18×10^{-7}
Fire (Dock)	2.00×10^{-6}	6.48×10^{-12}	6.48×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Room)	0.008	1.44×10^{-13}	1.63×10^{-14}	2.02×10^{-9}	4.80×10^{-11}	9.60×10^{-14}
Spill (Glovebox)	0.800	2.00×10^{-13}	2.27×10^{-13}	2.81×10^{-8}	6.68×10^{-10}	1.34×10^{-12}
Spill (Dock)	0.001	5.40×10^{-9}	5.40×10^{-10}	0.000063	1.50×10^{-6}	3.36×10^{-8}
Earthquake	0.000094	4.70×10^{-8}	4.70×10^{-9}	0.000548	0.0000131	2.92×10^{-7}
Cementation Process—Building 707						
Explosion	0.00005	2.40×10^{-8}	2.60×10^{-9}	0.000420	0.0000100	2.24×10^{-7}
Fire (Room)	0.0005	1.26×10^{-8}	1.37×10^{-9}	0.000221	5.26×10^{-6}	1.18×10^{-7}
Fire (Dock)	2.00×10^{-6}	4.32×10^{-12}	4.68×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Room)	0.008	1.54×10^{-14}	5.76×10^{-15}	7.20×10^{-10}	3.70×10^{-11}	7.30×10^{-15}
Spill (Glovebox)	0.8	2.14×10^{-13}	8.02×10^{-14}	1.00×10^{-8}	5.14×10^{-10}	1.02×10^{-13}
Spill (Dock)	0.001	3.60×10^{-9}	3.90×10^{-10}	0.0000630	1.50×10^{-6}	3.36×10^{-8}
Earthquake	0.0018	6.00×10^{-7}	6.50×10^{-8}	0.0105	0.000250	5.60×10^{-6}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.8.3 Processing and Storage with Plutonium Separation

The graphite residues processing technology considered for this alternative is mediated electrochemical oxidation. Processing of graphite residues with the mediated electrochemical oxidation process may be performed at either Rocky Flats or the Savannah River Site. At Rocky Flats, most of the mediated electrochemical oxidation process will be performed in Building 371, Room 3701; the final calcination in the process will be performed in Building 707A, Module J. For processing at the Savannah River Site, the

packaging of the residues at Rocky Flats will be performed in Building 371, Room 371. The mediated electrochemical oxidation process will be performed in the canyon facilities at the Savannah River Site.

Similar accidents are applicable to the mediated electrochemical oxidation processes at both sites. **Table D–123** provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of graphite residues processing using the mediated electrochemical oxidation technology at Rocky Flats. **Table D–124** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with the processing of graphite residues at Rocky Flats. The risks associated with this processing technology at Rocky Flats are summarized in **Table D–125**.

Table D–123 Graphite Residues Accident Scenarios Parameter
Mediated Electrochemical Oxidation Process at Rocky Flats

Accident Scenario	*Frequency (per year)*	*Graphite Residues*	*HEPA Banks*	*Material at Risk (grams)* — *Mediated Electrochemical Oxidation Process*	
				Building 371	*Building 707A* [a]
Explosion (Acetylene)	0.00005	2 drums	2/0 [b]	4,000 g [c]	2,000 g
Explosion (Ion Exchange Column)	0.0001	Solution	2	0.245 mg [d]	N/A
Nuclear Criticality	0.0001	Solution	2	1.0×10^{19} fissions	N/A [e]
Fire:					
a. Room	0.0005	5-day supply [f]	2	5,550 g	6,000 g
b. Loading Dock	2.0×10^{-6}	4 drums	0	6,000 g [g]	4,000 g
Spill:					
a. Room	0.008	1 container at the maximum limit [h]	2	600 g	N/A [j]
b. Glovebox	0.80	1 feed prep container	2	200 g	1,000 g
c. Loading Dock	0.001	1 drum	0	3,000 g [k]	1,000 g
Earthquake:					
a. Building 371	0.000094	5-day supply [f]	0	5,550 g	N/A
b. Building 707A	0.0008	5-day supply [f]	0	N/A	6,000 g
Aircraft Crash:					
a. Building 371	0.00004	The aircraft will not penetrate the building wall.	–	–	N/A
b. Building 707A	0.00001	Consequences enveloped by the earthquake.	–	N/A	–

Accident Scenario	*DR*	*ARF*	*RF*	*LPF*	*Release Point*
Explosion (Acetylene):					
a. Building 707A	1.0	0.001	0.10	1.0	Ground
b. Building 371	1.0	0.001	0.10	2.0×10^{-6}	Elevated
Explosion (Ion Exchange Column) [d]	1.0	1.0	1.0	1.0	Elevated
Nuclear Criticality [e, l]	–	–	–	–	Elevated
Fire:					
a. Room	1.0	0.006	0.01	0.10	Ground
b. Loading Dock	0.01	0.006	0.01	0.50	Ground

Accident Scenario	DR	ARF	RF	LPF	Release Point
Spill:					
a. Room [j]	1.0	0.00002	0.50	2.0×10^{-6}	Elevated
b. Glovebox	1.0	0.00002	0.50	2.0×10^{-6}	Elevated
c. Loading Dock	0.25	0.00008	0.50	0.10	Ground
Earthquake:					
Buildings 371 and 707A	1.0	0.002 [m]	0.30 [m]	0.10	Ground
Aircraft Crash:					
a. Building 707A [n]	–	–	–	–	–
b. Building 371 [p]	–	–	–	–	–

N/A = not applicable DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] 1,000-g product container transported from Building 371 to Building 707A for processing.
[b] Building 707A, 0 HEPA Banks; Building 371, 2 HEPA Banks.
[c] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content.
[d] Respirable source term value in milligrams of plutonium released up the stack.
[e] The wet nuclear criticality is not a viable accident scenario for the mediated electrochemical oxidation process in Building 707A.
[f] 3-day supply of feed and 2-day supply of product.
[g] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.
[h] 5 containers per drum of feed.
[j] Materials are opened in a glovebox in Building 707A. No room spill is considered.
[k] 1 drum at the maximum plutonium content level.
[l] Refer to Table D–28 for Building 371 mediated electrochemical oxidation criticality accident source term.
[m] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000792).
[n] Consequences enveloped by the earthquake.
[p] The aircraft will not penetrate the building walls.

Table D–124 Summary of the Graphite Residues Accident Analysis Doses Mediated Electrochemical Oxidation Process at Rocky Flats

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Mediated Electrochemical Oxidation Process—Building 371							
Explosion (Acetylene)	8.00×10^{-7}	Metal	2.40×10^{-6}	2.72×10^{-7}	0.0336	0.0008	2.00×10^{-6}
Explosion (Ion Exchange Column)	0.000245	Metal	0.000735	0.0000833	10.3	0.245	0.000613
Criticality (Liquid)	[a]	–	0.790	0.110	6,980	252	0.321
Fire (Room)	0.0333	Metal	0.120	0.012	1,400	33.3	0.932
Fire (Dock)	0.0018	Metal	0.00648	0.000648	75.6	1.80	0.0504
Spill (Room)	1.20×10^{-8}	Metal	3.60×10^{-8}	4.08×10^{-9}	0.000504	0.000012	3.00×10^{-8}
Spill (Glovebox)	4.00×10^{-9}	Metal	1.20×10^{-8}	1.36×10^{-9}	0.000168	4.00×10^{-6}	1.00×10^{-8}
Spill (Dock)	0.003	Metal	0.0108	0.00108	126	3.00	0.084
Earthquake	0.440	Metal	1.58	0.158	18,500	440	12.3

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Mediated Electrochemical Oxidation Process—Building 707A							
Explosion (Acetylene)	0.200	Oxide	0.240	0.026	5,000	120	4.20
Fire (Room)	0.036	Oxide	0.0432	0.00468	900	21.6	0.756
Fire (Dock)	0.0012	Oxide	0.00144	0.000156	30.0	0.720	0.0252
Spill (Glovebox)	2.00×10^{-8}	Oxide	3.20×10^{-9}	1.20×10^{-9}	0.000174	9.00×10^{-6}	2.80×10^{-9}
Spill (Dock)	0.001	Oxide	0.0012	0.00013	25.0	0.600	0.021
Earthquake	0.475	Oxide	0.570	0.0618	11,900	285	9.98

MEI = maximally exposed individual Met = meteorological data
[a] 1.0×10^{19} fissions.

Table D–125 Summary of the Graphite Residues Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year—Mediated Electrochemical Oxidation Process at Rocky Flats

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr) 95% Met	MEI (LCF/yr) 50% Met	Population (LCF/yr) 95% Met	Population (LCF/yr) 50% Met	Worker (LCF/yr) 50% Met
Mediated Electrochemical Oxidation Process—Building 371						
Explosion (Acetylene)	0.00005	6.00×10^{-14}	6.80×10^{-15}	8.40×10^{-10}	2.00×10^{-11}	4.00×10^{-14}
Explosion (Ion Exchange Column)	0.0001	3.68×10^{-11}	4.17×10^{-12}	5.15×10^{-7}	1.23×10^{-8}	2.45×10^{-11}
Criticality (Liquid)	0.0001	3.95×10^{-8}	5.50×10^{-9}	0.000349	0.0000126	1.28×10^{-8}
Fire (Room)	0.0005	3.00×10^{-8}	3.00×10^{-9}	0.00035	8.33×10^{-6}	1.86×10^{-7}
Fire (Dock)	2.0×10^{-6}	6.48×10^{-12}	6.48×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Room)	0.008	1.44×10^{-13}	1.63×10^{-14}	2.02×10^{-9}	4.80×10^{-11}	9.60×10^{-14}
Spill (Glovebox)	0.80	4.80×10^{-12}	5.44×10^{-13}	6.72×10^{-8}	1.60×10^{-9}	3.20×10^{-12}
Spill (Dock)	0.001	5.40×10^{-9}	5.40×10^{-10}	0.000063	1.50×10^{-6}	3.36×10^{-8}
Earthquake	0.000094	7.44×10^{-8}	7.44×10^{-9}	0.000868	0.0000207	4.63×10^{-7}
Mediated Electrochemical Oxidation Process—Building 707A						
Explosion (Acetylene)	0.00005	6.00×10^{-9}	6.50×10^{-10}	0.000125	3.00×10^{-6}	8.40×10^{-8}
Fire (Room)	0.0005	1.08×10^{-8}	1.17×10^{-9}	0.000225	5.40×10^{-6}	1.51×10^{-7}
Fire (Dock)	2.0×10^{-6}	1.44×10^{-12}	1.56×10^{-13}	3.00×10^{-8}	7.20×10^{-10}	2.02×10^{-11}
Spill (Glovebox)	0.80	1.28×10^{-12}	4.80×10^{-13}	6.96×10^{-8}	3.60×10^{-9}	8.96×10^{-13}
Spill (Dock)	0.001	6.00×10^{-10}	6.50×10^{-11}	0.0000125	3.00×10^{-7}	8.40×10^{-9}
Earthquake	0.0008	2.28×10^{-7}	2.47×10^{-8}	0.00475	0.000114	3.19×10^{-6}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

Table D–126 provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of packaging the graphite residues at Rocky Flats and of processing the residues using the mediated electrochemical oxidation technology at the Savannah River Site. **Table D–127** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with packaging the graphite residues at Rocky Flats and processing the graphite residues at the Savannah River Site. The risks associated with packaging at Rocky Flats and using the mediated electrochemical oxidation process at the Savannah River Site are summarized in **Table D–128**. The processes at the Savannah River Site could be performed in either the F-Canyon and FB-Line or the H-Canyon and HB-Line. Data are presented in Table D–126, Table D–127, and Table D–128 for both options.

Table D–126 Graphite Residues Accident Scenarios Parameters
Mediated Electrochemical Oxidation Process at the Savannah River Site

Accident Scenario	*Frequency (per year)*	*Graphite Residues*	*HEPA Banks*	*Material at Risk (grams)*
Rocky Flats Packaging of Residue for Shipment to the Savannah River Site				
Explosion	0.00005	2 drums [a]	2	4,000 g
Nuclear Criticality [b]	–	–	–	–
Fire:				
a. Room	0.0005	5-day supply [c]	2	5,992 g
b. Loading Dock	2.0×10^{-6}	4 drums [d]	0	6,000 g
Spill:				
a. Room	0.008	1 container at the maximum limit [e]	2	600 g
b. Glovebox	0.80	1 feed prep container	2	103 g
c. Loading Dock	0.001	1 drum [f]	0	3,000 g
Earthquake	0.000094	5-day supply [c]	0	5,992 g
Aircraft Crash	0.00004	The aircraft will not penetrate the building wall.	–	–

Accident Scenario	*DR*	*ARF*	*RF*	*LPF*	*Release Point*
Explosion	1.0	0.001	0.10	2.0×10^{-6}	Elevated
Nuclear Criticality [b]	–	–	–	–	–
Fire:					
a. Room	1.0	0.006	0.01	0.10	Ground
b. Loading Dock	0.01	0.006	0.01	0.50	Ground
Spill:					
a. Room	1.0	0.00002	0.50	2.0×10^{-6}	Elevated
b. Glovebox	1.0	0.00002	0.50	2.0×10^{-6}	Elevated
c. Loading Dock	0.25	0.00008	0.50	0.10	Ground
Earthquake	1.0	0.002 [g]	0.30 [g]	0.10	Ground
Aircraft Crash [h]	–	–	–	–	–

Mediated Electrochemical Oxidation Process at the Savannah River Site F-Canyon		
Accident Scenario	*Frequency (per year)*	*Material at Risk (grams)*
Explosion:		
a. Hydrogen	0.000015	4,000 g
b. Ion Exchange column	0.0001	120.5 mg [j]
Nuclear Criticality [k]	0.0001	1.0×10^{19} fissions
Fire	0.00061	4,000 g
Spill	0.01	103 g

Mediated Electrochemical Oxidation Process at the Savannah River Site F-Canyon				
Accident Scenario		***Frequency (per year)***	***Material at Risk (grams)***	
Earthquake: a. F-Canyon Liquid b. FB-Line Powder Metal Liquid		0.000125	 12,000 g 1,000 g 1,000 g 1,000 g	
Accident Scenario	***DR***	***ARF×RF***	***LPF***	***Release Point***
Explosion: a. Hydrogen b. Ion Exchange Column	 1.0 1.0	 0.001 1.0	 0.005 1.0	 Elevated Elevated
Nuclear Criticality [k]	–	–	–	–
Fire	1.0	0.01	0.005	Elevated
Spill	1.0	0.00001	0.005	Elevated
Earthquake: a. F-Canyon Liquid b. FB-Line Powder Metal Liquid	 1.0 1.0 1.0 1.0	 0.000047 0.002 0.0022 0.000047	 0.10 0.10 0.10 0.10	 Ground Ground Ground Ground
Mediated Electrochemical Oxidation Process at the Savannah River Site H-Canyon				
Accident Scenario		***Frequency (per year)***	***Material at Risk (grams)***	
Explosion: a. Hydrogen b. Ion Exchange column		 0.000015 0.0001	 4,000 g 241 mg [j,l]	
Nuclear Criticality [k]		0.0001	1.0×10^{19} fissions	
Fire		0.00061	6,000 g	
Spill		0.01	103 g	
Earthquake: a. H-Canyon Liquid b. HB-Line Powder Liquid		0.000182	 27,000 g 4,000 m 4,000 m	
Accident Scenario	***DR***	***ARF×RF***	***LPF***	***Release Point***
Explosion: a. Hydrogen b. Ion Exchange Column	 1.0 1.0	 0.001 1.0	 0.005 1.0	 Elevated Elevated
Nuclear Criticality [k]	–	–	–	–
Fire	1.0	0.01	0.005	Elevated
Spill	1.0	0.00001	0.005	Elevated
Earthquake: a. H-Canyon b. HB-Line Powder HB-Line Liquid	 1.0 1.0 1.0	 0.000047 0.002 0.000047	 0.10 0.10 0.10	 Ground Ground Ground

DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content.

[b] The wet nuclear criticality is not a viable accident scenario for the residue packaging process in Building 371.

[c] 3-day supply of feed and 2-day supply of product.
[d] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.
[e] 5 containers per drum of feed.
[f] 1 drum at the maximum plutonium content level.
[g] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000792).
[h] The aircraft will not penetrate the building walls.
[j] Respirable source term value in milligrams of plutonium released up the stack.
[k] Refer to Table D–28 for criticality accident source term.
[l] Duty cycle = 60%.

Table D–127 Summary of the Graphite Residues Accident Analysis Doses Mediated Electrochemical Oxidation Process at the Savannah River Site

	Building Source Term		*MEI (rem)*		*Population (person-rem)*		*Worker (rem)*
Accident Scenario	*(grams)*	*Type*	*95% Met*	*50% Met*	*95% Met*	*50% Met*	*50% Met*
Rocky Flats Packaging of Residue for Shipment to the Savannah River Site							
Explosion	8.00×10^{-7}	Metal	2.40×10^{-6}	2.72×10^{-7}	0.0336	0.0008	2.00×10^{-6}
Fire (Room)	0.036	Metal	0.129	0.0129	1,510	36.0	1.01
Fire (Dock)	0.0018	Metal	0.00648	0.000648	75.6	1.80	0.0504
Spill (Room)	1.20×10^{-8}	Metal	3.60×10^{-8}	4.08×10^{-9}	0.000504	0.000012	3.00×10^{-8}
Spill (Glovebox)	2.06×10^{-9}	Metal	6.18×10^{-9}	7.00-10	0.0000865	2.06×10^{-6}	5.15×10^{-9}
Spill (Dock)	0.003	Metal	0.0108	0.00108	126	3.00	0.084
Earthquake	0.475	Metal	1.71	0.171	19,900	475	13.3
Mediated Electrochemical Oxidation Process at the Savannah River Site F-Canyon							
Explosion (Hydrogen)	0.02	Metal	0.00068	0.00024	36.0	3.20	0.002
Explosion (Ion Exchange Column)	0.121	Metal-FB	0.00374	0.00133	193	18.1	0.0112
Criticality (Liquid)	[a]	–	0.011	0.0044	310	32.0	0.038
Fire	0.200	Metal	0.0068	0.0024	360	32.0	0.02
Spill	5.15×10^{-6}	Metal	1.75×10^{-7}	6.18×10^{-8}	0.00927	0.000824	5.15×10^{-7}
Earthquake	0.481	Metal	0.0443	0.00818	1,590	111	10.6
Mediated Electrochemical Oxidation Process at the Savannah River Site H-Canyon							
Explosion (Hydrogen)	0.02	Metal	0.00064	0.000192	32.0	3.00	0.002
Explosion (Ion Exchange Column)	0.241	Metal-HB	0.00699	0.00212	342	34.0	0.0224
Criticality (Liquid)	[a]	–	0.009	0.003	290	29.0	0.038
Fire	0.300	Metal	0.0096	0.00288	480	45.0	0.03
Spill	5.15×10^{-6}	Metal	1.65×10^{-7}	4.94×10^{-8}	0.00824	0.000773	5.15×10^{-7}
Earthquake	0.946	Metal	0.0653	0.0132	2,930	189	20.8

MEI = maximally exposed individual Met = meteorological data
[a] 1.0×10^{19} fissions.

Table D–128 Summary of the Graphite Residues Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year—Mediated Electrochemical Oxidation Process at the Savannah River Site

Accident Scenario	*Accident Frequency (per year)*	*MEI (LCF/yr)*		*Population (LCF/yr)*		*Worker (LCF/yr)*
		95% Met	*50% Met*	*95% Met*	*50% Met*	*50% Met*
Rocky Flats Packaging of Residue for Shipment to the Savannah River Site						
Explosion	0.00005	6.00×10^{-14}	6.80×10^{-15}	8.40×10^{-10}	2.00×10^{-11}	4.00×10^{-14}
Fire (Room)	0.0005	3.24×10^{-8}	3.24×10^{-9}	0.000377	8.99×10^{-6}	2.01×10^{-7}
Fire (Dock)	2.00×10^{-6}	6.48×10^{-12}	6.48×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Room)	0.008	1.44×10^{-13}	1.63×10^{-14}	2.02×10^{-9}	4.80×10^{-11}	9.60×10^{-14}
Spill (Glovebox)	0.800	2.47×10^{-12}	2.80×10^{-13}	3.46×10^{-8}	8.24×10^{-10}	1.65×10^{-12}
Spill (Dock)	0.001	5.40×10^{-9}	5.40×10^{-10}	0.000063	1.50×10^{-6}	3.36×10^{-8}
Earthquake	0.000094	8.03×10^{-8}	8.03×10^{-9}	0.000937	0.0000223	5.00×10^{-7}
Mediated Electrochemical Oxidation Process at the Savannah River Site F-Canyon						
Explosion (Hydrogen)	0.000015	5.10×10^{-12}	1.80×10^{-12}	2.70×10^{-7}	2.40×10^{-8}	1.20×10^{-11}
Explosion (Ion Exchange Column)	0.0001	1.87×10^{-10}	6.63×10^{-11}	9.64×10^{-6}	9.04×10^{-7}	4.48×10^{-10}
Criticality (Liquid)	0.0001	5.50×10^{-10}	2.20×10^{-10}	0.0000155	1.60×10^{-6}	1.52×10^{-9}
Fire	0.00061	2.07×10^{-9}	7.32×10^{-10}	0.00011	9.76×10^{-6}	4.88×10^{-9}
Spill	0.01	8.76×10^{-13}	3.09×10^{-13}	4.64×10^{-8}	4.12×10^{-9}	2.06×10^{-12}
Earthquake	0.000125	2.77×10^{-9}	5.11×10^{-10}	0.0000992	6.92×10^{-6}	5.29×10^{-7}
Mediated Electrochemical Oxidation Process at the Savannah River Site H-Canyon						
Explosion (Hydrogen)	0.000015	4.80×10^{-12}	1.44×10^{-12}	2.40×10^{-7}	2.25×10^{-8}	1.20×10^{-11}
Explosion (Ion Exchange Column)	0.0001	2.10×10^{-10}	6.36×10^{-11}	0.0000103	1.02×10^{-6}	5.38×10^{-10}
Criticality (Liquid)	0.0001	4.50×10^{-10}	1.50×10^{-10}	0.0000145	1.45×10^{-6}	1.52×10^{-9}
Fire	0.00061	2.93×10^{-9}	8.78×10^{-10}	0.000146	0.0000137	7.32×10^{-9}
Spill	0.01	8.24×10^{-13}	2.47×10^{-13}	4.12×10^{-8}	3.86×10^{-9}	2.06×10^{-12}
Earthquake	0.000182	3.88×10^{-9}	7.88×10^{-10}	0.000174	0.0000113	1.98×10^{-6}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.9 Inorganic Residues

D.3.4.9.1 No Action

The inorganic residues processing technology considered for this alternative is direct repackaging. Preparation of direct repackaging of residues will be conducted at Rocky Flats within glovebox lines in Modules D, E, and F in Building 707.

Table D–129 provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of direct repackaging of inorganic residues at Rocky Flats. **Table D–130** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with the repackaging of inorganic residues at Rocky Flats. The risks associated with this processing technology are summarized in **Table D–131**.

Table D–129 Inorganic Residues Accident Scenarios Parameters Direct Repackaging at Rocky Flats

Accident Scenario	*Frequency (per year)*	*Inorganic Residues*	*HEPA Banks*	*Material at Risk (grams)*
Explosion	0.00005	2 drums [a]	0	4,000 g
Nuclear Criticality	–	–	–	–
Fire:				
a. Room	0.0005	5-day supply [b]	2	8,016 g
b. Loading Dock	2.0×10^{-6}	4 drums [c]	0	6,000 g
Spill:				
a. Room [d]	–	–	–	–
b. Glovebox	0.80	1 feed prep container	2	83.5 g
c. Loading Dock	0.001	1 drum [e]	0	3,000 g
Earthquake	0.0018	5-day supply [b]	0	8,016 g
Aircraft Crash	0.00003	Consequences enveloped by the earthquake.	–	–

Accident Scenario	*DR*	*ARF*	*RF*	*LPF*	*Release Point*
Explosion	1.0	0.001	0.10	1.0	Ground
Nuclear Criticality [f]	–	–	–	–	–
Fire:					
a. Room	1.0	0.006	0.01	0.10	Ground
b. Loading Dock	0.01	0.006	0.01	0.50	Ground
Spill:					
a. Glovebox	1.0	1.0×10^{-6} [g]	1.0 [g]	2.0×10^{-6}	Elevated
b. Loading Dock	0.25	1.0×10^{-6} [g]	1.0 [g]	0.10	Ground
Earthquake	1.0	0.001 [h]	0.10 [h]	0.10	Ground
Aircraft Crash [j]	–	–	–	–	–

DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content

[b] 3-day supply of feed and 2-day supply of product.

[c] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.

[d] Materials are opened in a glovebox. No room spill is considered.

[e] 1 drum at the maximum plutonium content level.

[f] The wet nuclear criticality is not a viable accident scenario for the direct repackaging process in Building 707.

[g] The product of ARF×RF = 1.0×10^{-6}.

[h] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000292).

[j] Consequences enveloped by the earthquake.

Table D–130 Summary of the Inorganic Residues Accident Analysis Doses Direct Repackaging at Rocky Flats

	Building Source Term		*MEI (rem)*		*Population (person-rem)*		*Worker (rem)*
Accident Scenario	*(grams)*	*Type*	*95% Met*	*50% Met*	*95% Met*	*50% Met*	*50% Met*
Explosion	0.400	Metal	0.960	0.104	16,800	400	11.2
Fire (Room)	0.0481	Metal	0.115	0.0125	2,020	48.1	1.35
Fire (Dock)	0.0018	Metal	0.00432	0.000468	75.6	1.80	0.0504
Spill (Glovebox)	1.67×10^{-10}	Metal	5.34×10^{-11}	2.00×10^{-11}	2.51×10^{-6}	1.29×10^{-7}	3.17×10^{-11}
Spill (Dock)	0.000075	Metal	0.00018	0.0000195	3.15	0.075	0.0021
Earthquake	0.234	Metal	0.562	0.0609	9,830	234	6.55

MEI = maximally exposed individual Met = meteorological data

Table D–131 Summary of the Inorganic Residues Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year—Direct Repackaging at Rocky Flats

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr)		Population (LCF/yr)		Worker (LCF/yr)
		95% Met	50% Met	95% Met	50% Met	50% Met
Explosion	0.00005	2.40×10^{-8}	2.60×10^{-9}	0.00042	0.00001	2.24×10^{-7}
Fire (Room)	0.0005	2.89×10^{-8}	3.13×10^{-9}	0.000505	0.000012	2.69×10^{-7}
Fire (Dock)	2.0×10^{-6}	4.32×10^{-12}	4.68×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Glovebox)	0.80	2.14×10^{-14}	8.02×10^{-15}	1.00×10^{-9}	5.14×10^{-11}	1.02×10^{-14}
Spill (Dock)	0.001	9.00×10^{-11}	9.75×10^{-12}	1.58×10^{-6}	3.75×10^{-8}	8.40×10^{-10}
Earthquake	0.0018	5.06×10^{-7}	5.48×10^{-8}	0.00885	0.000211	4.72×10^{-6}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.9.2 Processing and Storage without Plutonium Separation

The inorganic residues processing technologies considered for this alternative are vitrification, blend down, and sonic wash. The vitrification process will be performed at Rocky Flats in Building 707, Modules D, E, and F. The blend down process will be performed at Rocky Flats in Building 707, Module E. Building 371 is under consideration as an alternate location for the blend down process. The accident analysis evaluates both the primary and alternate locations for the blend down process.

Evaluation of the sonic wash process indicated that it does not meet the safeguard termination limit of 2 percent for disposal of inorganic waste at WIPP. Sonic wash has been dropped as an alternative for inorganic residues processing.

Similar accidents are applicable to the vitrification and blend down technologies. **Table D–132** provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of inorganic residues processing at Rocky Flats. **Table D–133** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with the processing of inorganic residues. The risks associated with these processing technologies are summarized in **Table D–134**.

Table D–132 Inorganic Residues Accident Scenarios Parameters Vitrification Process and Blend Down Process at Rocky Flats

Accident Scenario	Frequency (per year)	Inorganic Residues	HEPA Banks	Material at Risk (grams)	
				Vitrification Process [a]	Blend Down Process [b]
Explosion	0.00005	2 drums [c]	0/2 [d]	4,000 g	4,000 g
Nuclear criticality [e]	–	–	–	–	–
Fire:					
a. Room	0.0005	5-day supply [f]	2	4,810 g feed + 3,206 g product [g]	8,016 g
b. Loading Dock	2.0×10^{-6}	4 drums [h]	0	6,000 g	6,000 g
Spill:					
a. Room [j]	–	–	–	–	–
b. Glovebox	0.80	1 feed prep container	2	83.5 g	83.5 g
c. Loading Dock	0.001	1 drum [k]	0	3,000 g	3,000 g

Accident Scenario	Frequency (per year)	Inorganic Residues	HEPA Banks	Material at Risk (grams)	
				Vitrification Process [a]	Blend Down Process [b]
Earthquake:					
a. Building 707	0.0018	5-day supply [f]	0	4,810 g feed + 3,206 g product [g]	8,016 g
b. Building 371	0.000094	5-day supply [f]	0	N/A	8,016 g
Aircraft Crash:					
a. Building 707	0.00003	Consequences enveloped by the earthquake.	–	–	–
b. Building 371	0.00004	The aircraft will not penetrate the building walls.	–	N/A	–

Accident Scenario	DR	ARF	RF	LPF	Release Point
Explosion:					
a. Building 707	1.0	0.001	0.10	1.0	Ground
b. Building 371	1.0	0.001	0.10	2.0×10^{-6}	Elevated
Nuclear criticality [e]	–	–	–	–	–
Fire:					
a. Room	1.0	0.006	0.01	0.10	Ground
b. Loading Dock	0.01	0.006	0.01	0.50	Ground
Spill:					
a. Glovebox	1.0	1.0×10^{-6} [l]	1.0 [l]	2.0×10^{-6}	Elevated
b. Loading Dock	0.25	1.0×10^{-6} [l]	1.0 [l]	0.10	Ground
Earthquake	1.0	0.001 [m]	0.10 [m]	0.10	Ground
Aircraft Crash:					
a. Building 707 [n]	–	–	–	–	–
b. Building 371 [p]	–	–	–	–	–

N/A = not applicable DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] Building 707, Modules D, E, and F.

[b] Building 707, Module E.

[c] 1 drum at the maximum plutonium content level (3,000 grams) and 1 drum at the administrative control level (1,000 grams) for plutonium content.

[d] Building 371 2 HEPA Banks; Building 707, 0 HEPA Banks.

[e] The wet nuclear criticality is not a viable accident scenario for the vitrification and blend down technology assessments.

[f] 3-day supply of feed and 2-day supply of product.

[g] The product is glass. The effect of the vitrified product on the accident source term is negligible.

[h] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.

[j] Materials are opened in a glovebox. No room spill is considered.

[k] 1 drum at the maximum plutonium content level.

[l] The product of ARF×RF = 1.0×10^{-6}.

[m] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000292).

[n] Consequences enveloped by the earthquake.

[p] The aircraft will not penetrate the building walls.

Table D–133 Summary of the Inorganic Residues Accident Analysis Doses Vitrification Process and Blend Down Process at Rocky Flats

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Vitrification Process							
Explosion	0.400	Metal	0.960	0.104	16,800	400	11.2
Fire (Room)	0.0289	Metal	0.0693	0.0075	1,210	28.9	0.808
Fire (Dock)	0.0018	Metal	0.00432	0.000468	75.6	1.80	0.0504
Spill (Glovebox)	1.67×10^{-10}	Metal	5.34×10^{-11}	2.00×10^{-11}	2.51×10^{-6}	1.29×10^{-7}	3.17×10^{-11}
Spill (Dock)	0.000075	Metal	0.00018	0.0000195	3.15	0.075	0.0021
Earthquake	0.140	Metal	0.337	0.0365	5,900	140	3.93
Blend Down Process—Building 707							
Explosion	0.400	Metal	0.960	0.104	16,800	400	11.2
Fire (Room)	0.0481	Metal	0.115	0.0125	2,020	48.1	1.35
Fire (Dock)	0.0018	Metal	0.00432	0.000468	75.6	1.80	0.0504
Spill (Glovebox)	1.67×10^{-10}	Metal	5.34×10^{-11}	2.00×10^{-11}	2.51×10^{-6}	1.29×10^{-7}	3.17×10^{-11}
Spill (Dock)	0.000075	Metal	0.00018	0.0000195	3.15	0.075	0.0021
Earthquake	0.234	Metal	0.562	0.0609	9,830	234	6.55
Blend Down Process—Building 371							
Explosion	8.00×10^{-7}	Metal	2.40×10^{-6}	2.72×10^{-7}	0.0336	0.000800	2.00×10^{-6}
Fire (Room)	0.0481	Metal	0.173	0.0173	2,020	48.1	1.35
Fire (Dock)	0.00180	Metal	0.00648	0.000648	75.6	1.80	0.0504
Spill (Glovebox)	1.67×10^{-10}	Metal	5.01×10^{-10}	5.68×10^{-11}	7.01×10^{-6}	1.67×10^{-7}	4.18×10^{-10}
Spill (Dock)	0.0000750	Metal	0.000270	0.0000270	3.15	0.0750	0.00210
Earthquake	0.234	Metal	0.843	0.0843	9,830	234	6.55

MEI = maximally exposed individual Met = meteorological data

Table D–134 Summary of the Inorganic Residues Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year—Vitrification Process and Blend Down Process at Rocky Flats

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr) 95% Met	MEI (LCF/yr) 50% Met	Population (LCF/yr) 95% Met	Population (LCF/yr) 50% Met	Worker (LCF/yr) 50% Met
Vitrification Process						
Explosion	0.00005	2.40×10^{-8}	2.60×10^{-9}	0.00042	0.00001	2.24×10^{-7}
Fire (Room)	0.0005	1.73×10^{-8}	1.88×10^{-9}	0.000303	7.22×10^{-6}	1.62×10^{-7}
Fire (Dock)	2.0×10^{-6}	4.32×10^{-12}	4.68×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Glovebox)	0.80	2.14×10^{-14}	8.02×10^{-15}	1.00×10^{-9}	5.14×10^{-11}	1.02×10^{-14}
Spill (Dock)	0.001	9.00×10^{-11}	9.75×10^{-12}	1.58×10^{-6}	3.75×10^{-8}	8.40×10^{-10}
Earthquake	0.0018	3.03×10^{-7}	3.29×10^{-8}	0.00531	0.000126	2.83×10^{-6}
Blend Down Process—Building 707						
Explosion	0.00005	2.40×10^{-8}	2.60×10^{-9}	0.00042	0.00001	2.24×10^{-7}
Fire (Room)	0.0005	2.89×10^{-8}	3.13×10^{-9}	0.000505	0.000012	2.69×10^{-7}
Fire (Dock)	2.0×10^{-6}	4.32×10^{-12}	4.68×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Glovebox)	0.80	2.14×10^{-14}	8.02×10^{-15}	1.00×10^{-9}	5.14×10^{-11}	1.02×10^{-14}
Spill (Dock)	0.001	9.00×10^{-11}	9.75×10^{-12}	1.58×10^{-6}	3.75×10^{-8}	8.40×10^{-10}
Earthquake	0.0018	5.06×10^{-7}	5.48×10^{-8}	0.00885	0.000211	4.72×10^{-6}

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr)		Population (LCF/yr)		Worker (LCF/yr)
		95% Met	50% Met	95% Met	50% Met	50% Met
Blend Down Process—Building 371						
Explosion	0.00005	6.00×10^{-14}	6.80×10^{-15}	8.40×10^{-10}	2.00×10^{-11}	4.00×10^{-14}
Fire (Room)	0.0005	4.33×10^{-8}	4.33×10^{-9}	0.000505	0.0000120	2.69×10^{-7}
Fire (Dock)	2.0×10^{-6}	6.48×10^{-12}	6.48×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Glovebox)	0.80	2.00×10^{-13}	2.27×10^{-14}	2.81×10^{-9}	6.68×10^{-11}	1.34×10^{-13}
Spill (Dock)	0.001	1.35×10^{-10}	1.35×10^{-11}	1.58×10^{-6}	3.75×10^{-8}	8.40×10^{-10}
Earthquake	0.000094	3.96×10^{-8}	3.96×10^{-9}	0.000462	0.0000110	2.46×10^{-7}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.9.3 Processing and Storage with Plutonium Separation

The inorganic residues processing technology considered for this alternative is mediated electrochemical oxidation. Processing of inorganic residues with the mediated electrochemical oxidation process may be performed at either Rocky Flats or the Savannah River Site. At Rocky Flats, most of the mediated electrochemical oxidation process will be performed in Building 371, Room 3701; the final calcination in the process will be performed in Building 707A, Module J. The packaging of the residues at Rocky Flats for processing at the Savannah River Site will be performed in Building 371, Room 371. The mediated electrochemical oxidation process will be performed in the canyon facilities at the Savannah River Site.

At each site similar accidents are applicable for the selected processes. **Table D–135** provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of processing inorganic residues using mediated electrochemical oxidation technology at Rocky Flats. **Table D–136** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with the processing of inorganic residues at Rocky Flats. The risks associated with this processing technology at Rocky Flats are summarized in **Table D–137**.

Table D–135 Inorganic Residues Accident Scenarios Parameters Mediated Electrochemical Oxidation Process at Rocky Flats

Accident Scenario	Frequency (per year)	Inorganic Residues	HEPA Banks	Material at Risk (grams) Mediated Electrochemical Oxidation Process	
				Building 371	Building 707A [a]
Explosion (Acetylene)	0.00005	2 drums	2/0 [b]	4,000 g [c]	1,966 g
Explosion (Ion Exchange Column)	0.0001	Solution	2	0.245 mg [d]	N/A
Nuclear Criticality	0.0001	Solution	2	1.0×10^{19} fissions	N/A [e]
Fire:					
a. Room	0.0005	5-day supply [f]	2	5,376 g	5,898 g
b. Loading Dock	2.0×10^{-6}	4 drums	0	6,000 g [g]	3,932 g
Spill:					
a. Room [h]	–	–	–	–	–
b. Glovebox	0.80	1 feed prep container	2	194 g	983 g
c. Loading Dock	0.001	1 drum	0	3,000 g [j]	983 g
Earthquake:					
a. Building 371	0.000094	5-day supply [f]	0	5,376 g	N/A
b. Building 707A	0.0008	5-day supply [f]	0	N/A	5,898 g

Accident Scenario	Frequency (per year)	Inorganic Residues	HEPA Banks	Material at Risk (grams) Mediated Electrochemical Oxidation Process: Building 371	Building 707A [a]
Aircraft Crash:					
a. Building 371	0.00004	The aircraft will not penetrate the building wall.	–	–	N/A
b. Building 707A	0.00001	Consequences enveloped by the earthquake.	–	N/A	–

Accident Scenario	DR	ARF	RF	LPF	Release Point
Explosion (Acetylene):					
a. Building 707A	1.0	0.001	0.010	1.0	Ground
b. Building 371	1.0	0.001	1.0	2.0×10^{-6}	Elevated
Explosion (Ion Exchange Column) [k]	1.0	1.0	1.0	1.0	Elevated
Nuclear Criticality [e, l]	–	–	–	–	Elevated
Fire:					
a. Room	1.0	0.006	0.01	0.10	Ground
b. Loading Dock	0.01	0.006	0.01	0.50	Ground
Spill:					
a. Glovebox	1.0	1.0×10^{-6} [m]	1.0 [m]	2.0×10^{-6}	Elevated
b. Loading Dock	0.25	1.0×10^{-6} [m]	1.0 [m]	0.10	Ground
Earthquake:					
Buildings 371 and 707A	1.0	0.001 [d]	0.10 [d]	0.10	Ground
Aircraft Crash:					
a. Building 707A [n]	–	–	–	–	–
b. Building 371 [p]	–	–	–	–	–

N/A = not applicable DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] 983-g product drums are transported from Building 371 to Building 707A for processing.

[b] Building 707A, 0 HEPA Banks; Building 371, 2 HEPA Banks.

[c] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content.

[d] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000292).

[e] The wet nuclear criticality is not a viable accident scenario for the mediated electrochemical oxidation process in Building 707A.

[f] 3-day supply of feed and 2-day supply of product.

[g] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.

[h] Materials are opened in a glovebox. No room spill is considered.

[j] 1 drum at the maximum plutonium content level.

[k] Respirable source term value in milligrams of plutonium released up the stack.

[l] Refer to Table D–28 for Building 371 mediated electrochemical oxidation criticality accident source term.

[m] The product of ARF×RF = 1.0×10^{-6}.

[n] Consequences enveloped by the earthquake.

[p] The aircraft will not penetrate the building walls.

Table D–136 Summary of the Inorganic Residues Accident Analysis Doses Mediated Electrochemical Oxidation Process at Rocky Flats

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Mediated Electrochemical Oxidation Process—Building 371							
Explosion (Acetylene)	8.00×10^{-7}	Metal	2.40×10^{-6}	2.72×10^{-7}	0.0336	0.0008	2.00×10^{-6}
Explosion (Ion Exchange Column)	0.000245	Metal	0.000735	0.0000833	10.3	0.245	0.000613
Criticality (Liquid)	[a]	–	0.790	0.110	6,980	252	0.321
Fire (Room)	0.0323	Metal	0.116	0.0116	1,350	32.3	0.903
Fire (Dock)	0.0018	Metal	0.00648	0.000648	75.6	1.80	0.0504
Spill (Glovebox)	3.88×10^{-10}	Metal	1.16×10^{-9}	1.32×10^{-10}	0.0000163	3.88×10^{-7}	9.70×10^{-10}
Spill (Dock)	0.0000750	Metal	0.00027	0.000027	3.15	0.075	0.0021
Earthquake	0.157	Metal	0.565	0.0565	6,590	157	4.40
Mediated Electrochemical Oxidation Process—Building 707A							
Explosion (Acetylene)	0.197	Oxide	0.236	0.0256	4,920	118	4.13
Fire (Room)	0.0354	Oxide	0.0425	0.0046	895	21.2	0.743
Fire (Dock)	0.00118	Oxide	0.00142	0.000153	29.5	0.708	0.0248
Spill (Glovebox)	1.97×10^{-9}	Oxide	3.15×10^{-10}	1.18×10^{-10}	0.0000171	8.85×10^{-7}	2.75×10^{-10}
Spill (Dock)	0.0000246	Oxide	0.0000295	3.19×10^{-6}	0.614	0.0147	0.000516
Earthquake	0.172	Oxide	0.207	0.0224	4,310	103	3.62

MEI = maximally exposed individual Met = meteorological data

[a] 1.0×10^{19} fissions.

Table D–137 Summary of the Inorganic Residues Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year—Mediated Electrochemical Oxidation Process at Rocky Flats

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr) 95% Met	MEI (LCF/yr) 50% Met	Population (LCF/yr) 95% Met	Population (LCF/yr) 50% Met	Worker (LCF/yr) 50% Met
Mediated Electrochemical Oxidation Process—Building 371						
Explosion (Acetylene)	0.00005	6.00×10^{-14}	6.80×10^{-15}	8.40×10^{-10}	2.00×10^{-11}	4.00×10^{-14}
Explosion (Ion Exchange Column)	0.0001	3.68×10^{-11}	4.17×10^{-12}	5.15×10^{-7}	1.23×10^{-8}	2.45×10^{-11}
Criticality (Liquid)	0.0001	3.95×10^{-8}	5.50×10^{-9}	0.000349	0.0000126	1.28×10^{-8}
Fire (Room)	0.0005	2.90×10^{-8}	2.90×10^{-9}	0.000339	8.06×10^{-6}	1.81×10^{-7}
Fire (Dock)	2.0×10^{-6}	6.48×10^{-12}	6.48×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Glovebox)	0.80	4.66×10^{-13}	5.28×10^{-14}	6.52×10^{-9}	1.55×10^{-10}	3.10×10^{-13}
Spill (Dock)	0.001	1.35×10^{-10}	1.35×10^{-11}	1.58×10^{-6}	3.75×10^{-8}	8.40×10^{-10}
Earthquake	0.000094	2.66×10^{-8}	2.66×10^{-9}	0.00031	7.38×10^{-6}	1.65×10^{-7}
Mediated Electrochemical Oxidation Process—Building 707A						
Explosion (Acetylene)	0.00005	5.90×10^{-9}	6.39×10^{-10}	0.000123	2.95×10^{-6}	8.26×10^{-8}
Fire (Room)	0.0005	1.06×10^{-8}	1.15×10^{-9}	0.000221	5.31×10^{-6}	1.49×10^{-7}
Fire (Dock)	2.0×10^{-6}	1.42×10^{-12}	1.53×10^{-13}	2.95×10^{-8}	7.08×10^{-10}	1.98×10^{-11}

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr)		Population (LCF/yr)		Worker (LCF/yr)
		95% Met	50% Met	95% Met	50% Met	50% Met
Spill (Glovebox)	0.80	1.26×10^{-13}	4.72×10^{-14}	6.84×10^{-9}	3.54×10^{-10}	8.81×10^{-14}
Spill (Dock)	0.001	1.47×10^{-11}	1.60×10^{-12}	3.07×10^{-7}	7.37×10^{-9}	2.06×10^{-10}
Earthquake	0.0008	8.27×10^{-8}	8.96×10^{-9}	0.00172	0.0000413	1.16×10^{-6}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

Table D–138 provides the applicable accident scenarios, assumptions, and parameters used in determining the impacts of packaging the inorganic residues at Rocky Flats and of processing the residues using the mediated electrochemical oxidation technology at the Savannah River Site. **Table D–139** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from accidental releases associated with packaging the inorganic residues at Rocky Flats and processing the inorganic residues at the Savannah River Site. The risks associated with the packaging at Rocky Flats and the mediated electrochemical oxidation processing technology at the Savannah River Site are summarized in **Table D–140**. The processes at the Savannah River Site could be performed in either the F-Canyon and FB-Line or the H-Canyon and HB-Line. Data are presented in Table D–138, Table D–139, and Table D–140 for both options.

Table D–138 Inorganic Residues Accident Scenarios Parameters Mediated Electrochemical Oxidation Process at the Savannah River Site

Accident Scenario	Frequency (per year)	Inorganic Residues	HEPA Banks	Material at Risk (grams)
Rocky Flats Packaging of Residue for Shipment to the Savannah River Site				
Explosion	0.00005	2 drums [a]	2	4,000 g
Nuclear Criticality [b]	–	–	–	–
Fire:				
a. Room	0.0005	5-day supply [c]	2	6,636 g
b. Loading Dock	2.0×10^{-6}	4 drums [d]	0	6,000 g
Spill:				
a. Room [e]	–	–	–	–
b. Glovebox	0.80	1 feed prep container	2	79 g
c. Loading Dock	0.001	1 drum [f]	0	3,000 g
Earthquake	0.000094	5-day supply [c]	0	6,636 g
Aircraft Crash	0.000040	The aircraft will not penetrate the building wall.	–	–

Rocky Flats Packaging of Residue for Shipment to the Savannah River Site					
Accident Scenario	DR	ARF	RF	LPF	Release Point
Explosion	1.0	0.001	0.10	2.0×10^{-6}	Elevated
Nuclear Criticality [b]	–	–	–	–	–
Fire:					
a. Room	1.0	0.006	0.01	0.10	Ground
b. Loading Dock	0.01	0.006	0.01	0.50	Ground
Spill:					
a. Glovebox	1.0	1.0×10^{-6} [g]	1.0 [g]	2.0×10^{-6}	Elevated
b. Loading Dock	0.25	1.0×10^{-6} [g]	1.0 [g]	0.10	Ground
Earthquake	1.0	0.001 [h]	0.10 [h]	0.10	Ground
Aircraft Crash [j]	–	–	–	–	–

Mediated Electrochemical Oxidation Process at the Savannah River Site F-Canyon				
Accident Scenario	***Frequency (per year)***		***Material at Risk (grams)***	
Explosion: a. Hydrogen b. Ion Exchange Column	 0.000015 0.0001		 4,000 g 120.5 mg [k]	
Nuclear Criticality [l]	0.0001		1.0×10^{19} fissions	
Fire	0.00061		4,000 g	
Spill	0.01		79 g	
Earthquake: a. F-Canyon Liquid b. FB-Line Powder Molten Metal Liquid	0.000125		 12,000 g 1,000 g 1,000 g 1,000 g	
Accident Scenario	***DR***	***ARF×RF***	***LPF***	***Release Point***
Explosion: a. Hydrogen b. Ion Exchange Column	 1.0 1.0	 0.0010 1.0	 0.0050 1.0	 Elevated Elevated
Nuclear Criticality [l]	–	–	–	–
Fire	1.0	0.01	0.005	Elevated
Spill	1.0	0.00001	0.005	Elevated
Earthquake: a. F-Canyon Liquid b. FB-Line Powder Molten Metal Liquid	 1.0 1.0 1.0 1.0	 0.000047 0.002 0.0022 0.000047	 0.10 0.10 0.10 0.10	 Ground Ground Ground Ground
Mediated Electrochemical Oxidation Process at the Savannah River Site H-Canyon				
Accident Scenario	***Frequency (per year)***		***Material at Risk (grams)***	
Explosion: a. Hydrogen b. Ion Exchange Column	 0.0000150 0.0001		 4,000 g 241 mg [k, m]	
Nuclear Criticality [l]	0.0001		1.0×10^{19} fissions	
Fire	0.00061		6,000 g	
Spill	0.01		79 g	
Earthquake: a. H-Canyon Liquid b. HB-Line Powder Liquid	0.000182		 27,000 g 4,000 g [m] 4,000 g [m]	
Accident Scenario	***DR***	***ARF×RF***	***LPF***	***Release Point***
Explosion: a. Hydrogen b. Ion Exchange Column	 1.0 1.0	 0.001 1.0	 0.005 1.0	 Elevated Elevated
Nuclear Criticality [l]	–	–	–	–
Fire	1.0	0.01	0.005	Elevated
Spill	1.0	0.00001	0.005	Elevated

Accident Scenario	DR	ARF×RF	LPF	Release Point
Earthquake:				
a. H-Canyon				
Liquid	1.0	0.000047	0.10	Ground
b. HB-Line				
Powder	1.0	0.002	0.10	Ground
Liquid	1.0	0.000047	0.10	Ground

DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content.

[b] The wet nuclear criticality is not a viable accident scenario for the residue packaging process in Building 371.

[c] 3-day supply of feed and 2-day supply of product.

[d] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.

[e] Materials are opened in a glovebox. No room spill is considered.

[f] 1 drum at the maximum plutonium content level.

[g] The product of ARF×RF = 1.0×10^{-6}.

[h] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000292).

[j] The aircraft will not penetrate the building walls.

[k] Respirable source term value in milligrams of plutonium released up the stack.

[l] Refer to Table D–28 for criticality accident source term.

[m] Duty cycle = 60%.

Table D–139 Summary of the Inorganic Residues Accident Analysis Doses Mediated Electrochemical Oxidation Process at the Savannah River Site

	Building Source Term		MEI (rem)		Population (person-rem)		Worker (rem)
Accident Scenario	(grams)	Type	95% Met	50% Met	95% Met	50% Met	50% Met
Rocky Flats Packaging of Residues for Shipment to the Savannah River Site							
Explosion	8.00×10^{-7}	Metal	2.40×10^{-6}	2.72×10^{-7}	0.0336	0.0008	2.00×10^{-6}
Fire (Room)	0.0398	Metal	0.143	0.0143	1,670	39.8	1.11
Fire (Dock)	0.0018	Metal	0.00648	0.000648	75.6	1.80	0.0504
Spill (Glovebox)	1.58×10^{-10}	Metal	4.74×10^{-10}	5.37×10^{-11}	6.64×10^{-6}	1.58×10^{-7}	3.95×10^{-10}
Spill (Dock)	0.000075	Metal	0.00027	0.000027	3.15	0.075	0.0021
Earthquake	0.194	Metal	0.698	0.0698	8,140	194	5.43
Mediated Electrochemical Oxidation Process at the Savannah River Site F-Canyon							
Explosion (Hydrogen)	0.02	Metal	0.00068	0.00024	36.0	3.20	0.002
Explosion (Ion Exchange Column)	0.121	Metal-FB	0.00374	0.00133	193	18.1	0.0112
Criticality (Liquid)	[a]	–	0.011	0.0044	310	32.0	0.038
Fire	0.200	Metal	0.0068	0.0024	360	32.0	0.02
Spill	3.95×10^{-6}	Metal	1.34×10^{-7}	4.74×10^{-8}	0.00711	0.000632	3.95×10^{-7}
Earthquake	0.481	Metal	0.0443	0.00818	1,590	111	10.6
Mediated Electrochemical Oxidation Process at the Savannah River Site H-Canyon							
Explosion (Hydrogen)	0.02	Metal	0.00064	0.000192	32.0	3.00	0.002
Explosion (Ion Exchange Column)	0.241	Metal-HB	0.00699	0.00212	342	34.0	0.0224
Criticality (Liquid)	[a]	–	0.009	0.003	290	29.0	0.038
Fire	0.300	Metal	0.0096	0.00288	480	45.0	0.03

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Spill	3.95×10^{-6}	Metal	1.26×10^{-7}	3.79×10^{-8}	0.00632	0.000593	3.95×10^{-7}
Earthquake	0.946	Metal	0.0653	0.0132	2,930	189	20.8

MEI = maximally exposed individual Met = meteorological data
[a] 1.0×10^{19} fissions.

Table D–140 Summary of the Inorganic Residues Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year—Mediated Electrochemical Oxidation Process at the Savannah River Site

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr) 95% Met	MEI (LCF/yr) 50% Met	Population (LCF/yr) 95% Met	Population (LCF/yr) 50% Met	Worker (LCF/yr) 50% Met
Rocky Flats Packaging of Residues for Shipment to the Savannah River Site						
Explosion	0.00005	6.00×10^{-14}	6.80×10^{-15}	8.40×10^{-10}	2.00×10^{-11}	4.00×10^{-14}
Fire (Room)	0.0005	3.58×10^{-8}	3.58×10^{-9}	0.000418	9.95×10^{-6}	2.23×10^{-7}
Fire (Dock)	2.00×10^{-6}	6.48×10^{-12}	6.48×10^{-13}	7.56×10^{-8}	1.80×10^{-9}	4.03×10^{-11}
Spill (Glovebox)	0.800	1.90×10^{-13}	2.15×10^{-14}	2.65×10^{-9}	6.32×10^{-11}	1.26×10^{-13}
Spill (Dock)	0.001	1.35×10^{-10}	1.35×10^{-11}	1.58×10^{-6}	3.75×10^{-8}	8.40×10^{-10}
Earthquake	0.000094	3.28×10^{-8}	3.28×10^{-9}	0.000383	9.11×10^{-6}	2.04×10^{-7}
Mediated Electrochemical Oxidation Process at the Savannah River Site F-Canyon						
Explosion (Hydrogen)	0.000015	5.10×10^{-12}	1.80×10^{-12}	2.70×10^{-7}	2.40×10^{-8}	1.20×10^{-11}
Explosion (Ion Exchange Column)	0.0001	1.87×10^{-10}	6.63×10^{-11}	9.64×10^{-6}	9.04×10^{-7}	4.48×10^{-10}
Criticality (Liquid)	0.0001	5.50×10^{-10}	2.20×10^{-10}	0.000155	1.60×10^{-6}	1.52×10^{-9}
Fire	0.00061	2.07×10^{-9}	7.32×10^{-10}	0.00011	9.76×10^{-6}	4.88×10^{-9}
Spill	0.01	6.72×10^{-13}	2.37×10^{-13}	3.56×10^{-8}	3.16×10^{-9}	1.58×10^{-12}
Earthquake	0.000125	2.77×10^{-9}	5.11×10^{-10}	0.0000992	6.92×10^{-6}	5.29×10^{-7}
Mediated Electrochemical Oxidation Process at the Savannah River Site H-Canyon						
Explosion (Hydrogen)	0.000015	4.80×10^{-12}	1.44×10^{-12}	2.40×10^{-7}	2.25×10^{-8}	1.20×10^{-11}
Explosion (Ion Exchange Column)	0.0001	2.10×10^{-10}	6.36×10^{-11}	0.0000103	1.02×10^{-6}	5.38×10^{-10}
Criticality (Liquid)	0.0001	4.50×10^{-10}	1.50×10^{-10}	0.0000145	1.45×10^{-6}	1.52×10^{-9}
Fire	0.00061	2.93×10^{-9}	8.78×10^{-10}	0.000146	0.0000137	7.32×10^{-9}
Spill	0.01	6.32×10^{-13}	1.90×10^{-13}	3.16×10^{-8}	2.96×10^{-9}	1.58×10^{-12}
Earthquake	0.000182	3.88×10^{-9}	7.88×10^{-10}	0.000174	0.0000113	1.980×10^{-6}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.10 Scrub Alloy

D.3.4.10.1 No Action

The scrub alloy processing technology considered for this alternative is direct repackaging. Direct repackaging of residues will be conducted within glovebox lines in Modules D, E, and F in Building 707 at Rocky Flats.

Table D–141 provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of direct repackaging of scrub alloy at Rocky Flats. **Table D–142** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with repackaging scrub alloy at Rocky Flats. The risks associated with this processing technology are summarized in **Table D–143**.

Table D–141 Scrub Alloy Accident Scenarios Parameters
Direct Repackaging at Rocky Flats

Accident Scenario	*Frequency (per year)*	*Scrub Alloy*	*HEPA Banks*	*Material at Risk (grams)*
Explosion	0.00005	2 drums [a]	0	4,000 g
Nuclear Criticality	–	–	–	–
Fire:				
a. Room	0.0005	5-day supply [b]	2	34,800 g
b. Loading Dock	2.0×10^{-6}	4 drums [c]	0	6,000 g
Spill:				
a. Room	0.008	1 container at the maximum limit [d]	2	3,000 g
b. Glovebox	0.80	1 feed prep container	2	725 g
c. Loading Dock	0.001	1 drum [e]	0	3,000 g
Earthquake	0.0018	5-day supply [b]	0	34,800 g
Aircraft Crash	0.00003	Consequences enveloped by the earthquake.	–	–

Accident Scenario	*DR*	*ARF*	*RF*	*LPF*	*Release Point*
Explosion:	0.01	0.00001	1.0	1.0	Ground
Nuclear Criticality [f]	–	–	–	–	–
Fire:					
a. Room	0.01	0.006	0.01	0.10	Ground
b. Loading Dock	0.01	0.006	0.01	0.50	Ground
Spill:					
a. Room	0.01	1.0×10^{-6} [g]	1.0 [g]	2.0×10^{-6}	Elevated
b. Glovebox	0.01	1.0×10^{-6} [g]	1.0 [g]	2.0×10^{-6}	Elevated
c. Loading Dock	0.01	1.0×10^{-6} [g]	1.0 [g]	0.10	Ground
Earthquake	0.01	0.001 [h]	0.10 [h]	0.10	Ground
Aircraft Crash [j]	–	–	–	–	–

DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content.

[b] 3-day supply of feed and 2-day supply of product.

[c] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.

[d] 1 container per drum of feed.

[e] 1 drum at the maximum plutonium content level.

[f] The wet nuclear criticality is not a viable accident scenario for the direct repackaging process in Building 707.

[g] The product of ARF×RF + 1.0×10^{-6}.

[h] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000292).

[j] Consequences enveloped by the earthquake.

Table D–142 Summary of the Scrub Alloy Accident Analysis Doses Direct Repackaging at Rocky Flats

	Building Source Term		*MEI (rem)*		*Population (person-rem)*		*Worker (rem)*
Accident Scenario	*(grams)*	*Type*	*95% Met*	*50% Met*	*95% Met*	*50% Met*	*50% Met*
Explosion	0.0004	Salt-O	0.0056	0.0006	104	2.48	0.068
Fire (Room)	0.00209	Salt-O	0.0292	0.00313	543	12.9	0.355
Fire (Dock)	0.0018	Salt-O	0.0252	0.0027	468	11.2	0.306
Spill (Room)	6.00×10^{-11}	Salt-O	1.14×10^{-10}	4.32×10^{-11}	5.40×10^{-6}	2.76×10^{-7}	7.20×10^{-11}
Spill (Glovebox)	1.45×10^{-11}	Salt-O	2.76×10^{-11}	1.04×10^{-11}	1.31×10^{-6}	6.67×10^{-8}	1.74×10^{-11}
Spill (Dock)	3.00×10^{-6}	Salt-O	0.0000420	4.50×10^{-6}	0.780	0.0186	0.00051
Earthquake	0.0102	Salt-O	0.142	0.0152	2,640	63.0	1.73

MEI = maximally exposed individual Met = meteorological data Salt-O = oxide salt

Table D–143 Summary of the Scrub Alloy Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year—Direct Repackaging at Rocky Flats

	Accident Frequency (per year)	*MEI (LCF/yr)*		*Population (LCF/yr)*		*Worker (LCF/yr)*
Accident Scenario		*95% Met*	*50% Met*	*95% Met*	*50% Met*	*50% Met*
Explosion	0.00005	1.40×10^{-10}	1.50×10^{-11}	2.60×10^{-6}	6.20×10^{-8}	1.36×10^{-9}
Fire (Room)	0.0005	7.31×10^{-9}	7.83×10^{-10}	0.000136	3.24×10^{-6}	7.10×10^{-8}
Fire (Dock)	2.0×10^{-6}	2.52×10^{-11}	2.70×10^{-12}	4.68×10^{-7}	1.12×10^{-8}	2.45×10^{-10}
Spill (Room)	0.008	4.56×10^{-16}	1.73×10^{-16}	2.16×10^{-11}	1.10×10^{-12}	2.30×10^{-16}
Spill (Glovebox)	0.80	1.10×10^{-14}	4.18×10^{-15}	5.22×10^{-10}	2.67×10^{-11}	5.57×10^{-15}
Spill (Dock)	0.001	2.10×10^{-11}	2.25×10^{-12}	3.90×10^{-7}	9.30×10^{-9}	2.04×10^{-10}
Earthquake	0.0018	1.28×10^{-7}	1.37×10^{-8}	0.00238	0.0000567	1.24×10^{-6}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.10.2 Processing and Storage without Plutonium Separation

The scrub alloy processing technology considered for this alternative is vitrification. The vitrification process will be performed at Rocky Flats in Building 707, Modules D, E, and F. **Table D–144** provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of scrub alloy processing at Rocky Flats. **Table D–145** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with the processing of scrub alloy. The risks associated with this processing technology are summarized in **Table D–146**.

Table D–144 Scrub Alloy Accident Scenarios Parameters Vitrification Process at Rocky Flats

Accident Scenario	*Frequency (per year)*	*Scrub Alloy*	*HEPA Banks*	*Material at Risk (grams)*
Explosion	0.00005	2 drums [a]	0	4,000 g
Nuclear criticality [b]	–	–	–	–
Fire:				
a. Room	0.0005 2.0×10^{-6}	5-day supply [c]	2	1,043 g supply + 695 g product [d]
b. Loading Dock		4 drums [e]	0	6,000 g
Spill:				
a. Room	0.008	1 container at the limit [f]	2	3,000 g
b. Glovebox	0.80	1 feed prep container [f]	2	725 g
c. Loading Dock	0.001	1 drum [g]	0	3,000 g
Earthquake	0.0018	5-day supply [c]	0	1,043 g supply + 695 g product [d]
Aircraft Crash	0.00003	Consequences enveloped by the earthquake.	–	–

Accident Scenario	*DR*	*ARF*	*RF*	*LPF*	*Release Point*
Explosion	0.01	0.00001	1.0	1.0	Ground
Nuclear Criticality [b]	–	–	–	–	–
Fire:					
a. Room	0.01	0.006	0.01	0.10	Ground
b. Loading Dock	0.01	0.006	0.01	0.50	Ground
Spill:					
a. Room	0.01	1.0×10^{-6} [h]	1.0 [h]	2.0×10^{-6}	Elevated
b. Glovebox	0.01	1.0×10^{-6} [h]	1.0 [h]	2.0×10^{-6}	Elevated
c. Loading Dock	0.01	1.0×10^{-6} [h]	1.0 [h]	0.10	Ground
Earthquake	0.01	0.001 [j]	0.10 [j]	0.10	Ground
Aircraft Crash [k]	–	–	–	–	–

DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] 1 drum at the maximum plutonium content level (3,000 grams) and 1 drum at the administrative control level (1,000 grams) for plutonium content.

[b] The wet nuclear criticality is not a viable accident scenario for the vitrification technology assessment.

[c] 3-day supply of feed and 2-day supply of product.

[d] The product is glass. The effect of the vitrified product on the accident source term is negligible.

[e] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.

[f] 1 container per drum of feed.

[g] 1 drum at the maximum plutonium content level.

[h] The product of ARF×RF = 1.0×10^{-6}.

[j] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000292).

[k] Consequences enveloped by the earthquake.

Table D–145 Summary of the Scrub Alloy Accident Analysis Doses Vitrification Process at Rocky Flats

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Explosion	0.0004	Salt-O	0.0056	0.0006	104	2.48	0.068
Fire (Room)	0.0000626	Salt-O	0.000876	0.0000939	16.3	0.388	0.0106
Fire (Dock)	0.0018	Salt-O	0.0252	0.0027	468	11.2	0.306
Spill (Room)	6.00×10^{-11}	Salt-O	1.14×10^{-10}	4.32×10^{-11}	5.40×10^{-6}	2.76×10^{-7}	7.20×10^{-11}
Spill (Glovebox)	1.45×10^{-11}	Salt-O	2.76×10^{-11}	1.04×10^{-11}	1.31×10^{-6}	6.67×10^{-8}	1.74×10^{-11}
Spill (Dock)	3.00×10^{-6}	Salt-O	0.000042	4.50×10^{-6}	0.780	0.0186	0.00051
Earthquake	0.000305	Salt-O	0.00426	0.000457	79.2	1.89	0.0518

MEI = maximally exposed individual Met = meteorological data Salt-O = oxide salt

Table D–146 Summary of the Scrub Alloy Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year—Vitrification Process at Rocky Flats

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr) 95% Met	MEI (LCF/yr) 50% Met	Population (LCF/yr) 95% Met	Population (LCF/yr) 50% Met	Worker (LCF/yr) 50% Met
Explosion	0.00005	1.40×10^{-10}	1.50×10^{-11}	2.60×10^{-6}	6.20×10^{-8}	1.36×10^{-9}
Fire (Room)	0.0005	2.19×10^{-10}	2.35×10^{-11}	4.07×10^{-6}	9.70×10^{-8}	2.13×10^{-9}
Fire (Dock)	2.0×10^{-6}	2.52×10^{-11}	2.70×10^{-12}	4.68×10^{-7}	1.12×10^{-8}	2.45×10^{-10}
Spill (Room)	0.008	4.56×10^{-16}	1.73×10^{-16}	2.16×10^{-11}	1.10×10^{-12}	2.30×10^{-16}
Spill (Glovebox)	0.80	1.10×10^{-14}	4.18×10^{-15}	5.22×10^{-10}	2.67×10^{-11}	5.57×10^{-15}
Spill (Dock)	0.001	2.10×10^{-11}	2.25×10^{-12}	3.90×10^{-7}	9.30×10^{-9}	2.04×10^{-10}
Earthquake	0.0018	3.84×10^{-9}	4.11×10^{-10}	0.0000713	1.70×10^{-6}	3.73×10^{-8}

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.4.10.3 Processing and Storage with Plutonium Separation

The scrub alloy processing technology considered for this alternative is the Purex/plutonium metal (or oxide) recovery process at the Savannah River Site. The scrub alloy will be packaged at Rocky Flats and shipped to the Savannah River Site for processing. The packaging of the residues at Rocky Flats will be performed in Building 371, Room 3701. The Purex process will be performed in the canyon facilities at the Savannah River Site.

Similar accidents are applicable to the facilities at both sites. **Table D–147** provides the applicable accident scenarios, assumptions, and parameters used in determining the impact of scrub alloy processing at the Savannah River Site. **Table D–148** summarizes the consequences to the maximally exposed individual, the public, and workers resulting from the accidental releases associated with the processing of scrub alloy. The risks associated with this processing technology are summarized in **Table D–149**. The processes at the Savannah River Site could be performed either in the F-Canyon and FB-Line or in the H-Canyon and HB-Line. Data are presented in Table D–147, Table D–148, and Table D–149 for both options.

Table D–147 Scrub Alloy Accident Scenarios Parameters Purex/Plutonium Metal Recovery Process at the Savannah River Site

Accident Scenario	*Frequency (per year)*	*Scrub Alloy*	*HEPA Banks*	*Material at Risk (grams)*
Rocky Flats Packaging of Residues for Shipment to the Savannah River Site				
Explosion	0.00005	2 drums [a]	2	4,000 g
Nuclear Criticality [b]	–	–	–	–
Fire:				
a. Room	0.0005	5-day supply [c]	2	20,412 g
b. Loading Dock	2.0×10^{-6}	4 drums [d]	0	6,000 g
Spill:				
a. Room	0.008	1 container at the maximum limit [e]	2	3,000 g
b. Glovebox	0.80	1 feed prep container	2	725 g
c. Loading Dock	0.001	1 drum [f]	0	3,000 g
Earthquake	0.000094	5-day supply [c]	0	20,412 g
Aircraft Crash	0.00004	The aircraft will not penetrate the building wall.	–	–

Accident Scenario	*DR*	*ARF*	*RF*	*LPF*	*Release Point*
Explosion	0.01	0.00001	1.0	2.0×10^{-6}	Elevated
Nuclear Criticality [b]	–	–	–	–	–
Fire:					
a. Room	0.01	0.006	0.01	0.10	Ground
b. Loading Dock	0.01	0.006	0.01	0.50	Ground
Spill:					
a. Room	0.01	1.0×10^{-6} [g]	1.0 [g]	2.0×10^{-6}	Elevated
b. Glovebox	0.01	1.0×10^{-6} [g]	1.0 [g]	2.0×10^{-6}	Elevated
c. Loading Dock	0.01	1.0×10^{-6} [g]	1.0 [g]	0.10	Ground
Earthquake	0.01	0.001 [h]	0.10 [h]	0.10	Ground
Aircraft Crash [j]	–	–	–	–	–

Purex/Plutonium Metal Recovery Process at the Savannah River Site F-Canyon		
Accident Scenario	*Frequency (per year)*	*Material at Risk (grams)*
Explosion:		
a. Hydrogen	0.000015	8,000 g
b. Ion Exchange Column	0.0001	241 mg [k]
Nuclear Criticality [l]	0.0001	1.0×10^{19} fissions
Fire	0.00061	8,000 g
Spill [m]	–	–
Earthquake:	0.000125	
a. F-Canyon		
Liquid		24,000 g
b. FB-Line:		
Powder		2,000 g
Molten Metal		2,000 g
Liquid		2,000 g

Accident Scenario	*DR*	*ARF×RF*	*LPF*	*Release Point*
Explosion:				
a. Hydrogen	1.0	0.001	0.005	Elevated
b. Ion Exchange Column	1.0	1.0	1.0	Elevated
Nuclear Criticality [l]	–	–	–	–
Fire	1.0	0.01	0.005	Elevated

Accident Scenario	*DR*	*ARF×RF*	*LPF*	*Release Point*
Spill [m]	–	–	–	–
Earthquake:				
a. F-Canyon				
Liquid	1.0	0.000047	0.10	Ground
b. FB-Line				
Powder	1.0	0.002	0.10	Ground
Molten Metal	1.0	0.0022	0.10	Ground
Liquid	1.0	0.000047	0.10	Ground

Purex/Plutonium Metal Recovery Process at the Savannah River Site H-Canyon

Accident Scenario	*Frequency (per year)*	*Material at Risk (grams)*
Explosion:		
a. Hydrogen	0.000015	6,000 g
b. Ion Exchange Column	0.0001	241 mg [m]
Nuclear Criticality [l]	0.0001	1.0×10^{19} fissions
Fire	0.00061	6,000 g
Spill [m]	–	–
Earthquake:	0.000182	
a. H-Canyon		
Liquid		18,000 g
b. HB-Line		
Powder		4,000 g
Liquid		4,000 g

Accident Scenario	*DR*	*ARF×RF*	*LPF*	*Release Point*
Explosion:				
a. Hydrogen	1.0	0.001	0.005	Elevated
b. Ion Exchange Column	1.0	1.0	1.0	Elevated
Nuclear Criticality [l]	–	–	–	–
Fire	1.0	0.01	0.005	Elevated
Spill [m]	–	–	–	–
Earthquake:				
a. H-Canyon				
Liquid	1.0	0.000047	0.10	Ground
b. HB-Line				
Powder	1.0	0.002	0.10	Ground
Liquid	1.0	0.000047	0.10	Ground

DR = damage ratio ARF = airborne release fraction RF = respirable fraction LPF = leak path factor

[a] 1 drum at the maximum plutonium content level (3,000 g) and 1 drum at the administrative control level (1,000 g) for plutonium content.

[b] The wet nuclear criticality is not a viable accident scenario for the residue packaging process in Building 371.

[c] 3-day supply of feed and 2-day supply of product.

[d] 1 drum at the maximum plutonium content level and 3 drums at the administrative control level for plutonium content.

[e] 1 container per drum of feed.

[f] 1 drum at the maximum plutonium content level.

[g] The product of ARF×RF = 1.0×10^{-6}.

[h] Add 0.000192 to all ARF×RF values for the resuspension of respirable particulates after the earthquake (e.g., ARF×RF + 0.000192 = 0.000292).

[j] The aircraft will not penetrate the building walls.

[k] Respirable source term value in milligrams of plutonium released up the stack.

[l] Refer to Table D–28 for criticality accident source term.

[m] Powder spill is not a viable accident scenario for processing scrub alloy at the Savannah River Site.

Table D–148 Summary of the Scrub Alloy Accident Analysis Doses Purex/Plutonium Metal Recovery Process at the Savannah River Site

Accident Scenario	Building Source Term (grams)	Building Source Term Type	MEI (rem) 95% Met	MEI (rem) 50% Met	Population (person-rem) 95% Met	Population (person-rem) 50% Met	Worker (rem) 50% Met
Rocky Flats Packaging of Residues for Shipment to the Savannah River Site							
Explosion	8.00×10^{-10}	Salt-O	1.44×10^{-8}	1.68×10^{-9}	0.000208	4.88×10^{-6}	1.28×10^{-8}
Fire (Room)	0.00122	Salt-O	0.0269	0.00269	318	7.59	0.208
Fire (Dock)	0.0018	Salt-O	0.0396	0.00396	468	11.2	0.306
Spill (Room)	6.00×10^{-11}	Salt-O	1.08×10^{-9}	1.26×10^{-10}	0.0000156	3.66×10^{-7}	9.60×10^{-10}
Spill (Glovebox)	1.45×10^{-11}	Salt-O	2.61×10^{-10}	3.05×10^{-11}	3.77×10^{-6}	8.85×10^{-8}	2.32×10^{-10}
Spill (Dock)	3.00×10^{-6}	Salt-O	0.000066	6.60×10^{-6}	0.780	0.0186	0.00051
Earthquake	0.00596	Salt-O	0.131	0.0131	1,550	37.0	1.01
Purex/Plutonium Metal Recovery Process at the Savannah River Site F-Canyon							
Explosion (Hydrogen)	0.04	Salt-M	0.0088	0.00328	480	40.0	0.0264
Explosion (Ion Exchange Column)	0.241	Salt-FB	0.00747	0.00265	386	36.2	0.0224
Criticality (Liquid)	[a]	–	0.011	0.0044	310	32.0	0.038
Fire	0.400	Salt-M	0.088	0.0328	4,800	400	0.264
Earthquake	0.962	Salt-M	0.577	0.106	20,200	1,440	144
Purex/Plutonium Oxide Recovery Process at the Savannah River Site H-Canyon							
Explosion (Hydrogen)	0.03	Salt-M	0.0063	0.00189	330	28.8	0.0198
Explosion (Ion Exchange Column)	0.241	Salt-HB	0.00747	0.00205	354	34.7	0.0231
Criticality (Liquid)	[a]	–	0.009	0.003	290	29.0	0.038
Fire	0.300	Salt-M	0.063	0.0189	3,300	288	0.198
Earthquake	0.903	Salt-M	0.407	0.0813	18,100	1,170	136

MEI = maximally exposed individual Met = meteorological data Salt-M = metal salt Salt-O = oxide salt
Salt-FB = salt generated in FB area Salt HB = salt generated in HB area
[a] 1.0×10^{19} fissions.

Table D–149 Summary of the Scrub Alloy Accident Analysis Risks in Terms of Latent Cancer Fatalities per Year—Purex/Plutonium Metal Recovery Process at the Savannah River Site

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr) 95% Met	MEI (LCF/yr) 50% Met	Population (LCF/yr) 95% Met	Population (LCF/yr) 50% Met	Worker (LCF/yr) 50% Met
Rocky Flats Packaging of Residues for Shipment to the Savannah River Site						
Explosion	0.00005	3.60×10^{-16}	4.20×10^{-17}	5.20×10^{-12}	1.22×10^{-13}	2.56×10^{-16}
Fire (Room)	0.0005	6.74×10^{-9}	6.74×10^{-10}	0.0000796	1.90×10^{-6}	4.16×10^{-8}
Fire (Dock)	2.0×10^{-6}	3.96×10^{-11}	3.96×10^{-12}	4.68×10^{-7}	1.12×10^{-8}	2.45×10^{-10}
Spill (Room)	0.008	4.32×10^{-15}	5.04×10^{-16}	6.24×10^{-11}	1.46×10^{-12}	3.07×10^{-15}
Spill (Glovebox)	0.80	1.04×10^{-13}	1.22×10^{-14}	1.51×10^{-9}	3.54×10^{-11}	7.42×10^{-14}
Spill (Dock)	0.001	3.30×10^{-11}	3.30×10^{-12}	3.90×10^{-7}	9.30×10^{-9}	2.04×10^{-10}
Earthquake	0.000094	6.16×10^{-9}	6.16×10^{-10}	0.0000728	1.74×10^{-6}	3.81×10^{-8}
Purex/Plutonium Metal Recovery Process at the Savannah River Site F-Canyon						
Explosion (Hydrogen)	0.000015	6.60×10^{-11}	2.46×10^{-11}	3.60×10^{-6}	3.00×10^{-7}	1.58×10^{-10}
Explosion (Ion Exchange Column)	0.0001	3.74×10^{-10}	1.33×10^{-10}	0.0000193	1.81×10^{-6}	8.97×10^{-10}
Criticality (Liquid)	0.0001	5.50×10^{-10}	2.20×10^{-10}	0.0000155	1.60×10^{-6}	1.52×10^{-9}
Fire	0.00061	2.68×10^{-8}	1.00×10^{-8}	0.00146	0.000122	6.44×10^{-8}
Earthquake	0.000125	3.61×10^{-8}	6.62×10^{-9}	0.00126	0.0000902	0.0000144

Accident Scenario	Accident Frequency (per year)	MEI (LCF/yr)		Population (LCF/yr)		Worker (LCF/yr)
		95% Met	50% Met	95% Met	50% Met	50% Met
Purex/Plutonium Metal Recovery Process at the Savannah River Site H-Canyon						
Explosion (Hydrogen)	0.000015	4.73×10^{-11}	1.42×10^{-11}	2.48×10^{-6}	2.16×10^{-7}	1.19×10^{-10}
Explosion (Ion Exchange Column)	0.0001	3.74×10^{-10}	1.02×10^{-10}	0.0000177	1.74×10^{-6}	9.25×10^{-10}
Criticality (Liquid)	0.0001	4.50×10^{-10}	1.50×10^{-10}	0.0000145	1.45×10^{-6}	1.52×10^{-9}
Fire	0.00061	1.92×10^{-8}	5.76×10^{-9}	0.00101	0.0000878	4.83×10^{-8}
Earthquake	0.000182	3.70×10^{-8}	7.40×10^{-9}	0.00164	0.000107	0.0000197

MEI = maximally exposed individual LCF = latent cancer fatality Met = meteorological data

D.3.5 Secondary Impacts of Accidents

The primary impact of accidents are measured in terms of public and worker exposures to radiation and toxic chemicals. The secondary impacts of accidents affect elements of the environment other than humans. For example, a radiological release may contaminate farmland, surface and underground water, recreational areas, industrial parks, historical sites, or the habitat of an endangered species. As a result, farm products may have to be destroyed; the supply of drinking water may be lowered; recreational areas may be closed; industrial parks may suffer economic losses during shutdown for decontamination; historical sites may have to be closed to visitors; and the endangered species may move closer to extinction.

Accidents during the processing of salts at Rocky Flats, the Savannah River Site, and Los Alamos National Laboratory were selected to assess secondary impacts of accidents. Doses to the public maximally exposed individual at the site boundary, attributable to ground contamination from the highest consequence accident, were calculated. In all cases, the dose to the maximally exposed individual at the site boundary attributable to ground contamination was less than 1 mrem. The GENII computer code model for the maximally exposed individual assumes that the maximally exposed individual is exposed to soil contamination for 0.7 years. The soil contamination level at the site boundary was estimated based on the maximally exposed individual dose. The soil contamination level at the site boundaries for Rocky Flats, the Savannah River Site, and Los Alamos National Laboratory was less than 1 mrem per year.

D.4 IMPACTS OF EXPOSURES TO HAZARDOUS CHEMICALS ON HUMAN HEALTH

The potential impacts of exposure to hazardous chemicals released to the atmosphere as a result of the processing of plutonium residues were evaluated for the routine operation of processing facilities.

The receptors considered in these evaluations include the offsite population living within an 80-km (50-mi) radius of the sites and noninvolved workers located onsite at Rocky Flats and the Savannah River Site. Impacts were also evaluated for the maximally exposed individual member of the offsite population. The maximally exposed individual is the hypothetical person in the population who has the highest potential exposure. Impacts of exposures to hazardous chemicals for workers directly involved in processing plutonium residues were not quantitatively evaluated because the use of personal protective equipment and engineering process controls will limit their exposure to levels within applicable Occupational Safety and Health Administration Permissible Exposure Limits or American Conference of Governmental Industrial Hygienists Threshold Limit Values.

As a result of releases from routine processing facility operations, receptors are expected to be potentially exposed to concentrations of hazardous chemicals that are below those that could cause acutely toxic health effects. Acutely toxic health effects generally result from short-term exposure to relatively high concentrations

of contaminants, such as those that may be encountered during facility accidents. Long-term exposure to relatively lower concentrations of hazardous chemicals can produce adverse chronic health effects that include both carcinogenic and noncarcinogenic effects. The health effect endpoints evaluated in this analysis include excess incidences of latent cancers for carcinogenic chemicals and a spectrum of chemical-specific noncancer health effects (e.g., headaches, membrane irritation, neurotoxicity, immunotoxicity, liver toxicity, kidney toxicity, developmental toxicity, reproductive toxicity, and genetic toxicity) for noncarcinogens.

D.4.1 Methodology

Estimates of airborne concentrations of hazardous chemicals were developed using the Industrial Source Complex air dispersion model. This model was developed by the EPA for regulatory air dispersion modeling applications. ISC3 is the most recent version of the model and is approved for use for a wide variety of emission sources and conditions. The Industrial Source Complex estimates atmospheric concentrations based on the airborne emissions from the processing facility for each block in a circular grid comprising 16 directional sectors (e.g., north, north-northeast, northeast) at radial distances out to 80 km (50 mi) from the point of release, producing a distribution of atmospheric concentrations. The maximally exposed individual is located in the block with the highest estimated concentration.

The long-term version of the model (ISCLT3) was used to estimate potential exposures to offsite populations. The short-term version of the model (ISCST3) was used to develop estimates of the 8-hour and annual concentrations of airborne contaminants to which noninvolved workers may potentially be exposed (EPA 1995c, 1995d). The meteorological data used as input to the models include short-term surface and upper data and joint frequency (STAR) data. The short-term data were obtained from National Weather Service sites at Augusta/Bush Field and Waycross, Georgia, for the Savannah River Site and from the Denver/Stapleton Airport for Rocky Flats. Joint frequency data for both sites were obtained from DOE. Additional information about the processing of model input data can be found in the technical support document (SAIC 1997).

This EIS estimates noncancer health risks by quantifying an individual's intake of a contaminant, which is the usual method. Intake is expressed as milligrams of contaminant ingested, inhaled, or absorbed per kilogram of body weight per day. When evaluating health effects from chemical exposure, intake values for noncarcinogenic chemicals are compared to EPA Reference Doses or Reference Concentrations, as published in the Health Effects Assessment Summary Tables and the Integrated Risk Information System.

The airborne exposure concentrations estimated by ISC3 are converted to chemical intake estimates using the following standard algorithm and exposure parameters developed by the EPA (EPA 1989):

$$\text{Intake (mg/kg-day)} = \frac{CA \times IR \times ET \times EF \times ED}{BW \times AT}$$

where

CA = contaminant concentration in air (mg/m^3) (from ISC3)
IR = inhalation rate (assumed average 20 m^3/day for an adult)
ET = exposure time (hours/day)
EF = exposure frequency (days/year)
ED = exposure duration (years)
BW= body weight (assumed average 70 kg for an adult)
AT = averaging time (period over which exposure is averaged in days; assumed 6.6 years for workers and 9 years for the affected public)

For each noncarcinogenic chemical, potential health risks are estimated by dividing the estimated airborne intake by the chemical-specific Reference Dose value to obtain a noncancer hazard quotient:

Noncancer Hazard Quotient = Intake/Reference Dose

Reference Dose and Reference Concentration are estimates, with uncertainty spanning perhaps an order of magnitude, of a daily exposure to the human population (including sensitive subgroups) that is likely to be without appreciable risk of deleterious effects during a lifetime. Hazard Quotients are calculated for each hazardous chemical to which receptors may be exposed. Hazard Quotients for each chemical are summed to generate a Hazard Index. For example, **Table D–150** lists the Hazard Quotient values that were summed to develop the Hazard Index estimates for the Purex and mediated electrochemical oxidation processes at the Savannah River Site. The Hazard Index is an estimate of the worst-case, total noncancer toxicity from exposure to hazardous chemicals. According to EPA risk assessment guidelines (EPA 1989), if the Hazard Index value is less than or equal to 1.0, the exposure is unlikely to produce adverse toxic effects. If the Hazard Index exceeds 1.0, adverse noncancer health effects may result from the exposure.

For carcinogenic chemicals, risk is estimated by the following equation:

$$\text{Risk} = \text{CA} \times \text{URF}$$

where

Risk = a unitless probability of cancer incidence
CA = contaminant concentration in air (in $\mu g/m^3$)
URF = cancer inhalation unit risk factor (in units of cancers per $\mu g/m^3$)

CA is estimated by multiplying the output of the ISC3 model by the process duration to obtain estimates of total airborne exposure for each process.

Cancer unit risk factors are used in risk assessments to estimate an upper-bound lifetime probability of an individual developing cancer as a result of exposure to a particular level of a potential carcinogen.

The proposed action processes involve emissions of carcinogenic chemicals only at Rocky Flats. For the Rocky Flats region of influence, offsite population cancer incidences were estimated by multiplying the estimated cancer incidences for each radial sector by the population living within that sector.

D.4.2 Assumptions

The airborne pathway is assumed to be the principal exposure route by which the offsite public and noninvolved workers are exposed to hazardous chemicals released from processing facilities. Under routine operating conditions, hazardous chemicals are released from processing facilities only to the atmosphere; no releases are assumed to occur to surface water, groundwater, or soil. Noninvolved workers are assumed to be potentially exposed to hazardous chemicals during an 8-hour per day, 40-hour per week time period for a maximum working lifetime of 40 years. The noninvolved worker is assumed to be located onsite downwind of the release source at a distance corresponding to the point of maximum exposure.

No synergistic or antagonistic effects are assumed to occur from exposure to the hazardous chemicals released from processing facilities. Synergistic effects among released contaminants may result in adverse health effects that are greater than those estimated, whereas antagonistic effects among released chemicals may result in less severe health effects than those estimated.

Table D–150 Savannah River Site Noncancer Risk Estimates (Hazard Quotient and Hazard Index Values)

	Purex Process										*Mediated Electrochemical Oxidation Process*					
	Ash Residues		*Fluoride Residues*		*Existing Scrub Alloy*		*Salt Scrub Alloy*		*Sand, Slag, and Crucible Residue*		*Ash Residue*		*Graphite Residues*		*Inorganic Residues*	
Chemical	*Worker HQ*	*Offsite MEI HQ*	*Worker HQ*	*Offsite MEI HQ*	*Worker HQ*	*Offsite MEI HQ*	*Worker HQ*	*Offsite MEI HQ*	*Worker HQ*	*Offsite MEI HQ*	*Worker HQ*	*Offsite MEI HQ*	*Worker HQ*	*Offsite MEI HQ*	*Worker HQ*	*Offsite MEI HQ*
Phosphoric acid	0.720	0.0480	0.0900	0.00590	0.0830	0.00550	0.310	0.0210	0.200	0.0130	0.150	0.00970	0.0830	0.00550	0.0160	0.00110
Ammonium nitrate	0.0800	0.00530	0.0100	0.000660	0.0170	0.00110	0.0660	0.00420	0.0420	0.00270	0.0240	0.00150	0.0170	0.00110	0.00340	0.000220
Fluorides (H and Ca)	0.0270	0.00180	0.00480	0.000290	0.00510	0.000330	0.0190	0.00130	0.00770	0.000510	0.710	0.0470	0.000940	0.0000620	0.000190	0.0000120
Hazard Index [a]	0.827	0.0551	0.105	0.00685	0.105	0.00693	0.395	0.0265	0.250	0.0162	0.884	0.0582	0.101	0.00666	0.0196	0.00133

MEO = mediated electrochemical oxidation MEI = maximally exposed individual HQ = Hazard Quotient

[a] Sum of Hazard Quotients

D.4.3 Hazardous Chemical Source Terms

Emissions from the proposed action processes at Rocky Flats and the Savannah River Site were modeled so that individual source contributions to potential receptors could be estimated. At Rocky Flats, all hazardous chemicals were released from the Building 371 stack. At the Savannah River Site, emissions were from one stack located in the F-Area. To develop conservative estimates of exposure, all modeled emissions assumed no plume rise. The proposed action processes at the Los Alamos National Laboratory do not involve emissions of hazardous chemicals; therefore, contaminant ambient air concentrations were not modeled for this site.

The hazardous chemical source terms for the processes proposed for Rocky Flats are presented in **Table D–151**. The equivalent chemical emission rate data for these processes are presented in **Table D–152**. **Table D–153** and **Table D–154** present the source term and emission rate data, respectively, for the Savannah River Site.

D.4.4 Health Risks from Routine Operation Chemical Exposures

The results of the health risk analyses for routine operation chemical exposures are presented in Chapter 4 of this EIS. As discussed in Section 4.1, not all of the chemicals potentially released from the proposed action processing at Rocky Flats and the Savannah River Site were used to estimate health risks. Some of the chemicals are inert (e.g., argon) and some are innocuous (e.g., calcium and calcium oxide). The toxicity of some chemicals (e.g., n-dodecane and tributyl phosphate) is not well characterized, and some chemicals are addressed as air pollutants in Section 4.12 (e.g., volatile organic compounds, nitrogen oxide gases).

D.4.5 Facility Accident Chemical Exposure Impacts

The potential health risks resulting from exposure to hazardous chemicals released as a result of accidents at processing facilities were not quantitatively evaluated in this EIS. The impacts of chemical exposures from relevant facility accidents at Building 371 at Rocky Flats and at the F-Area separation facilities of the Savannah River Site have been evaluated in other investigations, such as the *Rocky Flats Draft Cumulative Impacts Document, the Rocky Flats Environmental Technology Site, Basis for Interim Operation, Building 371/374 complex* (KHC 1997) and the Savannah River Site *Final Environmental Impact Statement, Interim Management of Nuclear Materials* (DOE 1995a). These investigations concluded that the consequences for the most exposed member of the offsite population and onsite noninvolved workers would be low and could be mitigated by emergency response actions. Workers involved in the facility processes may experience serious injury or fatalities as a result of their proximity to the release sources. The impacts of chemical releases as a result of accidents at the proposed plutonium residue and scrub alloy processing facilities at Building 371 and the F-Area are expected to be bounded by the impacts estimated in these other investigations. Because chemical inventories for the H-Area separation facilities of the Savannah River site are similar to those estimated for the F-Area, potential impacts also are expected to be similar. At Los Alamos National Laboratory, no hazardous chemicals are used in the proposed distillation of pyrochemical salts, and only relatively small amounts of hydrochloric acid are used in the proposed water leach processing of direct oxide reduction pyrochemical salts. Therefore, the potential impacts of chemical exposures from facility accidents at this site were not quantitatively evaluated in this EIS.

Table D–151 Chemical Emissions from the Processing of Plutonium Residues and Scrub Alloy at Rocky Flats

	Process Emissions (kg/process duration)										
	Sonic Washing Process		*Thermal Desorption Process*	*CCO Process*	*Acid Dissolution Process*		*Mediated Electrochemical Oxidation Process*				
Chemicals Released [a]	*Filter Media Residues*	*Combustible Residues*	*Combustible Residues*	*Combustible Residues*	*Sludge Residues*	*Fluoride Residues*	*Inorganic Residues*	*Filter Media Residues*	*Graphite Residues*	*Raschig Ring Residues*	*Combustible Residues*
Carbon Tetrachloride	1	1	1	–	–	–	–	–	–	–	–
Hydrochloric Acid	–	–	–	0.1	–	–	–	–	–	–	–
Nitrogen Oxide Gases	–	–	–	–	0.3	0.2	2	2.9	5	0.3	2.2

CCO = catalytic chemical oxidation

[a] In addition to these chemicals, several of the proposed action processes at Rocky Flats would release various amounts of water vapor, carbon dioxide, and oxygen. Emissions of these compounds were not modeled in this EIS because their contribution to concentrations in ambient air would be negligible.

Table D–152 Chemical Emission Rates from the Processing of Plutonium Residues and Scrub Alloy at Rocky Flats

	Emission Rates (g/sec)										
	Sonic Washing Process		*Thermal Desorption Process*	*CCO Process*	*Acid Dissolution Process*		*Mediated Electrochemical Oxidation Process*				
Chemicals Released [a]	*Filter Media Residues*	*Combustible Residues*	*Combustible Residues*	*Residue Matrix*	*Sludge Residues*	*Fluoride Residues*	*Inorganic Residues*	*Filter Media Residues*	*Graphite Residues*	*Raschig Ring Residues*	*Combustible Residues*
Carbon Tetrachloride	0.000062	0.00014	0.000093	–	–	–	–	–	–	–	–
Hydrochloric Acid	–	–	–	4.4×10^{-6}	–	–	–	–	–	–	–
Nitrogen Oxide Gases	–	–	–	–	0.000015	0.000019	0.0014	0.00033	0.00067	0.0007	0.00062

CCO = catalytic chemical oxidation

[a] In addition to these chemicals, several of the proposed action processes at Rocky Flats would release various amounts of water vapor, carbon dioxide, and oxygen. Emissions of these compounds were not modeled in this EIS because their contribution to concentrations in ambient air would be negligible.

Table D–153 Chemical Emissions from the Processing of Plutonium Residues and Scrub Alloy at the Savannah River Site

	Process Emissions (tons/batch)							
	Purex Process					*Mediated Electrochemical Oxidation Process*		
Chemicals Released	*Ash Residues*	*Fluoride Residues*	*Existing Scrub Alloy*	*Salt Scrub Alloy*	*SSC Residues*	*Ash Residues*	*Graphite Residues*	*Inorganic Residues*
Nitric Acid	0.029	0.029	0.0387	0.0387	0.0387	0.0114	0.0449	0.0483
Nitrogen Oxide Gases	0.0824	0.0824	0.1098	0.1098	0.1098	0.0324	0.0001	0.1373
Nitrous Oxide	0.0005	0.0005	0.0007	0.0007	0.0007	0.0002	0.0008	0.0009
Phosphoric Acid/Tributyl Phosphate	0.00008	0.00008	0.0001	0.0001	0.0001	0.00003	0.0001	0.0001
VOCs	0.0033	0.0033	0.0045	0.0045	0.0045	0.0013	0.0052	0.0056
Ammonium Nitrate	0.0001	0.0001	0.0002	0.0002	0.0002	0.00005	0.0002	0.0002
Hydrogen Fluoride	0.00001	0.00002	0.000005	0.000005	0.000005	0.0014	0	0
Argon	0.00007	0.00007	0.0002	0.0002	0.0001	0.00007	0.00007	0.00007
Calcium	0.000005	0.000005	0.00002	0.00002	0.00001	0.000005	0.000005	0.000005
Calcium Fluoride	0.00002	0.00002	0.00005	0.00005	0.00003	0.00002	0.00002	0.00002
Calcium Oxide	0.000004	0.000004	0.00001	0.00001	0.000008	0.000004	0.000004	0.000004
N-Dodecane	0.000003	0.000004	0.00001	0.00001	0.000007	0.000003	0.000003	0.000003

SSC = sand, slag, and crucible VOCs = volatile organic compounds

Table D–154 Chemical Emission Rates from the Processing of Plutonium Residues and Scrub Alloy at the Savannah River Site

Chemicals Released	Emission Rates (g/sec)							
	Purex Process					Mediated Electrochemical Oxidation Process		
	Ash Residues	Fluoride Residues	Existing Scrub Alloy	Salt Scrub Alloy	SSC Residues	Ash Residues	Graphite Residues	Inorganic Residues
Nitric Acid	0.083	0.089	0.056	0.070	0.076	0.033	0.1	0.3
Nitrous Oxide	0.0014	0.0015	0.001	0.0013	0.0014	0.00057	0.0018	0.0057
NOx	0.24	0.25	0.16	0.20	0.22	0.093	0.00023	0.87
Phosphoric Acid/ Tributyl Phosphate	0.00023	0.00025	0.00014	0.00018	0.0002	0.000086	0.00023	0.00063
VOCs	0.0095	0.010	0.0065	0.0081	0.0089	0.0037	0.012	0.035
Ammonium Nitrate	0.00029	0.00031	0.00029	0.00036	0.00039	0.00014	0.00046	0.0013
Hydrogen Fluoride	0.000029	0.000061	7.2×10^{-6}	9.1×10^{-6}	9.9×10^{-6}	0.004	0	0
Argon	0.0002	0.00021	0.00029	0.00036	0.0002	0.0002	0.00016	0.00044
Calcium	0.000014	0.000015	0.000029	0.000036	0.00002	0.000014	0.000012	0.000032
Calcium Fluoride	0.000057	0.000061	0.000072	0.000091	0.000059	0.000057	0.000046	1.3×10^{-6}
Calcium Oxide	0.000012	0.000012	0.000014	0.000018	0.000016	0.000012	9.2×10^{-6}	0.000025
N-Dodecane	8.6×10^{-6}	0.000012	0.000014	0.000018	0.000014	8.6×10^{-6}	6.9×10^{-6}	0.000019

SSC = sand, slag, and crucible VOCs = volatile organic compounds

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Appendix E

Evaluation of Human Health Effects of Overland Transportation

APPENDIX E
EVALUATION OF HUMAN HEALTH EFFECTS OF OVERLAND TRANSPORTATION

E.1 INTRODUCTION

The overland transportation of any commodity involves a risk to both transportation crew members and members of the public. This risk results directly from transportation-related accidents and indirectly from the increased levels of pollution from vehicle emissions, regardless of the cargo. The transportation of certain materials, such as hazardous or radioactive waste, can pose an additional risk due to the unique nature of the material itself. In order to permit a complete appraisal of the environmental impacts of the proposed action and alternatives, the human health risks associated with the overland transportation of plutonium residues and scrub alloy have been assessed.

This appendix provides an overview of the approach used to assess the human health risks that may result from the overland transportation. The appendix includes discussion of the scope of the assessment, analytical methods used for the risk assessment (i.e., computer models), important assessment assumptions, and determination of potential transportation routes. It also presents the results of the assessment. In addition, to aid in the understanding and interpretation of the results, specific areas of uncertainty are described, with an emphasis on how the uncertainties may affect comparisons of the alternatives.

The approach used in this appendix is modeled after that used in the *Storage and Disposition of Weapons-Usable Fissile Materials Final Programmatic Environmental Impact Statement* (DOE 1996). That environmental impact statement (EIS) did not perform as detailed of analysis of the specific actions taken for plutonium residues and scrub alloys because of the breadth necessary to analyze the entire plutonium disposition program. Nevertheless, the fundamental assumptions used in this analysis are consistent with those used in that EIS, and the same computer codes and generic release and accident data are used.

The risk assessment results are presented in this appendix in terms of "per-shipment" risk factors, as well as for the total risks associated with each material. Per-shipment risk factors provide an estimate of the risk from a single plutonium residue or scrub alloy shipment between the Rocky Flats Environmental Technology Site (Rocky Flats) and the interim management sites. The total risks for a given alternative are found by multiplying the expected number of shipments by the appropriate per-shipment risk factors.

E.2 SCOPE OF ASSESSMENT

The scope of the overland transportation human health risk assessment, including the alternatives and options, transportation activities, potential radiological and nonradiological impacts, and transportation modes considered, is described below. Additional details of the assessment are provided in the remaining sections of the appendix.

- **Proposed Action and Alternatives**—The transportation risk assessment conducted for this EIS estimates the human health risks associated with the transportation of plutonium residues and scrub alloy for a number of management alternatives.

- **Transportation-Related Activities**—The transportation risk assessment is limited to estimating the human health risks incurred during the overland transportation for each alternative. The risks to workers or to the public during loading, unloading, and handling prior to or after shipment are not included in the

overland transportation assessment, but are addressed in Appendix D of this EIS. Similarly, the transportation risk assessment does not address possible impacts from increased transportation levels on local traffic flow, noise levels, or infrastructure.

- **Radiological Impacts**—For each alternative, radiological risks (i.e., those risks that result from the radioactive nature of the plutonium residues and scrub alloy) are assessed for both incident-free (i.e., normal) and accident transportation conditions. The radiological risk associated with incident-free transportation conditions would result from the potential exposure of people to external radiation in the vicinity of a loaded shipment. The radiological risk from transportation accidents would come from the potential release and dispersal of radioactive material into the environment during an accident and the subsequent exposure of people through multiple exposure pathways (i.e., exposure to contaminated ground or air, or ingestion of contaminated food).

  All radiologically-related impacts are calculated in terms of committed dose and associated health effects in the exposed populations. The radiation dose calculated is the total effective dose equivalent (NRC 1993), which is the sum of the effective dose equivalent from external radiation exposure and the 50-year committed effective dose equivalent from internal radiation exposure. Radiation doses are presented in units of roentgen equivalent man (rem) for individuals and person-rem for collective populations. The impacts are further expressed as health risks in terms of latent cancer fatalities and cancer incidence in exposed populations. The health risk conversion factors (expected health effects per dose absorbed) were derived from *International Commission on Radiological Protection Publication 60* (ICRP 1991).

- **Nonradiological Impacts**—In addition to the radiological risks posed by overland transportation activities, vehicle-related risks are also assessed for nonradiological causes (i.e., related to the transport vehicles and not the radioactive cargo) for the same transportation routes. The nonradiological transportation risks are independent of the radioactive nature of the cargo and would be incurred for similar shipments of any commodity. The nonradiological risks are assessed for both incident-free and accident conditions. Nonradiological risks during incident-free transportation conditions would be caused by potential exposure to increased vehicle exhaust emissions. The nonradiological accident risk refers to the potential occurrence of transportation accidents that directly result in fatalities unrelated to the shipment cargo. State-specific transportation fatality rates are used in the assessment. Nonradiological risks are presented in terms of estimated fatalities.

- **Transportation Modes**—All shipments have been assumed to take place by truck transportation modes.

- **Receptors**—Transportation-related risks are calculated and presented separately for workers and members of the general public. The workers considered are truck crew members involved in the actual overland transportation. The general public includes all persons who could be exposed to a shipment while it is moving or stopped en route. Potential risks are estimated for the collective populations of exposed people, as well as for the hypothetical maximally exposed individual. The collective population risk is a measure of the radiological risk posed to society as a whole by the alternative being considered. As such, the collective population risk is used as the primary means of comparing various alternatives.

E.3 PACKAGING AND REPRESENTATIVE SHIPMENT CONFIGURATIONS

Regulations that govern the transportation of radioactive materials are designed to protect the public from the potential loss or dispersal of radioactive materials as well as from routine radiation doses during transit. The primary regulatory approach to promote safety is through the specification of standards for the packaging of radioactive materials. Because packaging represents the primary barrier between the radioactive material being transported and radiation exposure to the public and the environment, packaging requirements are an important consideration for the transportation risk assessment. Regulatory packaging requirements are discussed briefly

below and in Chapter 5. In addition, the representative packaging and shipment configurations assumed for this EIS are described.

E.3.1 Packaging Overview

Although several Federal and State organizations are involved in the regulation of radioactive waste transportation, primary regulatory responsibility resides with the U.S. Department of Transportation and the U.S. Nuclear Regulatory Commission. All transportation activities must take place in accordance with the applicable regulations of these agencies specified in 49 Code of Federal Regulations (CFR) Part 173 (DOT 1992a) and 10 CFR Part 71 (NRC 1996).

Transportation packaging for small quantities of radioactive materials must be designed, constructed, and maintained to contain and shield their contents during normal transport conditions. For large quantities and for more highly radioactive material, such as spent nuclear fuel or plutonium, they must contain and shield their contents in the event of severe accident conditions. The type of packaging used is determined by the total radioactive hazard presented by the material within the packaging. Four basic types of packaging are used: Excepted, Industrial, Type A, and Type B. Another packaging option, Strong, Tight, is still available for some domestic shipments.

Excepted packagings are limited to transporting materials with extremely low levels of radioactivity. Industrial packagings are used to transport materials that, because of their low concentration of radioactive materials, present a limited hazard to the public and the environment. Type A packagings are designed to protect and retain their contents under normal transport conditions and must maintain sufficient shielding to limit radiation exposure to handling personnel. These packagings are used to transport radioactive materials with higher concentrations or amounts of radioactivity than excepted or industrial packagings. Strong, Tight packagings are used in the United States for shipment of certain materials with low levels of radioactivity, such as natural uranium and rubble from the decommissioning of nuclear reactors.

The transportation of highway-route controlled quantities of plutonium (more than a few grams, depending on activity level) requires the use of Type B packaging. In addition to meeting the standards for Type A packaging, Type B packaging must provide a high degree of assurance that even in severe accidents the integrity of the package will be maintained with essentially no loss of the radioactive contents or serious impairment of the shielding capability. Type B packaging must satisfy stringent testing criteria specified in 10 CFR Part 71 (NRC 1996). The testing criteria were developed to simulate severe accident conditions, including impact, puncture, fire, and water immersion.

Beyond meeting U.S. Department of Transportation standards showing it can withstand normal conditions of transport without loss or dispersal of its radioactive contents or allowance of significant radiation fields, a Type B packaging must meet the 10 CFR Part 71 requirements administered by the U.S. Nuclear Regulatory Commission (NRC 1996). The complete sequence of tests is listed below:

- **Free-Drop Test**—A 9-meter (m) (30-foot [ft]) free-drop onto a flat, essentially unyielding, horizontal surface, striking the surface in a position for which maximum damage to the package is expected.

- **Puncture Test**—A 1-m (40-inch [in]) drop onto the upper end of a 15-centimeter (cm) (6-in) diameter solid, vertical, cylindrical, mild steel bar (at least 20 cm [8 in] long) mounted on an essentially unyielding, horizontal surface.

- **Thermal Test**—Exposure to a heat flux of no less than that of a thermal radiation environment of 800 degrees Celsius (°C) (1,475 degrees Fahrenheit [°F]) with an emissivity coefficient of at least 0.9 for a period of 30 minutes.

- **Water Immersion Test**—A separate, undamaged package specimen is subjected to water pressure equivalent to immersion under a head of water of at least 15 m (50 ft) for no less than 8 hours.

Effective April 1, 1996, 10 CFR Part 71 has been revised to require an additional immersion test in 200 m (660 ft) of water for Type B casks designed to contain material with activity levels greater than one million curies (Ci) (NRC 1996). Containers used for shipping plutonium residue and scrub alloy will not necessarily be subject to this test because they will contain much less than one million curies. The packaging may also be required to undergo the crush test if it is considered a light-weight, low-density package as most drum-type packages are. The crush test consists of dropping a 500-kilogram (kg) (100-pound [lb]) steel plate from 9 m (30 ft) onto the package, which is resting on an essentially unyielding surface.

Additional restrictions apply to package surface contamination levels, but these restrictions are not important for the transportation radiological risk assessment. For risk assessment purposes, it is important to note that all packaging of a given type is designed to meet the same performance criteria. Therefore, two different Type B designs would be expected to perform similarly during incident-free and accident transportation conditions. The specific containers selected, however, will determine the total number of shipments necessary to transport a given quantity of plutonium residue or scrub alloy.

External radiation from a package must be below specified limits that minimize the exposure of the handling personnel and general public. For these types of shipments, the external radiation dose rate during normal transportation conditions must be maintained below the following limits of 49 CFR Part 173 (DOT 1992a):

- 10 millirem per hour (mrem/hr) at any point 2 m (6.6 ft) from the vertical planes projected by the outer lateral surfaces of the transport vehicle (referred to as the regulatory limit throughout this document)

- 2 mrem/hr in any normally occupied position in the transport vehicle.

Plutonium residues and scrub alloy would be shipped from Rocky Flats to other sites for processing in Type B containers. The U.S. Department of Energy (DOE) uses several containers that meet the Type B specifications and which may be selected for these shipments. The 6M container has been used for transporting plutonium metal and is the packaging assumed in this Draft EIS for shipment of those materials. Most likely plutonium-bearing residues that are in a granular or powder form would be shipped in other containers such as the 9975 container. Other containers, such as TRUPACT, 9965, 9968, or 9972 through 9974 could be evaluated and used in place of 6M and 9975. These containers are described in the following sections.

E.3.1.1 Type 6M Packaging

The original Department of Transportation 6M packaging (49 CFR 173.354) was Dow Chemical Corporation's Model 1518, a 38-liter (L) (10-gallon [gal]) container, approved by the U.S. Atomic Energy Commission (now DOE) in March 1967 and issued as U.S. Department of Transportation Special Permit 5000 the following month. The 6M packaging was issued in December 1968 to cover a variety of similar containers ranging in capacity from 38 to 417 L (10 to 110 gal). The 6M packaging is currently authorized by the Department of Transportation regulations for shipment of Type B quantities of radioactive materials (49 CFR 173, Subpart I).

In 1980, the U.S. Nuclear Regulatory Commission expressed concern about shipping plutonium in the 6M packaging. Because of changing specifications, secondary containment for plutonium was required (NRC 1996). The U.S. Nuclear Regulatory Commission decided the 6M packaging was adequate as an overpack.

As secondary containment was required, the U.S. Nuclear Regulatory Commission also wanted assurance that the Department of Transportation Specification 2R (Inside Containment Vessel) would meet the new leak rates specified in the International Atomic Energy Agency regulations (Kelly 1994).

General construction requirements for the 6M packaging may be found in 49 CFR 178.354, "Specification 6M; Metal Packaging," and for the 2R vessel in 49 CFR 178.360. Refer to **Figure E–1** for an example of a typical 6M and the 2R inner vessel or container.

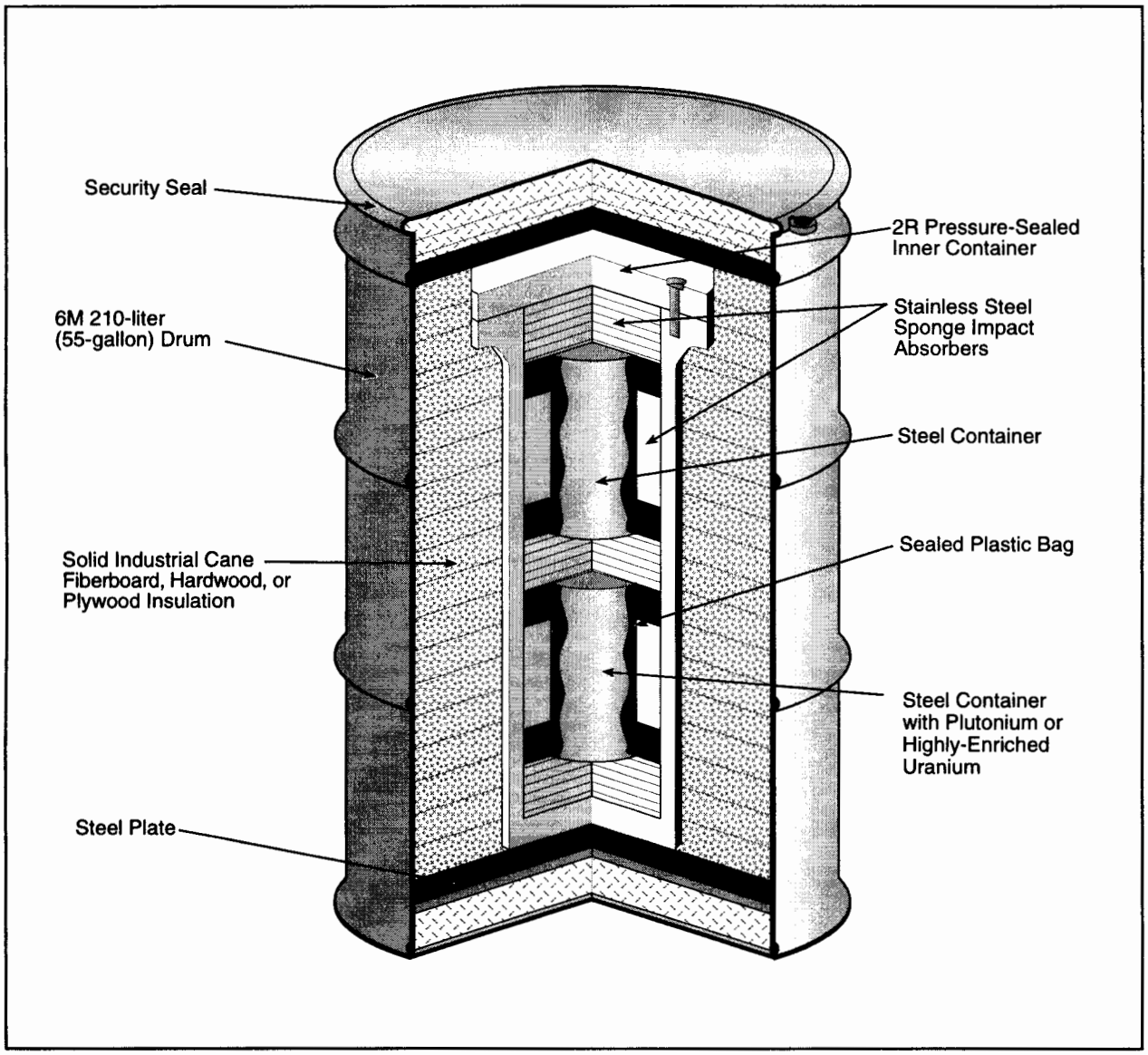

Figure E–1 Typical Assembly of 6M, Type B Packaging for Plutonium (Other than Pits)

In response to U.S. Nuclear Regulatory Commission concerns, the DOE and its contractors expended considerable effort to determine what role the 6M packaging should have for shipping DOE-owned plutonium. The three alternatives selected for evaluation were as follows:

- Improve the 6M procedures to resolve specific concerns raised by the U.S. Nuclear Regulatory Commission
- Procure and use packaging that is presently certified for shipment of plutonium
- Design and certify a new packaging to ship plutonium.

The first alternative was chosen. Technical reviews and safety assessments have been performed on 6M specification packaging, 2R inner container welds associated with 6M packaging, the types and quantities of radioactive material being shipped in 6M packaging, and future packaging to replace the 6M. In 1988, a DOE task force performed a technical review of the 6M packaging configuration. The review and subsequent documentation found that the 6M packaging configuration merits continued use (SNL 1988).

The task force that studied this subject recognized that the use of the 6M is authorized by current U.S. Department of Transportation regulations and recommended procedural improvements for its continued use. It was determined that the number of product can configurations and the number of 6M drum sizes should be reduced, and that the major shipping sites should coordinate an effort to minimize the number of can configurations and drum sizes used for shipment of plutonium.

In 1988, weld defects were found in the DT-14A packages fabricated by a particular manufacturer. Because the manufacturer was a major supplier of 2R inner containers, the integrity of 2R inner containers became a concern. In 1989, DOE Headquarters issued directives (Wade 1989) to all Defense Programs Operations Offices that future shipments of Type B radioactive material in the 6M packaging implement the applicable requirements as specified in the DOE task force's technical document (SNL 1988). The Container Weld Advisory Committee was formed in 1989 to develop recommendations and provide criteria for specific weld issues related to the 2R inner container. The Container Weld Advisory Committee recommended static force testing to ensure that the weld was strong enough to withstand the postulated hypothetical accident condition loadings. The leak testing was to ensure no leak paths existed in the weld. The safety enhancements developed will allow interim use of the 6M until a replacement container is available. As a result, 2R inner-containment vessels have had their bottom plate welds static force tested and leak tested. Additional requirements for Type B plutonium oxide shipments were also imposed, including an evaluation of the payload configuration against hypothetical accident conditions, load testing of the existing inner vessel (2R) welds, and DOE approval of the configuration. The purpose of the added requirements is to allow interim use of the 6M configuration until a replacement container is available (Kelly 1994).

- **Drum**—The outer shell is made of straight-sided steel, with welded body seams, and in accordance with Department of Transportation Specification 6C or 17C, with each length to contain 3 wedged or rolled rolling hoops as prescribed for either of these specifications. A removable head has one or more corrugations in the cover near the periphery. For a packaging exceeding 57 L (15 gal) volume, the head must be crowned (convex), not extending beyond the level of the chime, with a minimum convexity of 1 cm (3/8 in).

  Each drum has at least four 1.2-cm (0.5-in) diameter vents near the top, each covered with a weatherproof tape or fusible plug, or equivalent device. A layer of porous refractory fiber may be placed behind the pressure-relief vent holes.

  The outer drum closure is at least a 16-gauge bolt-type locking ring having at least a 5/16-in steel bolt for drum sizes not over 15 gal or a 12-gauge bolted ring with drop-forged lugs, one of which is threaded, and a 5/8-in steel bolt for drum sizes over 15 gal. Each bolt is provided with a lock nut or equivalent device.

  The closure device has means for the attachment of a tamper-proof lock wire and seal.

- **Insulation**—The inner containment vessel is fixed within the outer shell by solid centering media, with the sides of the inner vessel protected by at least 9.5 cm (3.75 in) of insulation media, and the ends with at least the thickness as prescribed in 49 CFR 178.104-3(a)(1). The centering media is usually machined discs and rings made of solid industrial can fiberboard having a density of at least 0.24 grams per cubic centimeter (15 lb per cubic foot) fitted such that the radial clearances between the fiberboard, inner vessel, and shell do not exceed 6 millimeters (1/4-in).

- **Shielding**—When necessary, shielding may be provided within the 2R containment vessel. Any radiation shielding material used must be placed within the inner containment vessel or must be protected in all directions by at least the thickness of the thermal insulating material.

- **Primary Containment Vessel**—The primary containment vessel is constructed to Department of Transportation Specification 2R (49 CFR 178.360). Each vessel is made of stainless steel, malleable iron, or brass, or other material having equivalent physical strength and fire resistance.

  The closure device is a screw-type cap or plug. The number of threads per inch must not be less than U.S. standard pipe threads and must have sufficient length of thread to engage at lease five threads when securely tightened. Pipe threads are luted with an appropriate nonhardening compound which must be capable of withstanding up to 149°C (300°F) without loss of efficiency. Tightening torque is adequate to maintain leak tightness with the specific luting compound.

- **Product Cans**—The following cans are authorized for Rocky Flats shipments (SNL 1988):

Material to be Packaged	*Can Dimensions*	*Descriptions*
Plutonium/ Aluminum/ Americium Alloy Button	Can (outer), 11.9-cm diameter (dia), 25.07-cm tall (4.7-in dia, 9.87-in tall)	Ellisco #110345, aluminum, with D-ring handle.
	Can (inner), 11.11-cm dia, 11.89-cm tall (4.375-in dia, 4.68-in tall)	Ellisco #113044, aluminum.
Plutonium Metal	Can (outer), 10.8-cm dia, 17.8-cm tall (4.25-in dia, 7-in tall)	• Per Federal Specification PPP-C-96E, Type 1, Class 3, round, open-top style, welded side seam with compound-lined double-seamed ends. • 0.25 electrolytic tinplate for all cans. Body is 0.038-cm (0.015-in) thick, ends are 0.03-cm (0.812-in) thick, no end profile.
	Can (inner), 10.31-cm dia, 14.12-cm tall (4.06-in dia, 5.56-in tall)	• Per Federal Specification PPP-C-96E, Type 1, Class 3, round, open-top style, welded side seam with compound-lined double-seamed ends. • 0.25 electrolytic tinplate for all cans. Body is 0.038-cm (0.012-in) thick, any end profile authorized.
Plutonium Oxide	Can (outer), 10.8-cm dia, 17.8-cm tall (4.25-in dia, 7-in tall)	• Per Federal Specification PPP-C-96E, Type 1, Class 3, round, open-top style, welded side seam with compound-lined double-seamed ends. • 0.25 electrolytic tinplate for all cans. Body is 0.038-cm (0.015-in) thick, ends are 0.03-cm (0.012-in.) thick, no end profile.
	Can (middle) 10.31-cm dia, 14.12-cm tall (4.06-in dia, 5.56-in tall)	• Per Federal Specification PPP-C-96E, Type 1, Class 3, round, open-top style, welded side seam with compound-lined double-seamed ends. • 0.25 electrolytic tinplate for all cans. Body is 0.038-cm (0.012-in) thick, any end profile authorized.
	Can (inner), 8.74-cm dia, 11.58-cm tall (3.44-in dia, 4.56-in tall)[c]	• Per Federal Specification PPP-C-96E, Type 1, Class 3, round, open-top style, welded side seam with compound-lined double-seamed ends. • 0.25 electrolytic tinplate for all cans. Body and ends are 0.025-cm (0.010-in) thick, any end profile authorized.
Plutonium/ Aluminum/ Americium Alloy Button, Anode Heels, and Category 3 Metal	Can (outer), 11.43-cm dia, 12.4-cm tall (4.5-in dia, 4.88-in tall)	• Special order. Welded side seam body. • Unsealed end, round, open-top style lid, compound lined with Parexd compound 313 (38.5-40.5) or Parex exp compound AD 23118 LS, double-seamed closure. • Sealed end, no compound allowed, double-seamed, sealed with lead-free tin solder; 0.25 electrolytic tinplate all surfaces of can body and lids. • 0.038-cm (0.015-in) thick body, 0.03-cm (0.012-in) thick ends, no end profile.

- **Impact Absorbers**—Silicone sponge impact absorbers, made of medium-grade closed-cell silicone sponge rubber, are used.

- **Contents of Package**—A list of the authorized contents of package, by Rocky Flats drawing number, follows:

Drawing Number	Material to be Packaged	Maximum Material per 2R kg (lb)	Maximum Material per Inner Can kg (lb)
33021-01	Plutonium/Aluminum/Americium Alloy Button	4.5 (9.92)	2.3 (5.07)
33021-02	Plutonium-Contaminated ^{235}Uranium	2.0 (4.41)	2.0 (4.41)
33021-03	Enriched Uranium or Plutonium Metal ^{238}Plutonium Metal	4.5 (9.92) 0.02 (0.04)	2.3 (5.07) 0.02 (0.04)
33021-04	Plutonium Oxide ^{238}Plutonium Oxide	4.5 (9.92) 0.02 (0.04)	2.3 (5.07) 0.02 (0.04)
33021-05	Plutonium Oxide ^{238}Plutonium Oxide	4.5 (9.92) 0.02 (0.04)	2.3 (5.07) 0.02 (0.04)
33020-09	Plutonium/Aluminum/Americium Alloy Button, Anode Heels, and Category 3 Metal	4.5 (9.92)	2.3 (5.07)

E.3.1.2 Type 9975 Packaging

The 9975 type packagings consist of stainless steel containment vessels enclosed within cane fiberboard insulation within a steel drum. The packagings have a double containment assembly of a primary containment vessel with a secondary containment vessel. The 9975 type packagings is the last of a series of Type B containers designed to overcome the drawbacks of the 6M container. The other Type B packagings are 9965, 9968, 9972, and 9974. The 9975 type packaging has a lead shielding insert between the secondary containment vessel and the insulation. The steel drum defines the confinement boundary, and the containment vessels define the containment boundary (WSRC 1996).

The 9975 package assembly is shown in **Figure E–2**. Lead shielding is provided in the 9975 packaging. The 9975 packaging weighs 163 kg (360 lb). The 13-cm (5-in) extension to the 30-gal drum results in a drum that is 89 cm (35-in) high with a 132-L (35-gal) capacity. The containment vessels and the drum are all made of Type 304L stainless steel. The bolts are high-strength alloy steel and the shielding is lead. Containers 9965, 9968, and 9972 through 9974 are similarly constructed, and are technically capable of transporting plutonium-bearing material. The following paragraphs describe specific aspects of the packagings.

- **Drum**—The drum is fabricated as a 132-L (35-gal) removable-head drum. The drum is fabricated of 18–gauge Type 304L stainless steel. Four vent holes are drilled into the drum, approximately 90 degrees apart, just below the top curl and are covered with a Caplug (fusible plug).

  The plugging device prevents water or moisture from entering the drum through the vent holes under normal conditions of transport. In the event a fire occurs, the plug melts, allowing the drum to vent gases generated from the insulation to prevent rupture of the drum. A locking ring with lugs, installed with a high-strength steel bolt, secures the cover to the drum. The steel bolt threads into the lug and must be provided with a jam nut to prevent loosening during transit. A small hole is drilled through both lugs for insertion of a wire seal to function as a tamperproof device.

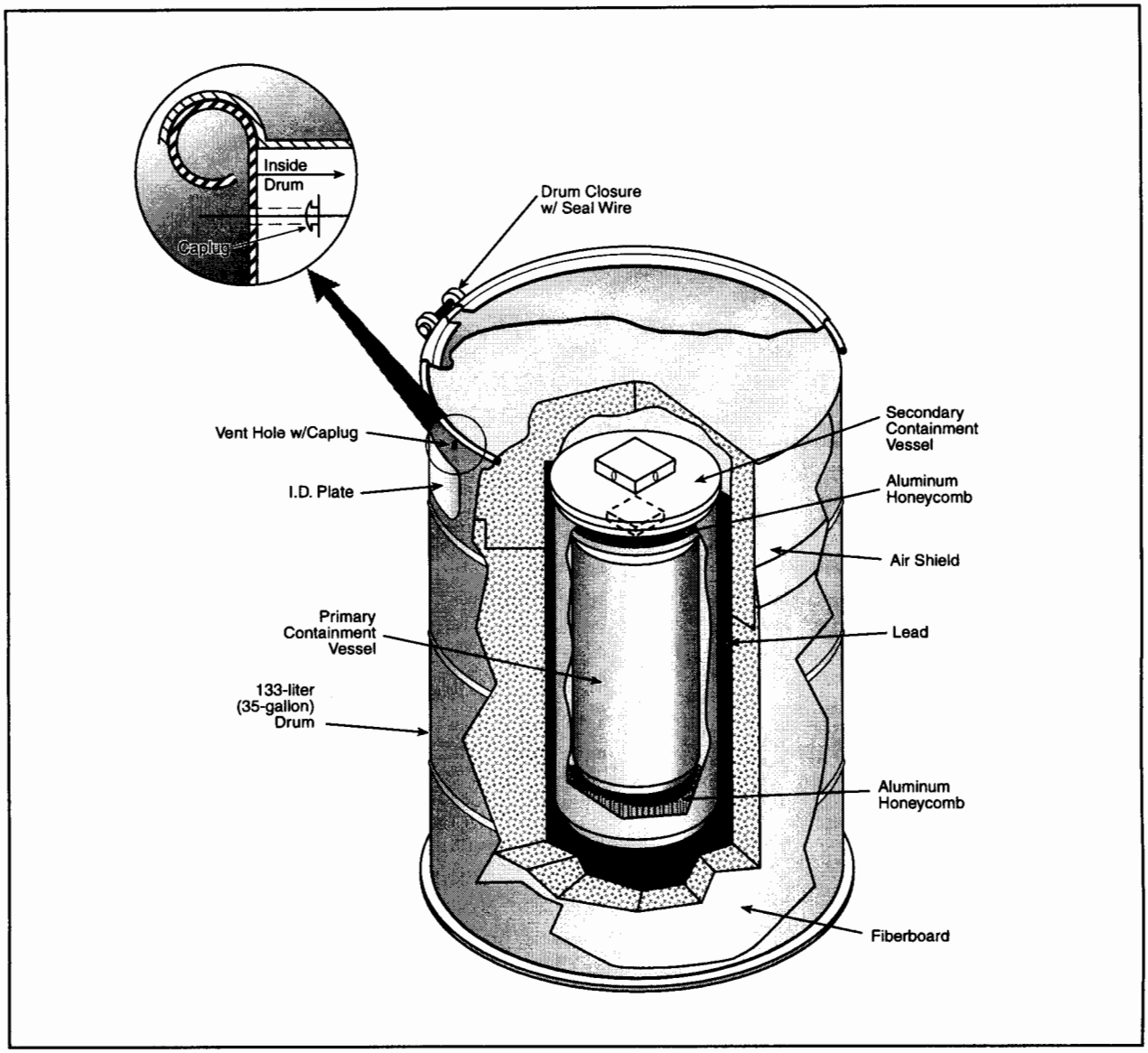

Figure E–2 Typical Assembly of Type 9975 Package

- **Insulation**—The insulation material that surrounds the containment vessels is cane fiberboard and is manufactured per American Society for Testing and Materials Specification C-208-72. The cane fiberboard insulation comes in sheets that are bonded together into top and bottom subassemblies with a water-based carpenter's glue. The insulation subassemblies are fitted to the drum so that the radial clearances between the insulation, the lead cylinder, and the drum do not exceed 0.635 cm (1/4 in). Placed over and glued to the top fiberboard subassembly is an air shield made of stainless steel. This thin-walled shield prevents possible smoldering of the top fiberboard layers when exposed to air in a fire. A length of sash chain welded to the top of the air shield serves as a handle for removing the top subassembly.

  A filler pad is required between the top insulation subassembly and the drum lid. The filler pad consists of a ceramic fiber blanket (Kaowool) encapsulated in stainless steel foil and heat sealed.

- **Shielding**—The radiation shielding configuration is a lead cylinder assembly that surrounds the primary containment vessel/secondary containment vessel double-containment assembly. The shielding assembly consists of an inside cylinder fabricated of lead, surrounding a stainless steel tubing weldment. The lid is made of aluminum. The lid has four equally spaced bolt holes near the edge for attachment to the cylinder body. The shielding assembly has no lead lid since the thickness of the stainless steel lids for the primary and secondary containment vessels provide sufficient shielding.

- **Bearing Plates**—Two aluminum bearing plates are added to the packaging to provide additional load-bearing surfaces against the cane fiberboard insulation.

- **Primary Containment Vessel**—The primary containment vessel is of a stainless steel pressure vessel designed in accordance with Section III of the *American Society of Mechanical Engineers Boiler and Pressure Vessel Code,* 1992 edition, with design conditions of 10.3 bar (150 lb per square in gauge [psig]) at 260°C (500°F) for normal conditions of transport and 20.6 bar (300 psig) at 260°C (500°F) for hypothetical accident conditions. By definition, the design conditions shall be higher than the pressures and temperatures that can be generated under normal or accident conditions of transport.

  The primary containment vessel is fabricated from 12.7-cm (5-in) Schedule 40, seamless, Type 304L stainless steel pipe and has a standard Schedule Type 304L stainless steel pipe cap at the blind end. Both vessel body joints are circumferential full penetration butt welds examined by radiographic and liquid penetrant methods. These welds satisfy *American Society of Mechanical Engineers Boiler and Pressure Vessel Code*, Section III, Subsection NB, requirements.

  A 10-cm (4-in), Schedule 40 pipe of the same material is welded to the convex side of the cap to form a skirt to vertically support the primary containment vessel. The skirt has two slots on the bottom surface (180 degrees apart) to engage a rectangular key to prevent vessel rotation.

  The primary containment vessel closure is male-female cone joint with surfaces that have been machined to identical angles so that they mate with zero clearance. Two grooves for O-rings have been machined onto the face of the Type 304L stainless steel male cone. A leak test port is provided between the two O-ring grooves. A small rectangular groove is present on the face of the male cone between the two O-ring grooves. This is to ensure helium detection during leakage testing. Two Viton GLT fluoroelastomer O-rings (greased with high vacuum silicone grease) are placed in the grooves to form a leaktight seal. Zero clearance behind the two O-rings prevents extrusion and loss of sealing ability at design pressures and temperatures. The leak test port allows for simple leakage tests (pressure drop method) when opening a loaded containment vessel. When the leak test port is plugged (as in normal shipment), a redundant O-ring seal is formed. A snap-ring fits onto the male cone for use in unseating the cone during disassembly. The seal nut, which forces the male cone against the female cone, is threaded into the containment vessel body. Dissimilar materials were selected for the seal nut (Nitronic 60) and the containment vessel body (Type 304L stainless steel) to minimize galling.

- **Honeycomb Spacer**—An aluminum honeycomb spacer is inserted into the concave cavity of the primary containment vessel to provide a flat horizontal surface for the product cans.

- **Product Cans**—The uranium and plutonium metal and oxides are normally placed inside metal cans prior to removing the items from the glove box. Metal cans with organic food liners cannot be used. A rubber gasket material may be applied to the edge of the lid to ensure an hermetic is achieved. The lid is then mechanically crimped to the can wall. The cans are made from either tin-plated mild steel or aluminum.

  The can containing the radioactive material is then placed in a low-density polyethylene bag. The low-density polyethylene bag must meet American Society for Testing and Materials Specification D-4635.

Sometimes a second or even a third can is used. More than one bag can also be used. The use of polyvinyl chloride tape is allowed to seal slip-lid cans. However, the package content is limited to 100 grams of polyethylene. No credit for containment is taken for the can assembly.

- **Secondary Containment Vessel**—The secondary containment vessel shown in Figure E–2 consists of a stainless steel pressure vessel that is designed in accordance with Section III of the *American Society of Mechanical Engineers Boiler and Pressure Vessel Code*, 1992 edition. The secondary containment vessel is fabricated from 15.2-cm (6-in) Schedule 40, seamless, Type 304L stainless steel pipe and has a standard Schedule Type 304L stainless steel pipe cap at the blind end. Both vessel body joints are circumferential full penetration butt welds examined by radiographic and liquid penetrant methods. These welds satisfy *American Society of Mechanical Engineers Boiler and Pressure Vessel Code* Section III, Subsection NB requirements.

  A 12.7-cm (5-in), Schedule 40 pipe of the same material is welded to the convex side of the cap to form a skirt to vertically support the secondary containment vessel. Like the primary containment vessel, the secondary containment vessel skirt has two slots on the bottom surface (180 degrees apart) to engage a rectangular key to prevent vessel rotation. The secondary containment vessel closure is identical to that used on the primary containment vessel except that the secondary containment vessel is 2.5 cm (1 in) larger in diameter.

- **Impact Absorbers**—Aluminum honeycomb impact absorbers fit axially between the primary containment vessel and the secondary containment vessel. The top impact absorber has the shape of a ring. The bottom impact absorber is machined on the bottom face to fit the contour of the inside of the secondary containment vessel.

- **Operational Features**—The primary containment vessel and secondary containment vessel may be loaded by placing them in a support stand. A lifting tool, which attaches to the seal nut on the primary containment vessel or secondary containment vessel, may be used to lift the assembled containment vessel, by the cone seal nut, from the drum overpack.

  A vacuum lifting tool may be used for raising and lowering product cans into the primary containment vessel. A socket extension may be used with a commercial torque wrench to tighten the closure.

  After the radioactive material is inserted and the containment vessel closure tightened to the prescribed torque, the containment closure is leak tested. The plug at the top of the leak test port is removed, the cavity between the two O-rings in the cone seal is pressurized, and any loss of pressure is recorded.

- **Contents of Packaging**—Type B radioactive material, in addition to fissile materials, may be shipped in these packagings. The requirement of 10 CFR 71.63, *Special Requirements for Plutonium Shipments*, states that solid plutonium in excess of 20 Ci must be provided with double containment for shipment, with the exception of reactor fuel elements, metal or metal alloy, or other plutonium solids that U.S. Nuclear Regulatory Commission determines should be exempt. Because the 9975 packagings provide double containment, they are also authorized for products of oxide, scrap, or powders in amounts that exceed 20 Ci.

  The radioactive material contents of the 9975 packages must be limited to meet the criticality and shielding requirements of 10 CFR Part 71. In addition, a maximum allowable decay heat load of 19 watts is established to ensure that the packages meet performance requirements.

- **Thermal Design**—These packagings have been designed to ensure that all safety-related internal components operate below regulatory thermal limits. The components of interest include the lead shield (shielding) and the primary containment vessel, secondary containment vessel, and vessel seals

(containment). The thermal limits and design pressures of these components are presented in the *Safety Analysis Report—Packages 9965, 9968, 9972–75* (WSRC 1996).

The thermal design features of the 9975 packagings include an air shield and a thermal blanket. The air shield, located at the drum top, is designed to minimize the potential for the fiberboard insulation to burn in a fire. Placement of a stainless steel cover on the upper portion of the fiberboard leaves an air gap between the cover and drum wall. The cover prevents fiberboard burning during a post-fire cooldown by prohibiting air flow into the fiberboard near the vent holes. The blanket is used as a filler material between the drum top and lid and is noncombustible. The fiberboard insulation consists of two main sections, each formed by stacking layers of fiberboard and gluing them together (from bottom to top). The sections are "stepped" to eliminate the possibility of a direct thermal shine path (i.e., radiant heat transfer path) from the drum wall to the lead shielding or the vessel wall after the 9.1-m (30-ft) free-drop test.

The packagings employ a passive cooling and insulation system. Radioactive decay heat from the contents is radiated and conducted to the inner and outer product cans and to the walls of the primary containment vessel. In packagings with a double containment assembly, the heat is primarily transported radially by radiation and conduction across an air gap to the secondary containment vessel and across another air gap directly to the lead shield. The decay heat is primarily conducted radially through the insulation to the outer 132-L (35-gal) drum where it is radiated and convected to the ambient.

E.3.2 Shipment Overview

E.3.2.1 Safe Secure Transportation

Currently the Department anticipates that any transportation of the scrub alloy and those plutonium residues with the highest plutonium concentrations would definitely be required to be made through use of the Transportation Safeguards System and shipped using the Safe Secure Trailer System. Nevertheless, the Department is evaluating whether it would be possible to use commercial carriers for shipments of plutonium residues containing low concentrations of plutonium, and whether there would be any advantage to such shipments. The Safe Secure Trailer is a fundamental component of the Transportation Safeguards System. The Transportation Safeguards System is operated by the DOE Transportation Safeguards Division of the Albuquerque Operations Office for the DOE Headquarters Office of Defense Programs. Based on operational experience between FY84 and FY93, the mean probability of an accident requiring the tow-away of the safe secure trailer was 0.11 accidents per million km (0.066 accidents per million mi). By contrast, the rate for commercial trucking in 1989 was about 4.3 accidents per million km (2.7 accidents per million mi). Commercial trucking accident rates (Saricks and Kvitek 1994) were used in the human health effects analysis. Since established in 1975, the Transportation Safeguards Division has accumulated more than 145 million km (90 million mi) of over-the-road experience transporting DOE-owned cargo with no accidents resulting in a fatality or release of radioactive material.

The safe secure trailer is a specially designed component of an 18-wheel tractor-trailer vehicle. Although details of vehicle enhancements and some operational aspects are classified, key characteristics of the safe secure trailer system include the following:

- Enhanced structural characteristics and a highly reliable tie-down system to protect cargo from impact
- Heightened thermal resistance to protect the cargo in case of fire
- Various deterrents to prevent unauthorized removal of cargo

- An armored tractor component that provides courier protection against attack and contains advanced communications equipment
- Specially designed escort vehicles containing advanced communications and additional couriers
- 24-hour-a-day real-time communications to monitor the location and status of all safe, secure trailer shipments via DOE's Security Communication system
- Couriers who are armed Federal Officers and receive rigorous specialized training and who are closely monitored through DOE's Personnel Assurance Program
- Significantly more stringent maintenance standards than those for commercial transport equipment
- Conduct of periodic appraisals of the Transportation Safeguards System operations by Defense Programs to ensure compliance with DOE orders and management directives.,

E.3.3 Ground Transportation Route Selection Process

According to DOE guidelines, plutonium shipments must comply with both U.S. Nuclear Regulatory Commission and U.S. Department of Transportation regulatory requirements. Commercial shipments are required by law to comply with both U.S. Nuclear Regulatory Commission and U.S. Department of Transportation requirements. U.S. Nuclear Regulatory Commission regulations cover the packaging and transport of plutonium, whereas the U.S. Department of Transportation specifically regulates the carriers and the conditions of transport, such as routing, handling and storage, and vehicle and driver requirements. The highway routing of nuclear material is systematically determined according to U.S. Department of Transportation regulations 49 CFR 171-179 and 49 CFR 397 for commercial shipments. Specific routes cannot be publicly identified in advance for Transportation Safeguards Division shipments because they are classified to protect national security interests.

The U.S. Department of Transportation routing regulations require that shipment of a "highway route controlled quantity" of radioactive material be transported over a preferred highway network including interstate highways, with preference toward interstate system bypasses and beltways around cities, and State-designated preferred routes. A State or Tribe may designate a preferred route to replace or supplement the interstate highway system in accordance with U.S. Department of Transportation guidelines (DOT 1992b).

Carriers of highway route controlled quantities are required to use the preferred network unless moving from origin to the nearest interstate or from the interstate to the destination, when making necessary repair or rest stops, or when emergency conditions render the interstate unsafe or impassible. The primary criterion for selecting the preferred route for a shipment is travel time. Preferred routing takes into consideration accident rate, transit time population density, activities, time of day, and day of week.

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

E.4 METHODS FOR CALCULATING TRANSPORTATION RISKS

The overland transportation risk assessment methodology are summarized in **Figure E–3**. After the EIS alternatives are identified and goals of the shipping campaign are understood, the first step is to collect data on material characteristics and accident parameters. Physical, radiological and packaging data were provided by the DOE sites. Accident parameters are largely based on the DOE-funded study of transportation accidents (Saricks and Kvitek 1994).

Representative routes that may be used for the shipment of plutonium residues and scrub alloy have been selected using the HIGHWAY code. These routes were selected for risk assessment purposes. They do not necessarily represent the actual routes that would be used to transport nuclear materials. Specific routes cannot be identified in advance because the routes would not be finalized until they had been reviewed and approved by U.S. Nuclear Regulatory Commission. The selection of the actual route would be responsive to environmental and other conditions that would be in effect or could be predicted at the time of shipment. Such conditions could include adverse weather conditions, road conditions, bridge closures, and local traffic problems. For security reasons, details about a route would not be publicized before the shipment.

The first analytic step in the ground transportation analysis was to determine the incident-free and accident risk factors, on a per-shipment basis, for transportation. Risk factors, as any risk estimate, are the product of the probability of exposure and the magnitude of the exposure. Accident risk factors were calculated for radiological and nonradiological traffic accidents. The probabilities, which are much lower than one, and the magnitudes of exposure were multiplied, yielding very low risk numbers. Incident-free risk factors were calculated for crew and public exposure to radiation emanating from the shipping container (cask) and public exposure to the chemical toxicity of the transportation vehicle exhaust. The probability of incident-free exposure is unity (one).

Radiological risk factors are expressed in units of rem. Later in the analysis, they will be multiplied by *International Commission on Radiation Protection Publication 60* (ICRP 1991) conversion factors and estimated number of shipments to give risk estimates in units of latent cancer fatalities. The vehicle emission risk factors are calculated in latent mortalities, and the vehicle accident risk factors are calculated in mortalities. The nonradiological risk factors will be multiplied by the number of shipments.

For each alternative, risks were assessed for both incident-free transportation and accident conditions. For the incident-free assessment, risks were calculated for both collective populations of potentially exposed individuals and for maximally exposed individuals. The accident assessment consists of two components: (1) a probabilistic accident risk assessment that considers the probabilities and consequences of a range of possible transportation accident environments, including low-probability accidents that have high consequences and high-probability accidents that have low consequences, and (2) an accident consequence assessment that considers only the consequences of the most severe transportation accidents postulated.

The RADTRAN 4 computer code (Neuhauser and Kanipe 1993) is used for incident-free and accident risk assessments to estimate the impacts on collective populations. RADTRAN 4 was developed by Sandia National Laboratories to calculate population risks associated with the transportation of radioactive materials by a variety of modes, including truck, rail, air, ship, and barge.

The RADTRAN 4 population risk calculations take into account both the consequences and probabilities of potential exposure events. The collective population risk is a measure of the total radiological risk posed to society as a whole by the alternative being considered. As such, the collective population risk is used as the primary means of comparing the various alternatives.

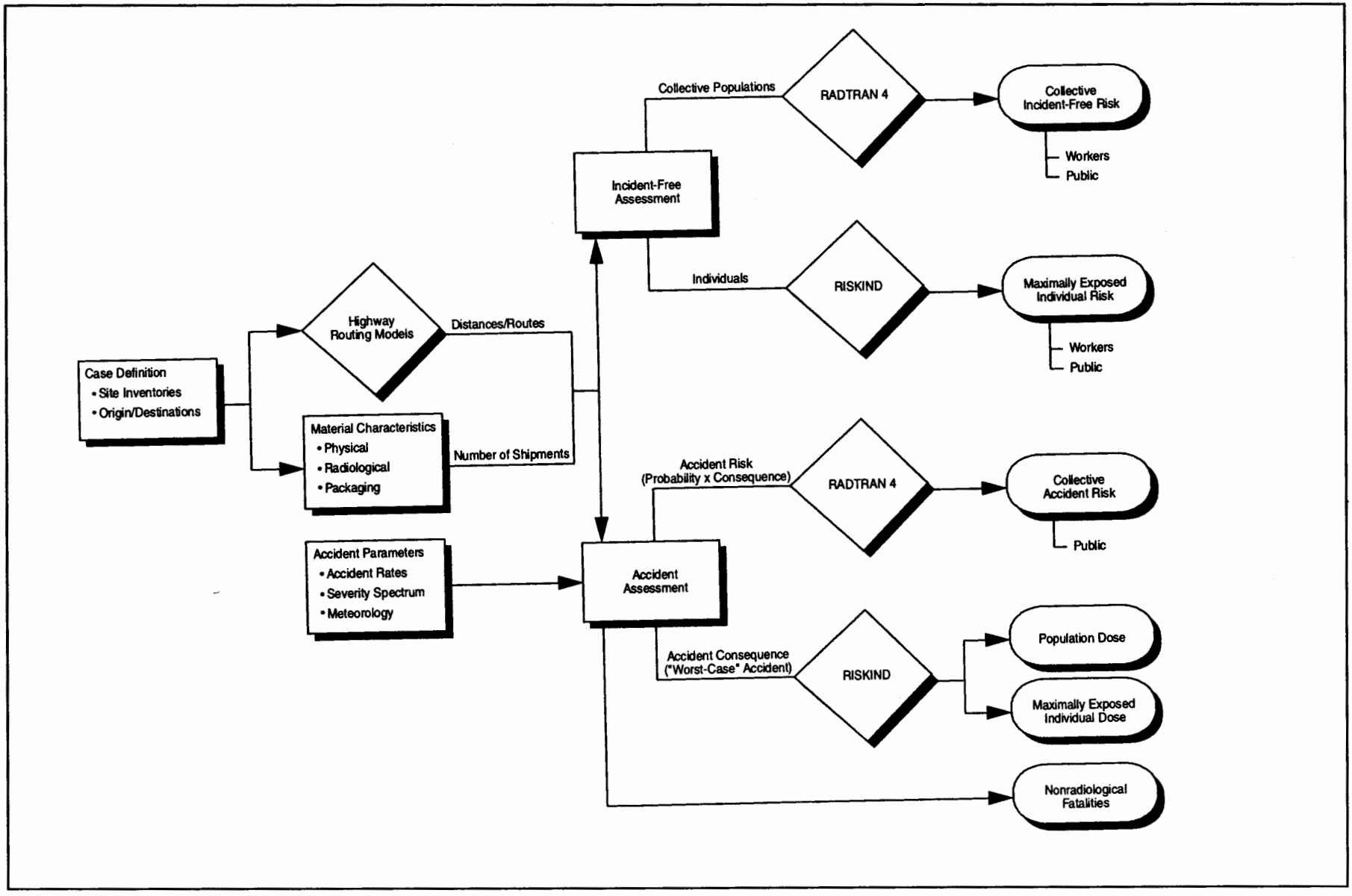

Figure E–3 Overland Transportation Risk Assessment

The RISKIND computer code (Yuan et al. 1995) is used to estimate the incident-free doses to maximally exposed individuals and for estimating impacts for the accident consequence assessment. The RISKIND computer code was developed for DOE's Office of Civilian Radioactive Waste Management to analyze the exposure of individuals during incident-free transportation. In addition, the RISKIND code was designed to allow a detailed assessment of the consequences to individuals and population subgroups from severe transportation accidents under various environmental settings.

The RISKIND calculations were conducted to supplement the collective risk results calculated with RADTRAN 4. Whereas the collective risk results provide a measure of the overall risks of each alternative, the RISKIND calculations are meant to address areas of specific concern to individuals and population subgroups. Essentially, the RISKIND analyses are meant to address "What if" questions, such as "What if I live next to a site access road?" or "What if an accident happens near my town?"

If highly specialized analytic codes had been used to model Safe Secure Trailer behavior in an accident (DOE-developed Analysis of Dispersal Risk Occurring In Transportation [Claus, et al. 1995] or ADROIT), the code would have provided a probabilistic risk analysis of nuclear explosive, nuclear explosive components and special nuclear materials shipped in a Safe Secure Trailer. Even though the radiological accident risk estimates would be lower than presented in this EIS, DOE would treat the actual analytic steps and assumptions as classified data, and could release only the results of the analysis.

E.5 Parameters and Assumptions

The transportation risk assessment is designed to ensure—through uniform and judicious selection of models, data and assumptions—that relative comparisons of risk among the various alternatives are meaningful. The major input parameters and assumptions used in the transportation risk assessment are discussed below.

E.5.1 Material Inventory

For the purposes of analysis, the plutonium residues and scrub alloy have been characterized into the different materials show in **Table E–1**. Note that several materials will not be shipped and were not considered further in the transportation analyses. All materials would be shipped from Rocky Flats to the Savannah River Site, except the possible shipment of pyrochemical salt residues. These pyrochemical salt residues could be shipped to the Los Alamos National Laboratory site, as noted in Table E–1.

E.5.2 Shipment External Dose Rates

The dose and corresponding risk to populations and maximally exposed individuals during incident-free transportation conditions are directly proportional to the assumed shipment external dose rate. The Federal regulations for maximum allowable dose rates for exclusive-use shipments were presented in Section E.3.1.

The actual shipment dose rate is a complex function of the composition and configuration of shielding and containment used in the cask, the geometry of the loaded shipments, and characteristics of the material shipped. Rocky Flats has years of experience handling the materials listed in Table E–1 and has regularly made radiation level measurements while handling these materials. The maximum predicted dose, based on experience at DOE facilities, from individual packages, would yield a dose rate less than the Federal regulatory limit in every case. However, in order to ensure a conservative analysis, a dose rate equal to the regulatory limit was used in all risk analyses.

Table E–1 Summary of Material Shipping Requirements

Shipments from Rocky Flats:					
Material	*Safe Secure Trailer Required* [a]	*Container*	*Number of Shipments*	*kg Pu per Shipment*	*Total Pu (kg)*
Ash Residues					
Incinerator Ash and Firebrick Fines					
Purex	No	9975	116	8	898
MEO/Purex	No	9975	86	10	898
Pulverized Sand, Slag, and Crucibles	No	9975	26	5	129
Graphite Fines for MEO	No	9975	7	11	74
Inorganic Ash	Not Shipped				
Salt Residues					
Direct Oxide Reduction Salts					
Water Leach at LANL	No	9975	13	9	122
Purex at SRS (Following Scrub)	No	9975	4	31	122
Electrorefining & Molten Salt Extraction					
Salt Distillation at LANL	No	9975	52	17	881
Purex at SRS (Following Scrub)	No	9975	24	37	881
Combustible Residues	Not shipped				
Plutonium Fluoride Residues	Yes	9975	7	20	142
Filter Media Residues	Not shipped				
Sludge Residues	Not shipped				
Glass Residues	Not shipped				
Graphite Residues (MEO)	No	9975	16	6	97
Inorganic (Metals and Others)	No	9975	4	19	74
Existing Scrub Alloy	Yes	6M	6	33	200

kg = kilogram Pu = plutonium MEO = Mediated Electrochemical Oxidation LANL = Los Alamos National Laboratory
SRS = Savannah River Site

[a] Interpreted from DOE Order 5633.3B, "Control and Accountability of Nuclear Materials." However, DOE currently expects to use the Safe, Secure Trailer for added assurance.

E.5.3 Material Characterization Data

For the purpose of analysis, the isotopic mixtures for aged weapons grade plutonium and high americium salt were used (see Table D–28). The weapons grade plutonium contains five different plutonium isotopes, as well as a measurable quantity of americium, which is produced as plutonium decays. As the plutonium ages, the mixture changes.

E.5.4 Representative Routes and Population

Representative overland truck routes have been selected for the shipments to the Savannah River Site and to the Los Alamos National Laboratory. The routes were selected consistent with current routing practices and all applicable routing regulations and guidelines. However, the routes were determined for risk assessment purposes. They do not necessarily represent the actual routes that would be used to transport plutonium residues and scrub alloy in the future. Specific routes cannot be identified in advance. The representative routes are shown in **Figure E–4**.

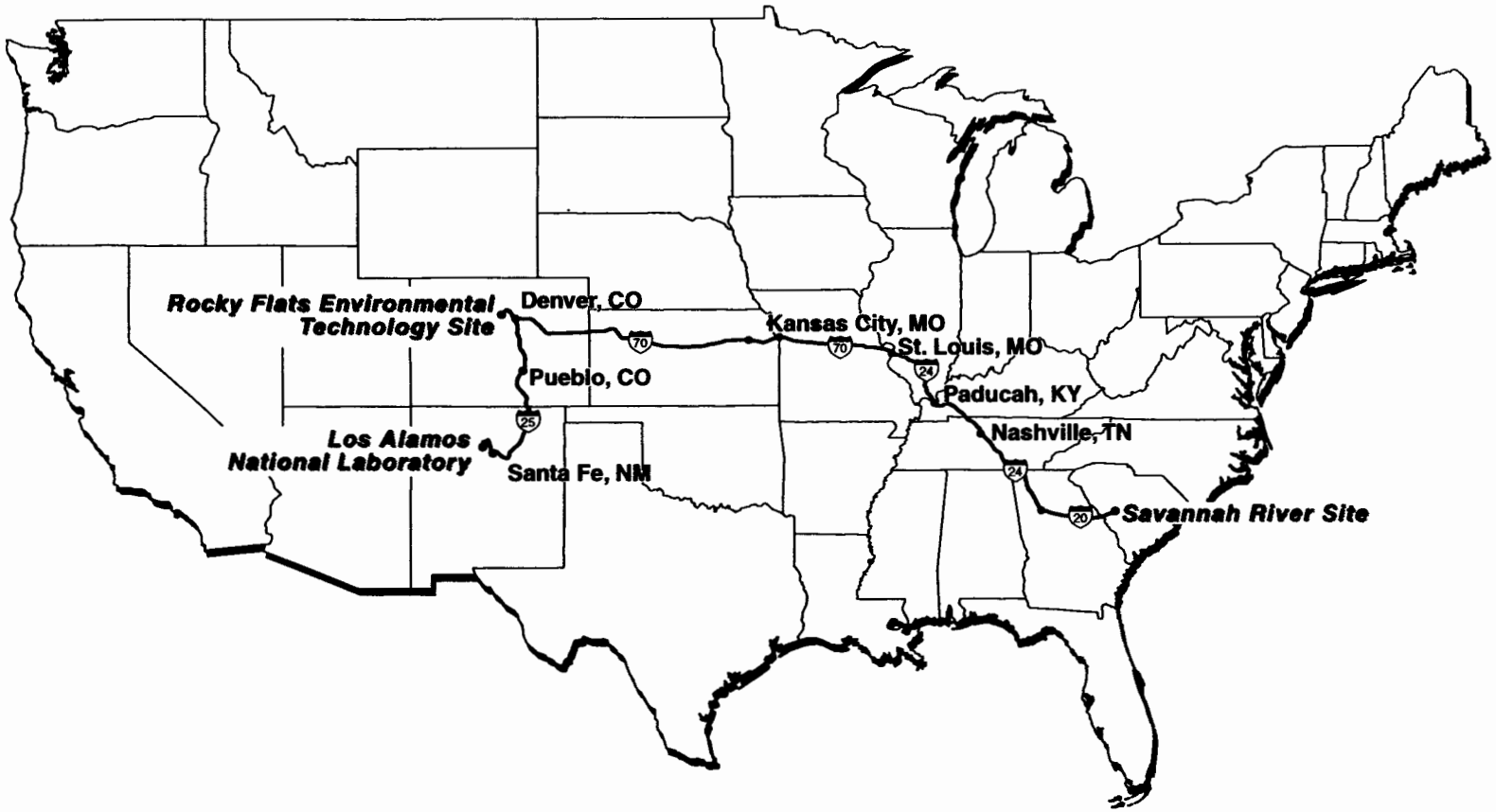

Figure E–4 Representative Routes

Route characteristics that are important to the radiological risk assessment include the total shipment distance and the population distribution along the route. The specific route selected determines both the total potentially exposed population and the expected frequency of transportation-related accidents. Route characteristics are summarized in **Table E–2**. The exposed population includes all persons living within 800 m (0.5 mi) of each side of the road.

Table E–2 Summary of Route Distances and Population Distributions [a]

Parameter	*Rocky Flats to the Savannah River Site*	*Rocky Flats to Los Alamos National Laboratory*
Distance	2616.7 km (1625.0 mi)	733.8 km (456.0 mi)
Percentages in Zones		
Rural	78.2	83.5
Suburban	19.3	13.4
Urban	2.5	3.1
Average Persons per km^2		
Rural	$8.9/km^2$ ($23.1/mi^2$)	$4.5/km^2$ ($11.7/mi^2$)
Suburban	$358.4/km^2$ ($931.8/mi^2$)	$451.5/km^2$ ($1169.4/mi^2$)
Urban	$2239.7/km^2$ ($5823.2/mi^2$)	$2260.6/km^2$ $5854.91/mi^2$)
Number of Affected Persons [b]	553,000	158,000

[a] Route characteristics were generated using the routing model HIGHWAY (Johnson et al. 1993).
[b] The affected population includes all persons within 800 m (0.5 mi) of the route.

E.5.5 Health Risk Conversion Factors

The health risk conversion factors used to estimate expected cancer fatalities were taken from *International Commission on Radiation Protection Publication 60* (ICRP 1991): 0.0005 and 0.0004 fatal cancer cases per person-rem for members of the public and workers, respectively. Cancer fatalities and incidence occur during the lifetimes of the exposed populations and, thus, are called latent cancer fatalities.

E.5.6 Accident Involvement Rates

For the calculation of accident risks, vehicle accident and fatality rates are taken from data provided in other reports (Saricks and Kvitek 1994). Accident rates are generically defined as the number of accident involvements (or fatalities) in a given year per unit of travel in that same year. Therefore, the rate is a fractional value, with accident-involvement count as the numerator of the fraction and vehicular activity (total travel distance) as its denominator. Accident rates are generally determined for a multi-year period. For assessment purposes, the total number of expected accidents or fatalities is calculated by multiplying the total shipment distance for a specific case by the appropriate accident or fatality rate.

For truck transportation, the rates presented are specifically for heavy combination trucks involved in interstate commerce (Saricks and Kvitek 1994). Heavy combination trucks are rigs composed of a separable tractor unit containing the engine and one to three freight trailers connected to each other. Heavy combination trucks are typically used for radioactive waste shipments. The truck accident rates are computed for each State based on statistics compiled by the Department of Transportation Office of Motor Carriers for 1986 to 1988. Saricks and Kvitek present accident involvement and fatality counts; estimated kilometers of travel by State; and the corresponding average accident involvement, fatality, and injury rates for the 3 years investigated. Fatalities are deaths (including crew members) attributable to the accident or that occurred at any time within 30 days thereafter.

E.5.7 Container Accident Response Characteristics and Release Fractions

The transportation accident model assigns accident probabilities to a set of accident categories. Eight accident-severity categories defined in the U.S. Nuclear Regulatory Commission's *Final Environmental Impact Statement on the Transportation of Radioactive Material by Air and Other Modes,* NUREG-0170 (NRC 1977), were used. The least severe categories (Category I and II) represent low magnitudes of crush force, accident-impact velocity, fire duration, and/or puncture-impact speed. The most severe category (Category VIII) represents a large crush force, high accident-impact velocity, long fire duration, and a high puncture-impact speed. The fraction of material released and material aerosolized, and the fraction of that material that is respirable (particles smaller than 10 microns) was assigned based on the accident categories. Since all shipments will use the previously described Type B containers and the Safe Secure Trailer System, even severe accidents release, at the most, a portion of the material being transported.

E.6 COLLECTIVE POPULATION RISK RESULTS

In this section, the risk assessment results are presented for the shipment materials and destinations being considered. The collective population risk results are presented in Section E.6.1, and the results are consolidated in Section E.6.2 so the different alternatives can be analyzed. Section E.6.3 describes the doses to the maximally exposed individuals.

E.6.1 Per-Shipment Risk Factors

Per-shipment risk factors have been calculated for the collective populations of exposed persons and for the crew for all anticipated routes and shipment configurations. The radiological risks are presented in doses per shipment for each unique route, material, and container combination. The radiological dose per shipment factors for incident-free transportation are presented in **Table E–3**. Doses are calculated for the crew, off-link public (i.e., people living along the route), on-link public (i.e., pedestrians and drivers along the route), and public at rest and fueling stops (i.e., stopped cars, buses and trucks, workers, and other bystanders). The radiological dose risk factors for accident transportation conditions are presented in **Table E–4**. The accident risk factors are called "dose risk" because the values incorporate the spectrum of accident severity probabilities and associated consequences.

Table E–3 Incident-Free Radiological Doses per Shipment for All Material Types (Person-rem/Shipment) [a]

Shipments from Rocky Flats:					
		Public			
Destination	*Crew*	*Off-Link*	*On-Link*	*Stops*	*Total*
Savannah River Site	0.155	0.00146	0.0112	0.0860	0.0987
Los Alamos National Laboratory	0.0415	0.000365	0.00293	0.0241	0.0274

[a] Incident-free risk factors are based on dose rates of 10 mrem at 2 m from the vehicle.

The nonradiological risk factors are presented in fatalities per shipment in **Table E–5**. Separate risk factors are provided for fatalities resulting from hydrocarbon emissions (known to contain carcinogens) and transportation accidents (fatalities resulting from impact).

Table E–4 Accident Radiological Dose Risk per Shipment for Each Material Type (Person-rem/Shipment)

Shipments from Rocky Flats:		
	Destination	
Material	*Savannah River Site*	*Los Alamos National Laboratory*
Ash Residues		
Incinerator Ash and Firebrick Fines		
Purex	0.000034	N/A
Mediated Electrochemical Oxidation/Purex	0.000046	N/A
Pulverized Sand, Slag, and Crucibles	0.000022	N/A
Graphite Fines for Mediated Electrochemical Oxidation	0.000047	N/A
Salt Residues		
Direct Oxide Reduction Salts	0.000013	0.000007
Electrorefining & Molten Salt Extraction	0.000016	0.000012
Fluoride Residues	0.0009	N/A
Graphite Residues	0.000027	N/A
Inorganic Residues	0.000082	N/A
Existing Scrub Alloy	0.000014	N/A

N/A = not applicable

Table E–5 Vehicle-Related (Nonradiological) Risk Factors per One-Way Shipment (Fatalities/Shipment)

Shipments from Rocky Flats:		
	Destination	
Risk Factor	*Savannah River Site*	*Los Alamos National Laboratory*
Vehicle Emissions	6.5×10^{-6}	2.2×10^{-6}
Vehicle Accident	0.000051	3.7×10^{-6}

E.6.2 Evaluation of Shipment Risks

Table E–6 shows the risks of transporting each of the plutonium residue and scrub alloy materials. The risks are calculated by multiplying the previously given per-shipment factors by the number of shipments and, in the case of the radiological doses, by the health risk conversion factors. Based on the results of the transportation risk analysis, it is unlikely that shipping plutonium residues and scrub alloy will result in a fatality.

Table E–6 Overland Transportation Risks for All Materials [a]

Material	Routine				Accidental
	Radiological		Nonradiological [b]		
	Crew	Public	Emissions	Traffic	Radiological
Ash Residues (to Savannah River Site)					
Incinerator Ash & Firebrick Fines					
Purex	0.0072	0.0057	0.00152	0.01181	2.0×10^{-6}
Mediated Electrochemical Oxidation/Purex	0.0053	0.0042	0.00113	0.00875	2.0×10^{-6}
Pulverized Sand, Slag & Crucibles	0.0016	0.0013	0.00034	0.00265	2.9×10^{-7}
Graphite Fines for Mediated Electrochemical Oxidation	0.0004	0.0003	0.00009	0.00071	1.6×10^{-7}
Salt Residues					
Direct Oxide Reduction Salts					
Water Leach (to Los Alamos National Laboratory)	0.0002	0.0002	0.00006	0.00010	4.4×10^{-8}
Purex Following Scrub (to Savannah River Site)	0.0001	0.0001	0.00002	0.00003	2.6×10^{-8}
Molten Salt Extraction/Electrorefining Salts					
Distillation (to Los Alamos National Laboratory)	0.0009	0.0007	0.00024	0.00038	3.2×10^{-7}
Purex Following Scrub (to Savannah River Site)	0.0004	0.0003	0.00011	0.00018	1.9×10^{-7}
Fluoride Residues (to Savannah River Site)	0.0004	0.0003	0.00009	0.00071	3.1×10^{-6}
Graphite Residues (to Savannah River Site)	0.0010	0.0008	0.00021	0.00163	2.1×10^{-7}
Inorganic Residues (to Savannah River Site)	0.0002	0.0002	0.00005	0.00041	1.6×10^{-7}
Existing Scrub Alloy (to Savannah River Site)	0.0004	0.0003	0.00008	0.00061	4.3×10^{-8}

[a] All risks are expressed in latent cancer fatalities during the implementation of the policy, except for the Accidental-Traffic column, which represents a number of fatalities.
[b] These risks are associated with round-trip shipments.

E.6.3 Maximally Exposed Individuals

The risks to maximally exposed individuals under incident-free transportation conditions have been estimated for hypothetical exposure scenarios. The estimated dose to inspectors and the public is presented in **Table E–7** on a per-event basis (person-rem per event). Note that the potential exists for individual exposures if multiple exposure events occur. For instance, the dose to a person stuck in traffic next to a shipment for 30 minutes is calculated to be 11 mrem. If the exposure duration was longer, the dose would rise proportionally. In addition, a person working at a truck service station could receive a significant dose if trucks were to use the same stops repeatedly. The dose to a person fueling a truck could be as much as 1 mrem. Administrative controls could be instituted to control the location and duration of truck stops if multiple exposures were to happen routinely.

The cumulative dose to a resident was calculated assuming all shipments passed his or her home. The cumulative doses assume that the resident is present for every shipment and is unshielded at a distance of 30 m (66 ft) from the route. Therefore, the cumulative dose is only a function of the number of shipments passing a particular point and is independent of the actual route being considered. The maximum dose to this resident, if all the material were to be shipped via this route, would be less than 0.1 mrem. The annual individual dose can be estimated by assuming that shipments would occur uniformly over a 15-year time period.

Table E–7 Estimated Dose to Maximally Exposed Individuals During Incident-Free Transportation Conditions [a, b]

Receptor		Dose to maximally exposed individual
Workers	Crew Member	0.1 rem/yr[c]
	Inspector	0.0029 rem/event
Public	Resident	4.0×10^{-7} rem/event
	Person in Traffic Congestion	0.011 rem/event
	Person at Service Station	0.001 rem/event

[a] The exposure scenario assumptions are described in Section E.6.3.
[b] Doses are calculated assuming that the shipment external dose rate is equal to the maximum expected dose 10 mrem/hr at 2 m (3.3 ft) from the package.
[c] Dose to truck drivers could exceed the legal limit of 100 mrem/yr in the absence of administrative controls.

The estimated dose to crew members (truck drivers) is presented for a commercial crew. No credit is taken for the shielding associated with the tractor or trailer.

The accident consequence assessment is intended to provide an estimate of the maximum potential impacts posed by the most severe potential transportation accidents involving a shipment. The accident consequence results are presented in **Table E–8** for the maximum severity accidents. The population doses are for a uniform population density within an 80-km (50-mi) radius (Neuhauser and Kanipe 1993). The location of the maximally exposed individual is determined based on atmospheric conditions at the time of the accident and the buoyant characteristics of the released plume. The locations of maximum exposure would be 100 m (330 ft) and 90 m (300 ft) from the accident site for neutral (average) and stable conditions, respectively. The dose to the maximally exposed individual is independent of the location of the accident. In general, the dose to maximally exposed individuals for the most severe accidents would be less than 10 mrem. No acute or early fatalities would be expected from radiological causes.

Table E–8 Estimated Dose to Maximally Exposed Individuals During the Specific Accident Conditions [a, b]

Mode and Accident Location	Neutral Conditions [c]				Stable Conditions [d]			
	Population [e]		Maximally Exposed Individual [f]		Population [e]		Maximally Exposed Individual [f]	
	Dose (person-rem)	Consequences (Cancer Fatalities)	Dose (rem)	Consequences (Probability of Cancer Fatality)	Dose (person-rem)	Consequences (Cancer Fatalities)	Dose (rem)	Consequences (Probability of Cancer Fatality)
Truck								
Urban	9.9	0.005	0.021	0.000015	4.7	0.0023	0.0018	8.85×10^{-7}
Suburban	1.1	0.0008	0.021	0.000015	0.8	0.0004	0.0018	8.85×10^{-7}
Rural	0.04	0.00002	0.021	0.000015	0.02	0.000009	0.0018	8.85×10^{-7}

[a] The most severe accidents correspond to the NUREG-0170 accident severity category VIII (NRC 1977).
[b] Buoyant plume rise resulting from fire for a severe accident was included in the exposure model.
[c] Neutral weather conditions result in moderate dispersion and dilution of the release plume. Neutral conditions were taken to be Pasquill stability Class D with a wind speed of 4 meters per second (m/sec) (9 miles per hour [mph]). Neutral conditions occur approximately 50 percent of the time in the United States.
[d] Stable weather conditions result in minimal dispersion and dilution of the release plume and are thus unfavorable. Stable conditions were taken to be Pasquill stability Class F with a wind speed of 1 m/sec (2.2 mph). Stable conditions occur approximately one-third of the time in the United States.
[e] Populations extend at a uniform density to a radius of 80 km (50 mi) from the accident site. Population exposure pathways include acute inhalation, acute cloudshine, groundshine, resuspended inhalation, resuspended cloudshine, and ingestion of food, including initially contaminated food (rural only) (Yuan et al. 1995). No decontamination or mitigative actions are taken.
[f] The maximally exposed individual is assumed to be at the location of maximum exposure. The locations of maximum exposure would be 100 m (330 ft) and 90 m (300 ft) from the accident site under neutral and stable atmospheric conditions, respectively. Individual exposure pathways include acute inhalation, acute cloudshine, and groundshine during passage of the plume. No ingested dose is considered.

The maximum foreseeable (frequency greater than 1×10^{-7} per year) offsite transportation accident involves a shipment of scrub alloy in a suburban population zone under neutral (average) weather conditions. The accident has a probability of occurrence of about 1 every 10 million years and could result in 1.1 person-rem and no fatalities. The probability of an accident occurring is at least 10 times smaller in either an urban area or under stable atmospheric conditions, and the consequences are less than 10 times greater.

E.7 CONCLUSIONS AND LONG-TERM IMPACTS OF TRANSPORTATION

E.7.1 Conclusions

It is unlikely that transportation will cause an additional fatality. The nonradiological risks (air pollution and traffic accidents) are greater than the radiological risks.

E.7.2 Long-Term Impacts of Transportation

The *Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement* (DOE 1995) analyzed the cumulative impacts of all transportation of radioactive materials, taking into account impacts from reasonably foreseeable actions that include transportation of radioactive material and general radioactive materials transportation that is not related to a particular action. The total worker and general population collective doses are summarized in **Table E–9**. Total collective worker doses from all types of shipments (historical, the alternatives, reasonably foreseeable actions, and general transportation) were estimated to be 320,000 person-rem (130 latent cancer fatalities) for the period of time 1943 through 2035 (93 years). Total general population collective doses were also estimated to be 320,000 person-rem (160 latent cancer fatalities). The majority of the collective dose for workers and the general population was due to the general transportation of radioactive material. Examples of these activities are shipments of radiopharmaceuticals to nuclear medicine laboratories and shipments of commercial low-level radioactive waste to commercial disposal facilities. The total number of latent cancer fatalities estimated to result from radioactive materials transportation over the period between 1943 and 2035 was 290. Over this same period of time (93 years), approximately 28 million people would die from cancer, based on 300,000 cancer fatalities per year (NRC 1977). It should be noted that the estimated number of transportation-related latent cancer fatalities would be indistinguishable from other latent cancer fatalities, and the transportation-related latent cancer fatalities are 0.0010 percent of the total number of latent cancer fatalities.

Table E–9 Cumulative Transportation-Related Radiological Collective Doses and Latent Cancer Fatalities (1943 to 2035)

Category	*Collective Occupational Dose (person-rem)*	*Collective General Population Dose (person-rem)*
Shipment of Plutonium Residues and Scrub Alloy	< 100	< 100
Reasonably Foreseeable Actions		
Truck	11,000	50,000
Rail	820	1,700
General Transportation (1943–2035)	310,000	270,000
Total Collective Dose	320,000	320,000
Total latent cancer fatalities	**130**	**160**

Source: DOE 1995.

E.8 UNCERTAINTY AND CONSERVATISM IN ESTIMATED IMPACTS

The sequence of analyses performed to generate the estimates of radiological risk for the transportation includes: (1) determination of the inventory and characteristics, (2) estimation of shipment requirements, (3) determination of route characteristics, (4) calculation of radiation doses to exposed individuals (including estimation of environmental transport and uptake of radionuclides), and (5) estimation of health effects. Uncertainties are associated with each of these steps. Uncertainties exist in the way that the physical systems being analyzed are represented by the computational models, in the data required to exercise the models (due to measurement errors, sampling errors, natural variability, or unknowns simply caused by the future nature of the actions being analyzed), and in the calculations themselves (e.g., approximate algorithms used by the computers).

In principle, one can estimate the uncertainty associated with each input or computational source and predict the resultant uncertainty in each set of calculations. Thus, one can propagate the uncertainties from one set of calculations to the next and estimate the uncertainty in the final, or absolute, result; however, conducting such a full-scale quantitative uncertainty analysis is often impractical and sometimes impossible, especially for actions to be initiated at an unspecified time in the future. Instead, the risk analysis is designed to ensure, through uniform and judicious selection of scenarios, models, and input parameters, that relative comparisons of risk among the various alternatives are meaningful. In the transportation risk assessment, this design is accomplished by uniformly applying common input parameters and assumptions to each alternative. Therefore, although considerable uncertainty is inherent in the absolute magnitude of the transportation risk for each alternative, much less uncertainty is associated with the relative differences among the alternatives in a given measure of risk.

In the following sections, areas of uncertainty are discussed for the assessment steps enumerated above. Special emphasis is placed on identifying whether the uncertainties affect relative or absolute measures of risk. The degree of reality conservatism of the assumption is addressed. Where practical, the parameters that most significantly affect the risk assessment results are identified.

E.8.1 Uncertainties in Plutonium Residue and Scrub Alloy Inventory and Characterization

The inventories and the physical and radiological characteristics are important input parameters to the transportation risk assessment. The potential amount of transportation for any alternative is determined primarily by the projected plutonium inventory and assumptions concerning shipment capacities. The physical and radiological characteristics are important in determining the amount of material released during accidents and the subsequent doses to exposed individuals through multiple environmental exposure pathways.

The development of projected plutonium inventory and characterization data used to support the EIS is described in Appendix B. Uncertainties in the inventory and characterization will be reflected to some degree in the transportation risk results. If the inventory is overestimated (or underestimated), the resulting transportation risk estimates also will be overestimated (or underestimated) by roughly the same factor. However, the same inventory estimates are used to analyze the transportation impacts of each of the EIS alternatives. Therefore, for comparative purposes, the observed differences in transportation risks among alternatives are believed to represent unbiased, reasonably accurate estimates from current information in terms of relative risk comparisons.

E.8.2 Uncertainties in Containers, Shipment Capacities, and Number of Shipments

The amount of transportation required for each alternative is based in part on assumptions concerning the packaging characteristics and shipment capacities for commercial trucks and safe secure transports. Representative shipment capacities have been defined for assessment purposes based on probable future shipment capacities. In reality, the actual shipment capacities may differ from the predicted capacities, so that

the projected number of shipments, and consequently the total transportation risk, would change. However, although the predicted transportation risks would increase or decrease accordingly, the relative differences in risks among alternatives would remain about the same. The maximum amount of material allowed in Type B containers is set by conservative safety analyses, such as WSRC 1996.

E.8.3 Uncertainties in Route Determination

Representative routes have been determined between all origin and destination sites considered in the EIS. The routes have been determined consistent with current guidelines, regulations, and practices, but may not be the actual routes that would be used in the future. In reality, the actual routes could differ from the representative ones in terms of distances and total population along the routes. Moreover, since plutonium residues and scrub alloy could be transported over an extended period of time starting at some time in the future, the highway infrastructures and the demographics along routes could change. These effects have not been accounted for in the transportation assessment; however, it is not anticipated that these changes would significantly affect relative comparisons of risk among the alternatives considered in the EIS. Specific routes cannot be identified in advance for the Transportation Safeguards Division shipments because the routes are classified to protect national security interests.

E.8.4 Uncertainties in the Calculation of Radiation Doses

The models used to calculate radiation doses from transportation activities introduce a further uncertainty in the risk assessment process. It is generally difficult to estimate the accuracy or absolute uncertainty of the risk assessment results. The accuracy of the calculated results is closely related to the limitations of the computational models and to the uncertainties in each of the input parameters that the model requires. The single greatest limitation facing users of RADTRAN, or any computer code of this type, is the scarcity of data for certain input parameters.

Uncertainties associated with the computational models are minimized by using state-of-the-art computer codes that have undergone extensive review. Because there are numerous uncertainties that are recognized but difficult to quantify, assumptions are made at each step of the risk assessment process that are intended to produce conservative results (i.e., overestimate the calculated dose and radiological risk). Because parameters and assumptions are applied to all alternatives, this model bias is not expected to affect the meaningfulness of relative comparisons of risk; however, the results may not represent risks in an absolute sense.

In order to understand the most important uncertainties and conservatism in the transportation risk assessment, the results for all cases were examined to identify the largest contributors to the collective population risk. The results of this examination are discussed briefly in the following paragraph.

For truck shipments, the largest contributors to the collective population dose, in decreasing order of importance, were found to be: (1) incident-free dose to members of the public at stops, (2) incident-free dose to transportation crew members, (3) incident-free dose to members of the public sharing the route (on-link dose), (4) incident-free dose to members of the public residing along the route (off-link dose), and (5) accident dose risk to members of the public. Approximately 80 percent of the estimated public dose was incurred at stops, 15 percent by the on-link population, and 5 percent by the off-link population. In general, the accident contribution to the total risk was negligible compared with the incident-free risks.

As shown above, incident-free transportation risks are the dominant component of the total transportation risk. The most important parameter in calculating incident-free doses is the shipment external dose rate (incident-free doses are directly proportional to the shipment external dose rate). For this assessment, it was assumed that all shipments would have an external dose rate at the regulatory limit of 10 mrem/hr at 2 m. In practice, the external dose rates would vary from shipment to shipment.

Finally, the single largest contributor to the collective population doses calculated with RADTRAN was found to be the dose to members of the public at truck stops. Currently, RADTRAN uses a simple point-source approximation for truck-stop exposures and assumes that the total stop time for a shipment is proportional to the shipment distance. The parameters used in the stop model were based on a survey of a very limited number of radioactive material shipments that examined a variety of shipment types in different areas of the country. It was assumed that stops occur as a function of distance, with a stop rate of 0.011 hour per km (0.018 hour per mi). It was further assumed that an average of 50 people at each stop are exposed at a distance of 20 m (66 ft). In RADTRAN, the population dose is directly proportional to the external shipment dose rate and the number of people exposed, and inversely proportional to the square of the distance. The stop rate assumed results in an hour of stop time per 100 km (62 mi) of travel.

Based upon the qualitative discussion with shippers, the parameter values used in the assessment appear to be conservative. However, data do not exist to quantitatively assess the degree of control, the location, frequency, and duration of truck stops. However, based on the regulatory requirements for continuous escort of the material (10 CFR Part 73) and the requirement for two drivers, it is clear that the trucks would be on the move much of the time until arrival at the destination. Therefore, the calculated impacts are extremely conservative. By using these conservative parameters, the calculations in this EIS are consistent with the RADTRAN default values.

Shielding of exposed populations is not considered. For all incident-free exposure scenarios, no credit has been taken for shielding of exposed individuals. In reality, shielding would be afforded by trucks and cars sharing the transport routes, rural topography, and the houses and buildings in which people reside. Incident-free exposure to external radiation could be reduced significantly depending on the type of shielding present. For residential houses, shielding factors (i.e., the ratio of shielded to unshielded exposure rates) have been estimated to range from 0.02 to 0.7, with a recommended value of 0.33. If shielding were to be considered for the maximally exposed resident living near a transport route, the calculated doses and risks would be reduced by approximately 70 percent. Similar levels of shielding may be provided to individuals exposed in vehicles. However, consideration of shielding does not significantly affect the overall incident-free risks to the general public.

Post-accident mitigative actions are not considered for dispersal accidents. For severe accidents involving the release and dispersal of radioactive materials in the environment, no post-accident mitigative actions, such as interdiction of crops or evacuation of the accident vicinity, have been considered in this risk assessment. In reality, mitigative actions would take place following an accident in accordance with U.S. Environmental Protection Agency (EPA) radiation protection guides for nuclear incidents (EPA 1991). The effects of mitigative actions on population accident doses are highly dependent upon the severity, location, and timing of the accident. For this risk assessment, ingestion doses are only calculated for accidents occurring in rural areas (the calculated ingestion doses, however, assumes all food grown on contaminated ground is consumed and is not limited to the rural population). Examination of the severe accident consequence assessment results has shown that ingestion of contaminated foodstuffs contributes on the order of 50 percent of the total population dose for rural accidents. Interdiction of foodstuffs would act to reduce, but not eliminate, this contribution.

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Appendix F

Analysis of Environmental Justice

APPENDIX F
ANALYSIS OF ENVIRONMENTAL JUSTICE

F.1 INTRODUCTION

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations*, directs Federal agencies to identify and address, as appropriate, disproportionately high and adverse health or environmental effects of their programs, policies, and activities on minority populations and low-income populations.

The Council on Environmental Quality has oversight responsibility for documentation prepared in compliance with the National Environmental Policy Act. In March 1997, the Council released updated draft guidance on environmental justice (CEQ 1997). The Council's guidance was adopted as the basis for the analysis of environmental justice contained in this Environmental Impact Statement (EIS).

F.2 DEFINITIONS AND APPROACH

The following definitions of minority individuals and population were used in this analysis of environmental justice:

- **Minority Individuals**—Persons who are members of any of the following population groups: Hispanic, Native American, Asian or Pacific Islander, or Black.

- **Minority Population**—The total number of minority individuals residing within a potentially affected area.

In the discussions of environmental justice in this document, persons self-designated as Hispanic are included in the Hispanic population regardless of race. The Asian or Pacific Islander population is comprised of persons self-designated as Asian or Pacific Islander and not of Hispanic origin. Asian or Pacific Islanders who designate themselves as having Hispanic origins are included in the Hispanic population. Data for the analysis of minorities were obtained from Table P12 of the Summary Tape File 3A published on CD-ROM by the United States Bureau of the Census (DOC 1992).

Executive Order 12898 specifically addresses "disproportionately high and adverse effects" on "low-income" populations. The Council recommends that poverty thresholds be used to identify "low-income" individuals.

The following definitions of low-income individuals and poverty-level population were used in this analysis:

- **Low-Income Individuals**—All persons whose self-reported income is less than the poverty threshold.

- **Low-Income Population**—The total number of poverty-level individuals residing within a potentially affected area.

Data for the analysis of low-income populations were extracted from Table P121 of Standard Tape File 3A (DOC 1992).

F.3 UNCERTAINTIES AND SPATIAL RESOLUTION

For the purposes of enumeration and analysis, the Census Bureau has defined a variety of areal units (DOC 1992). Areal units of concern in this document include (in order of increasing spatial resolution): States, counties, census tracts, block groups, and blocks. The "block" is generally the smallest of these entities and offers the finest spatial resolution. This term refers to a relatively small geographical area bounded on all sides by visible features such as streets and streams, or by invisible boundaries such as city limits and property lines. During the 1990 census, the Bureau subdivided the United States and its territories into 7,017,425 blocks. For comparison the number of counties, census tracts, and block groups used in the 1990 census were 3,248; 62,276; and 229,192; respectively. While blocks offer the finest spatial resolution, economic data required for identification of low-income populations are not available at the block-level of spatial resolution. In the analysis below, block groups are used throughout as the areal unit.

The initial step in an analysis of environmental justice is to identify minority populations and low-income populations residing within areas potentially affected by the proposed action and alternatives. In this analysis, potentially affected areas were defined as those areas which could be impacted by radiological effects or chemical releases. For example, radiological and chemical release impacts were evaluated in Chapter 4 of this document for persons residing within 80 kilometers (km) (50 miles [mi]) of management sites. Analyses were also performed for non-accident transportation of plutonium residues along highways from the Rocky Flats Environmental Technology Site (Rocky Flats) to the Savannah River Site and Los Alamos National Laboratory.

As discussed in Chapter 4, alternatives in this EIS are not likely to harm water quality or wildlife. It is unlikely that implementation of any of the alternatives would harm persons who rely on fish or other wildlife for subsistence.

F.4 RESULTS FOR DEPARTMENT OF ENERGY (DOE) SITES

Table F-1 shows the total population, minority population, and percentage minority population that resided within 80 km (50 mi) of the various DOE sites at the time of the 1990 census. The 80-km (50-mi) distance defines the radius of potential radiological effects, described in Chapter 4 of this EIS, for calculations of radiation dose to the general population from the proposed action. Columns 5 through 7 of the table show similar data for the summation of populations over all counties having boundaries that lie at least partly within a circle of the 80-km (50-mi) radius centered at each site.

Table F–1 Minority Populations Residing Within and Near Potentially Affected Areas

Site	*Population Within 80 km of Site*	*Minority Population Within 80 km of Site*	*% Minority Population Within 80 km of Site*	*Population in Counties Surrounding Site*	*Minority Population in Counties Surrounding Site*	*% Minority Population in Counties Surrounding Site*
Rocky Flats	2,165,727	414,505	19.1	2,214,399	418,802	18.9
Los Alamos National Laboratory	214,290	116,091	54.2	748,429	368,785	49.3
Savannah River Site	613,087	233,177	38.0	944,982	330,078	1.05

The percentage minority population residing within 80 km (50 mi) of Rocky Flats is about 5 percent less than the national average of 24.2 percent for the contiguous United States, and is nearly equal to the percentage minority population of 19.3 percent for the State of Colorado. The percentage minority population residing

within 80 km (50 mi) of the other two sites listed in Table F-1 is at least 14 percent larger than the national average for the contiguous United States. The States of Georgia, New Mexico, and South Carolina are among the 10 contiguous States with the largest percent minority populations. **Figures F-1** through **F-3** show the geographical distribution of minority populations surrounding the three sites. **Table F-2** shows the racial and ethnic composition of the population residing near the three sites.

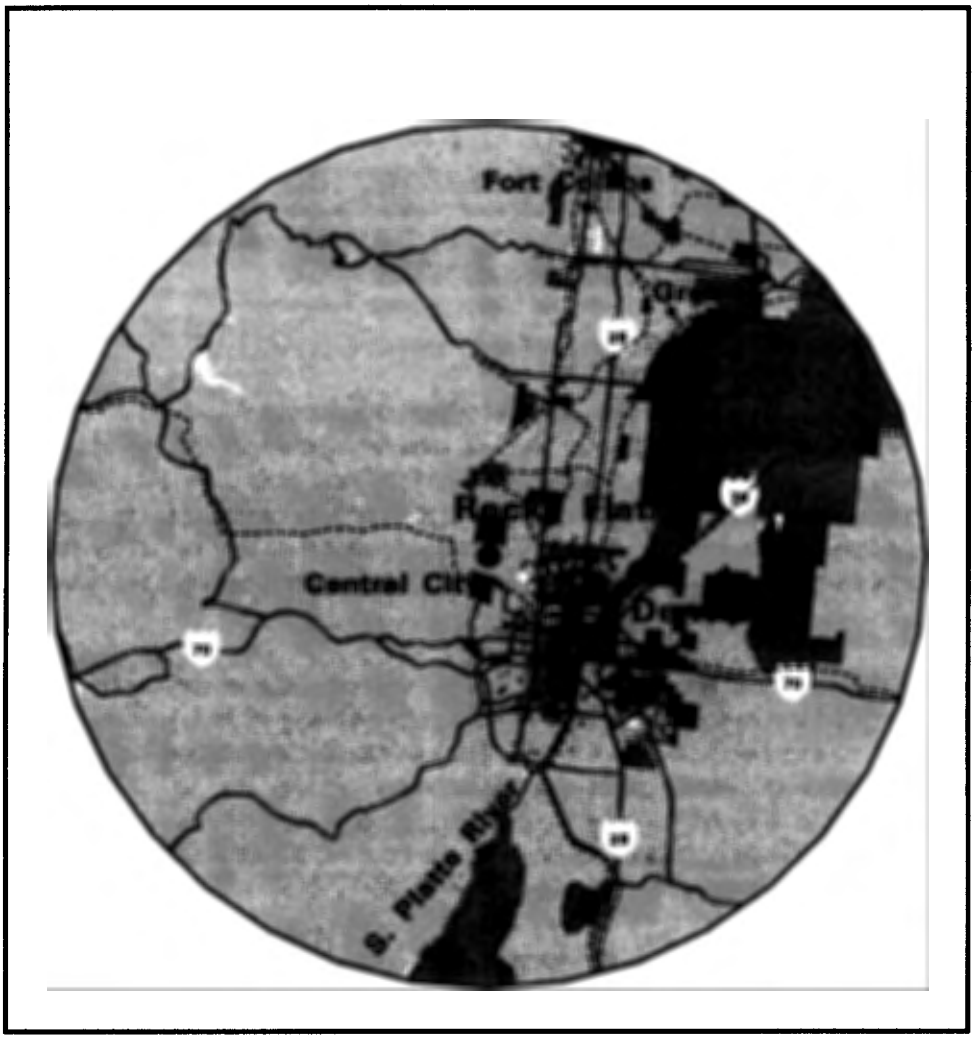
Table F-3 and **Figures F-4** through **F-6** characterize low-income populations residing near the three sites. The national percentage of persons with income below the poverty threshold residing in the contiguous States was 12.8 percent at the time of the 1990 census. The percentages of persons in poverty in the States of Colorado, New Mexico, and South Carolina during the 1990 census were 11.4 percent, 20.2 percent, and 14.9 percent, respectively. The Bureau of the Census estimates that by 1995 these percentages increased to 25.3 percent and 19.9 percent for New Mexico and South Carolina, respectively, while the percentage for Colorado declined to 8.8 percent (Baugher and Lamison-White, 1996).

F.5 Results for Transportation Routes

Overland transportation of plutonium residues and scrub alloy involves radiological and nonradiological risks to the public. **Tables F-4** and **F-5** show minority and low-income populations residing along highway routes from Rocky Flats to the Los Alamos National Laboratory and the Savannah River Site. Columns 2 and 3 of these tables show populations residing within a 1.6 km (1 mi) corridor centered along highway routes from Rocky Flats to candidate interim management sites. Columns 5 and 6 display the minority and low-income populations in counties which contain the highway routes. Data presented in the tables were resolved at the block-group level.

Percentage minority populations residing in the corridors exceed those in the counties surrounding the corridors and also exceed the national minority percentage population of 24.2 percent for the contiguous United States. With the exception of the route from Rocky Flats to Los Alamos National Laboratory, the percentage poverty-level population residing in the corridors is less than the national percentage of 13.3 percent, but higher than the percentage for the surrounding counties. The distances along highway routes connecting Rocky Flats with other candidate management sites are as follows: 759 km (472 mi) (Los Alamos National Laboratory), and 2,588.1 km (1,609 mi) (Savannah River Site).

As discussed in Sections E.6.2 and E.6.3 of Appendix E, it is unlikely that radiological or nonradiological harm to the public would result from highway transportation of plutonium residues and scrub alloy. The highway transportation of plutonium residues and scrub alloy would not likely harm any particular group within the general population, including low-income populations and minority populations.



LEGEND

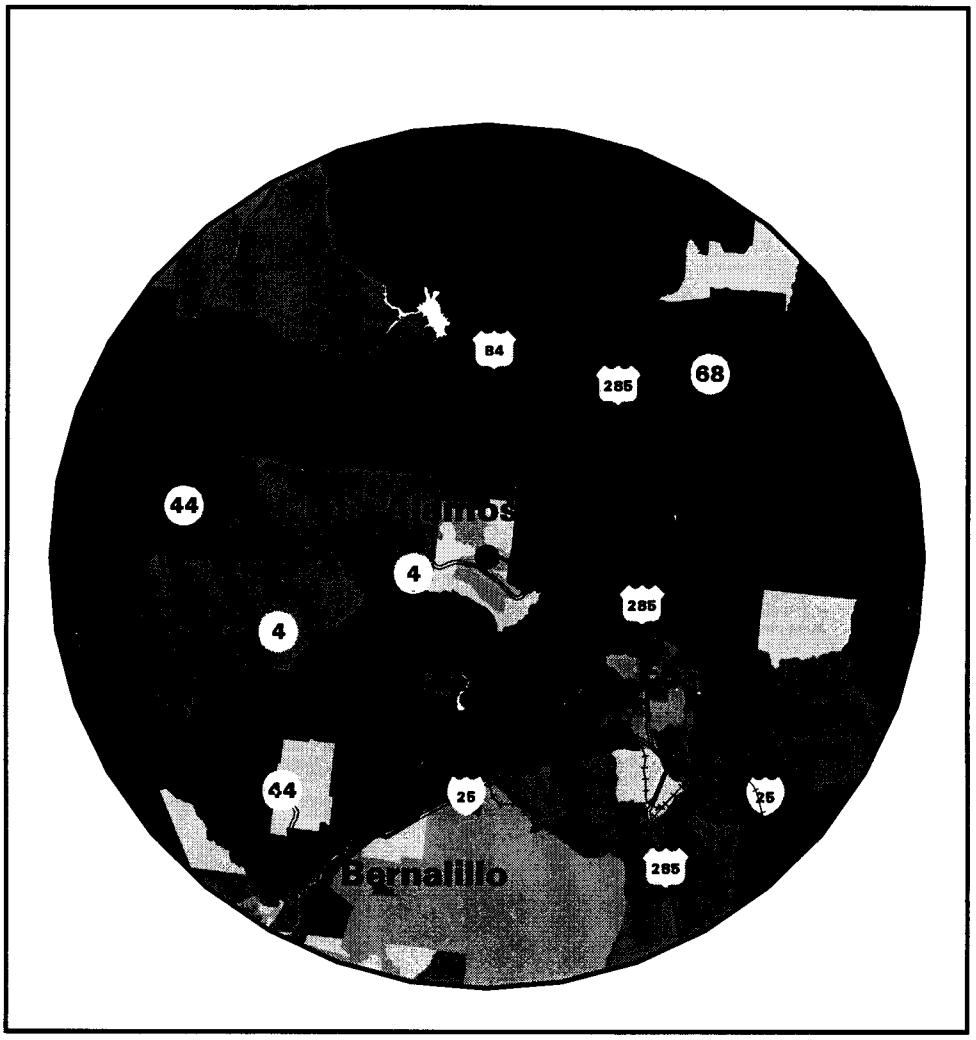
- Site
- Surface Water Shoreline
- Rail Lines
- State & US Highways

- 0 <= Pm < 12%
- 12% <= Pm < 24%
- 24% <= Pm < 48%
- Pm >= 48%

SUMMARY STATISTICS	
WITHIN 80 KM (50 MILES) RADIUS OF THE SITE	
TOTAL POPULATION	2,165,727
MINORITY POPULATION	414,505
PERCENTAGE	19 %

0 5 10 15 20 25 30
miles

Figure F–1 Minority Population Residing Within 80 km (50 mi) of the Rocky Flats Environmental Technology Site



LEGEND

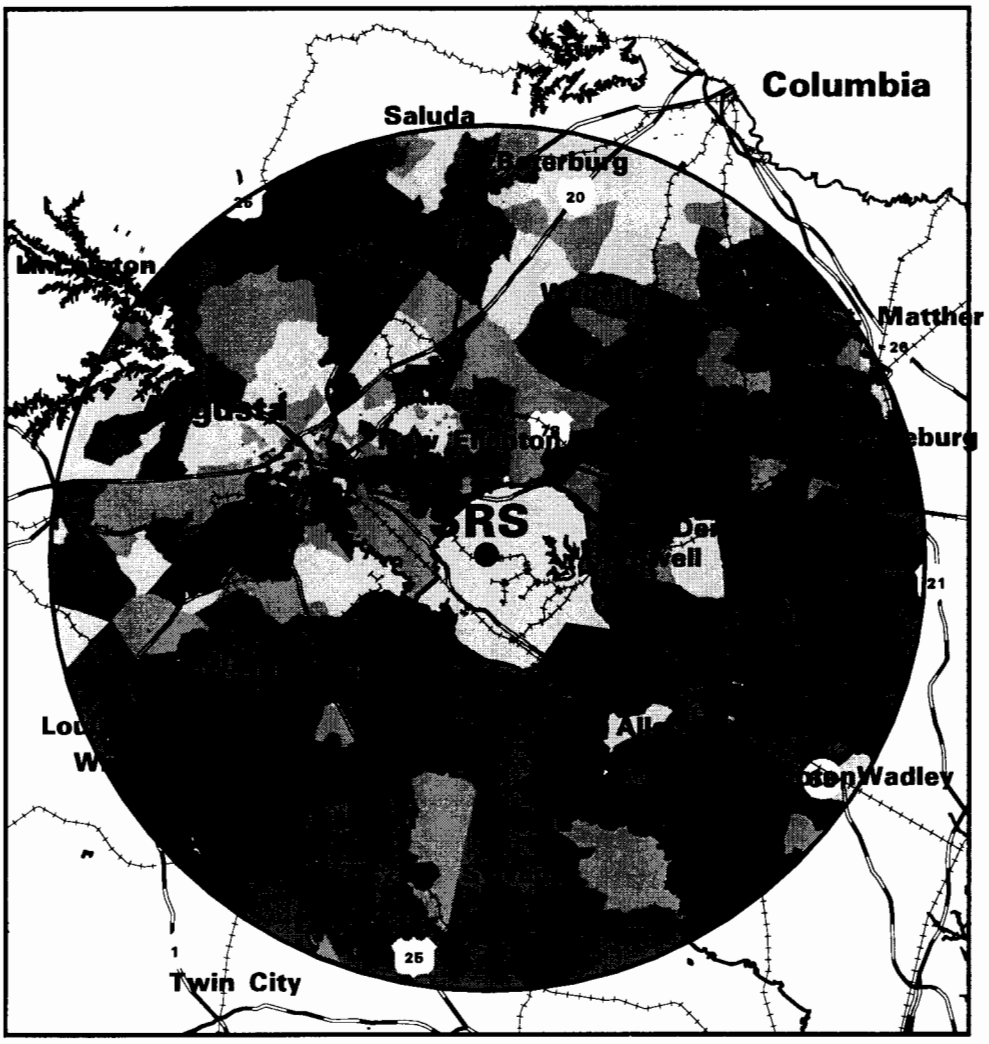
- Site
- Surface Water Shoreline
- Rail Lines
- State & US Highways

- 0 <= Pm < 12%
- 12% <= Pm < 24%
- 24% <= Pm < 48%
- Pm >= 48%

SUMMARY STATISTICS	
WITHIN 80 KM (50 MILES) RADIUS OF THE SITE	
TOTAL POPULATION	214,290
MINORITY POPULATION	116,091
PERCENTAGE	54%

0 5 10 15 20 25 30
miles

Figure F–2 Minority Population Residing Within 80 km (50 mi) of the Los Alamos National Laboratory



LEGEND

- Site
- Surface Water Shoreline
- Rail Lines
- State & US Highways

- 0 <= Pm < 12%
- 12% <= Pm < 24%
- 24% <= Pm < 48%
- Pm >= 48%

SUMMARY STATISTICS	
WITHIN 80 KM (50 Miles) RADIUS OF THE SITE	
TOTAL POPULATION	613,087
MINORITY POPULATION	233,177
PERCENTAGE	38%

0 5 10 15 20 25 30
miles

Figure F–3 Minority Population Residing Within 80 km (50 mi) of the Savannah River Site

Table F–2 Racial and Ethnic Composition of Minority Populations Residing Within 80 km (50 mi) of Potential Sites

Site	Total Pop.	Total Minority Pop.	% Minority Pop.	American Indian, Eskimo, or Aleut Pop.	% American Indian, Eskimo, or Aleut Pop.	Asian or Pacific Islander Pop.	% Asian or Pacific Islander Pop.	Black Pop.	% Black Pop.	Hispanic Origin Pop.	% Hispanic Origin Pop.
Rocky Flats	2,165,727	414,505	19.1	12,075	0.6	44,567	2.1	95,161	4.4	260,441	12.0
Los Alamos National Laboratory	214,290	116,091	54.2	15,081	7.0	1,242	0.6	1,306	0.6	97,897	45.7
Savannah River Site	613,087	233,177	38.0	1,533	0.3	5,885	1.0	219,317	35.8	6,442	1.1

Table F–3 Low-Income Populations Residing Within and Near Potentially Affected Areas

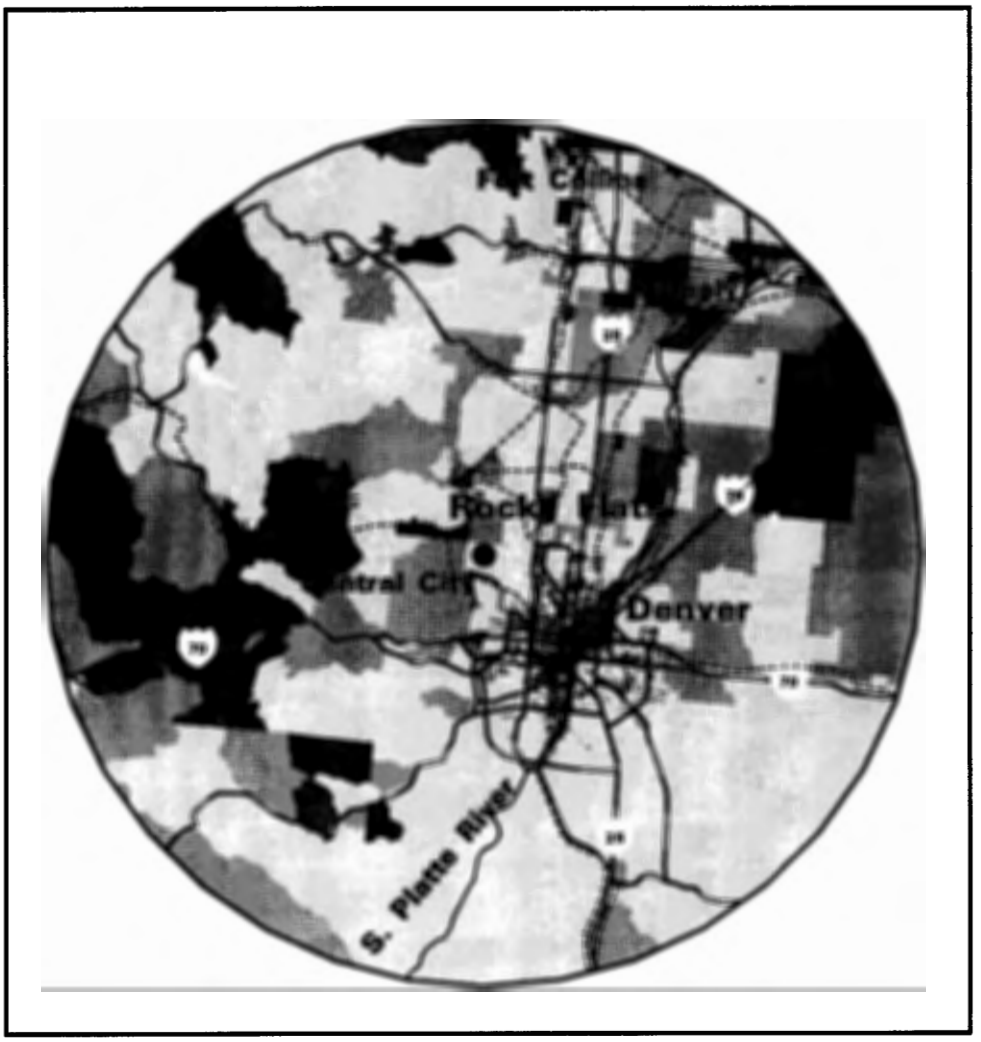
Site	Population Within 80 km of Site	Low-Income Population Within 80 km of Site	% Low-Income Population Within 80 km of Site	Population in Counties Surrounding Site	Low-Income Population in Counties Surrounding Site	% Low-Income Population in Counties Surrounding Site
Rocky Flats	2,165,727	219,263	10.1	2,214,399	224,455	10.1
Los Alamos National Laboratory	214,290	31,542	14.7	748,429	116,298	15.5
Savannah River Site	613,087	107,067	17.5	944,982	171,577	18.2

Table F–4 Minority Populations Residing Near Highway Routes from Rocky Flats to Candidate Management Sites

Destination	Population Along Route	Minority Population Along Route	% Minority Population Along Route	Population in Counties Surrounding the Route	Minority Population in Counties Surrounding the Route	% Minority Population in Counties Surrounding the Route
Los Alamos National Laboratory	183,618	60,200	32.8	2,611,159	616,483	23.6
Savannah River Site	561,135	145,540	25.9	9,850,030	2,305,994	23.4

Table F–5 Low-Income Populations Residing Along Highway Routes from Rocky Flats to Candidate Management Sites

Destination	Population Along Route	Low-Income Population Along Route	% Low-Income Population Along Route	Population in Counties Surrounding the Route	Low-Income Population in Counties Surrounding the Route	% Low-Income Population in Counties Surrounding the Route
Los Alamos National Laboratory	183,618	30,486	16.6	2,611,159	282,207	10.8
Savannah River Site	561,135	69,980	12.5	9,850,030	1,157,059	11.7



LEGEND

- Site
- Surface Water Shoreline
- Rail Lines
- State & US Highways

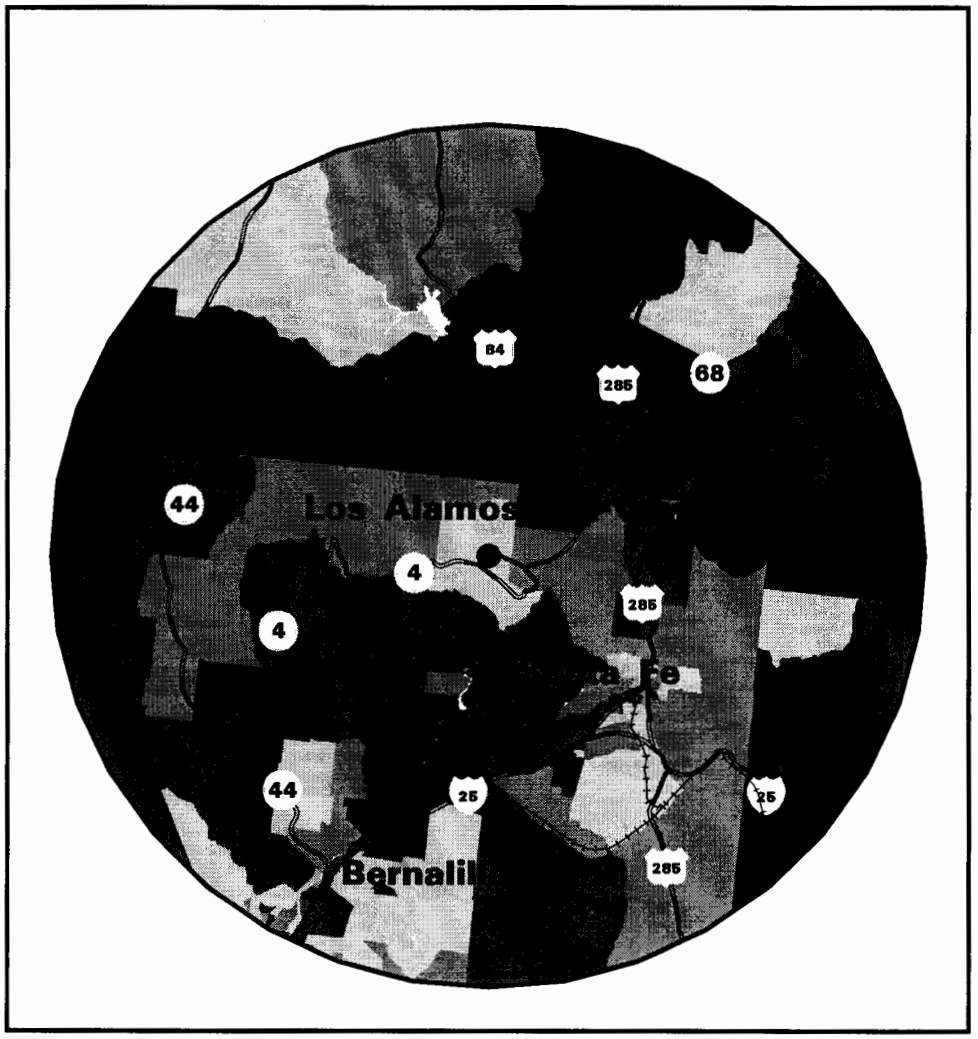
- 0 <= Pp < 6.5%
- 6.5% <= Pp < 13%
- 13% <= Pp < 26%
- Pp >= 26%

SUMMARY STATISTICS

WITHIN 80 KM (50 MILES) RADIUS OF THE SITE	
TOTAL POPULATION	2,165,727
POVERTY-LEVEL POPULATION	219,263
PERCENTAGE	10%

0 5 10 15 20 25 30
miles

Figure F–4 Low-Income Population Residing Within 80 km (50 mi) of the Rocky Flats Environmental Technology Site



LEGEND

- Site
- Surface Water Shoreline
- Rail Lines
- State & US Highways

- 0 <= Pp < 6.5%
- 6.5% <= Pp < 13%
- 13% <= Pp < 26%
- Pp >= 26%

SUMMARY STATISTICS	
WITHIN 80 KM (50 MILES) RADIUS OF THE SITE	
TOTAL POPULATION	214,290
POVERTY-LEVEL POPULATION	31,542
PERCENTAGE	15%

0 5 10 15 20 25 30
miles

Figure F–5 Low-Income Population Residing Within 80 km (50 mi) of the Los Alamos National Laboratory

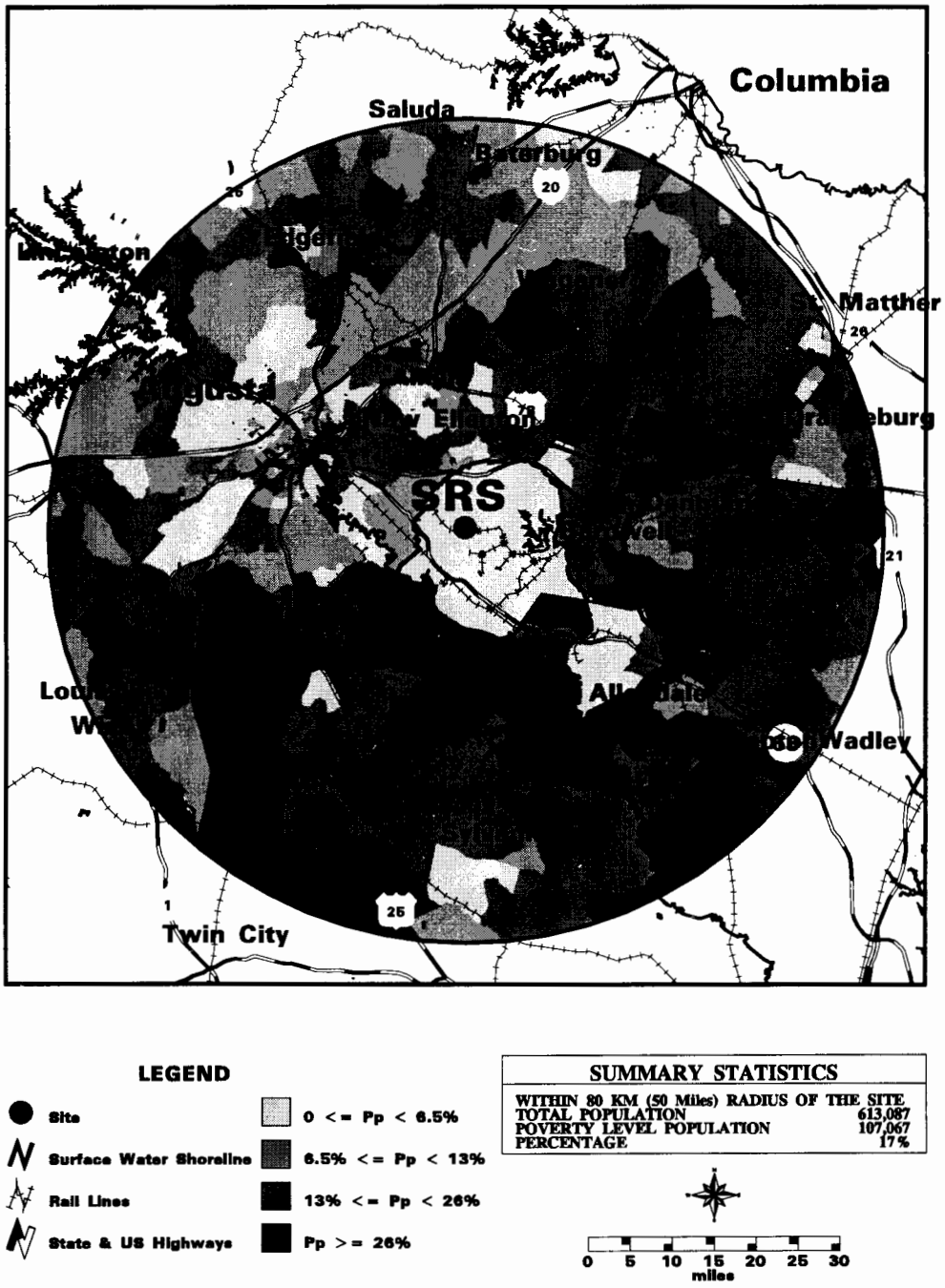


Figure F–6 Low-Income Population Residing Within 80 km (50 mi) of the Savannah River Site

F.6 REFERENCES

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Appendix G

Cost Analyses

APPENDIX G
COST ANALYSES

This appendix provides supporting data and calculations for Section 4.17 of this Environmental Impact Statement (EIS). It contains four major sections: G.1 Cost Estimating Bases, G.2 Schedules, G.3 Major Risks, and G.4 Estimated Absolute and Incremental Costs for Each Processing Option. The objective is to support the estimates of total and incremental costs, schedule durations, and risks.

G.1 COST ESTIMATING BASES

This section describes the common cost estimating bases used in this EIS. It is divided into the following six parts:

- Facilities and Equipment Costs
- Labor Costs
- Transuranic Waste Costs
- Low-Level Waste Costs at Rocky Flats and Los Alamos National Laboratory
- Other Materials Storage, Shipping, and Disposal Costs, including Costs at the Savannah River Site
- Costs Related to Delaying the Closure of Rocky Flats.

G.1.1 Facilities and Equipment Costs

Facilities and equipment costs are divided into two groups: costs that have been incurred, are being incurred, or will be incurred in support of the plutonium residues clean-up, independent of decisions in this EIS, and costs that will be incurred only as a result of decisions in this EIS. The former group includes costs to bring the facilities into compliance with the U.S. Department of Energy (DOE) regulations and Defense Nuclear Facilities Safety Board recommendations, to upgrade the facilities for their missions, to install facility-specific equipment, and to complete operational readiness reviews and startup tests. These costs are collectively referred to in this appendix as "common costs". In addition to these common costs are ongoing research and development costs for specific technologies. These common costs and research and development costs are allocable to the plutonium residues program, but are not incremental to existing DOE budgets or related to the decisions in this EIS. Allocable charges are estimated at $30 million for each building or module at the Rocky Flats Environmental Technology Site (Rocky Flats) required in an alternative and $20 million for ongoing research and development at Rocky Flats and Los Alamos National Laboratory. In almost all alternatives, five or six facilities (e.g., Building 707, Module A, Building 707 Module B, Building 371 Room 3701, etc.) are required. No common facilities costs are assigned at the Savannah River Site or Los Alamos National Laboratory.

Itemized equipment costs are those for specific, high-cost pieces of equipment used in a very small number of processing options. This EIS assumes that these pieces of equipment would not be purchased except in support of particular processing options. These costs are incremental to existing DOE budgets and related to the decisions in this EIS. These costs consist of:

- $30 million for the installation and start-up of two Silver II electrochemical dissolvers for mediated electrochemical oxidation at either F-Canyon, H-Canyon, (WSRC 1997) or Rocky Flats.

- $20 million for pre-installation decontamination and decommissioning of highly contaminated equipment at HB-Line for mediated electrochemical oxidation at H-Canyon (WSRC 1997).

- $12 million for pyro-oxidation and nondestructive assay equipment at Rocky Flats or Los Alamos National Laboratory.

- $4 million for distillation equipment at Rocky Flats or Los Alamos National Laboratory (DOE 1996c).

Because there is no necessarily correct way of allocating itemized equipment costs to an individual processing option that could share the equipment without knowing the complete management approach, these costs are excluded from the summary tables of costs for individual options presented at the end of this appendix.

Table G–1 shows the Rocky Flats facilities used in the No Action Alternative. These facilities are modules A, D, E, and F in Building 707 and Room 3701 in Building 371. Other management approaches use 707B (electrorefining and molten salt extraction salt scrub for shipment to the Savannah River Site, direct oxide reduction salt scrub for shipment to the Savannah River Site, and electrorefining and molten salt extraction distillation); 707J (mediated electrochemical oxidation, electrorefining and molten salt extraction salts water leach, and direct oxide reduction salt water leach); 776 (thermal destruction of combustibles and filter media); and 371–3305 (electrorefining and molten salt extraction salts water leach and direct oxide reduction salts water leach). This EIS assumes that any facilities-related upgrades, compliance with Defense Nuclear Facilities Safety Board recommendations, etc. will take place at these facilities independent of the decisions made in this EIS. Thus, common facilities costs at these facilities are not considered incremental to the No Action Alternative or incremental to DOE.

Table G–1 Facilities Required for No Action Alternative

No Action Processing Option	*Facilities*	*Number of No Action Processing Options at the Facility or Facilities*
Calcine and Cement Incinerator Ash	371–3701	10
Calcine and Cement Sand, Slag, and Crucible	371–3701	10
Cement Graphite Fines	371–3701	10
Pyro-Oxidize Electrorefining and Molten Salt Extraction Salts	707A, 707D	2,6
Pyro-Oxidize Direct Oxide Reduction Salts	707A, 707D	2,6
Neutralize/Dry Aqueous Combustibles	371–3701	10
Thermal Desorption Organic Combustibles	371–3701	10
Direct Repackage Dry Combustibles	707D, 707E, 707F	6,5,3
Acid Dissolve Plutonium Fluorides	707E, 371–3701	5,10
Neutralize/Dry High-Efficiency Particulate Air Filters	371–3701	10
Neutralize/Dry Ful Flo Filters	371–3701	10
Filter/Dry Sludge	371–3701	10
Neutralize/Dry Glass	371–3701	10
Direct Repackage Graphite	707D, 707E, 707F	6,5,3
Direct Repackage Inorganics	707D, 707E, 707F	6,5,3
Direct Repackage Scrub Alloy	707D, 707E	6,5

Table G-2 shows projected fiscal-year 1998 expenditures at Rocky Flats and Los Alamos National Laboratory for processing technologies independent of any decisions in the present EIS. Of the technologies for which spending is at the $1 million level or above, only salt distillation is among the preferred processing options. None of the technologies for which spending is at or above the $1 million level is among the No Action technologies. Total spending is estimated at about $20 million for the fiscal year. These costs are not included as incremental costs for individual processing options or the management approaches.

Table G–2 Development And Testing Costs for Rocky Flats Processing Technologies

Technology	*Cost ($000)*
Cementation	500
Calcination/Vitrification (except Scrub Alloy)	645
Calcination/Vitrification (Scrub Alloy)	500
Neutralize/Dry	81
Blend Down	250
Acid Dissolve Plutonium Oxide Recovery	200
Catalytic Chemical Oxidation	2,000
Fluidized Bed Incineration	10,000
Sonic Wash	1,000
Mediated Electrochemical Oxidation	2,000
Salt Distillation	2,000
Salt Scrub	500
Water Leach	500

Although development and testing work is ongoing at Rocky Flats and Los Alamos National Laboratory, all processing costs are based on facilities and equipment that are (or will be) up-and-running at production scale for this program, rather than on developmental or bench-scale technologies.

G.1.2 Labor Costs

Labor costs are estimated as a function of the number of hours that operations and support personnel are exposed to radiation (not the amount of radiation they are exposed to). These exposure-hours are then multiplied by a factor that relates allocable labor hours at the site to exposure-hours. The more allocable labor-hours per exposure-hour, the greater the multiplier. The multiplier captures the hours spent by exposed individuals in non-exposed activities (e.g., preparing for operations, down-time during maintenance, and administrative matters), the hours spent by non-exposed individuals in direct support of the operations, and the hours spent by indirect site support personnel. The multiplied figure is the labor cost allocated to the processing option, not DOE's incremental budgetary requirement to conduct the activity. The following steps describe the process used to develop the exposure-hour multipliers (SAIC 1997a):

- Identify total labor costs previously developed at Rocky Flats for work scheduled under certain processing options for fiscal year 1998. Labor cost estimates were available for distillation of salt residue, sonic wash of wet combustibles, repackaging of dry combustibles, and vitrification of ash (incinerator ash, graphite fines, and sand, slag, and crucible).

- Divide total annual labor costs by $100,000 per person-year, resulting in an estimate of the number of full-time equivalent personnel for each processing option per year.

- Divide annual full-time equivalent personnel by annual personnel exposure (calculated separately). The result is the ratio of personnel-hours to exposure-hours for each processing option. For the four specified residue categories and processing options, the resulting ratios were salt distillation, 3.1; sonic wash wet combustibles, 5.8; repackage dry combustibles, 1.1; and vitrify ash, 4.2.

- Apply the calculated exposure-hour multipliers to the other processing options according to the similarity of the options (e.g., all vitrification, blending, and thermal destruction processes are estimated at 4.2, distillation and pyro-oxidation processes are estimated at 3.1). **Tables G–3** and **G–4** show the complete estimates for Rocky Flats and the Savannah River Site, respectively. Costs at the Los Alamos National Laboratory are similar to those at Rocky Flats for the same types of activities.

Table G–3 Exposure-Years, Person-Year Multiplier, Allocable Labor Costs ($M) at Rocky Flats

Material	*Process*	*Exposure-Years*	*Multiplier*	*Labor Costs*
Incinerator Ash	Calcine & Cement	190	5.8	110
Incinerator Ash	Blending	123	4.2	52
Incinerator Ash	Furnace Vitrification	82	4.2	34
Incinerator Ash	Fusion->Purex at F-Canyon	74	5.8	43
Incinerator Ash	Fusion->Purex at H-Canyon	74	5.8	43
Incinerator Ash, Graphite Fines	Pack->Mediated Electrochemical Oxidation at F-Canyon	58	1.1	6
Incinerator Ash, Graphite Fines	Pack->Mediated Electrochemical Oxidation at H-Canyon	58	1.1	6
Sand, Slag & Crucible	Calcine & Cement	27	5.8	16
Sand, Slag & Crucible	Blending	71	4.2	30
Sand, Slag & Crucible	Furnace Vitrification	12	4.2	5
Sand, Slag & Crucible	Pack without Calc->Purex at F-Canyon	9	1.1	1
Sand, Slag & Crucible	Pack without Calc->Purex at H-Canyon	9	1.1	1
Inorganic Ash	Calcine & Cement	11	1.1	1
Inorganic Ash	Blending	28	1.1	3
Inorganic Ash	Furnace Vitrification	5	1.1	1
Graphite Fines	Cement	15	5.8	9
Graphite Fines	Furnace Vitrification	7	4.2	3
Graphite Fines	Blending	9	4.2	4
Pyro Salts (Electrorefining, Molten Salt Extraction)	Pyro-Oxidize	60	3.1	19
Pyro Salts (Electrorefining, Molten Salt Extraction)	Blending	268	4.2	113
Pyro Salts (Electrorefining, Molten Salt Extraction)	Salt Scrub->Purex at F-Canyon	77	3.1	24
Pyro Salts (Electrorefining, Molten Salt Extraction)	Salt Scrub->Purex at H-Canyon	77	3.1	24
Pyro Salts (Electrorefining, Molten Salt Extraction)	Distillation	88	3.1	27
Pyro Salts (Electrorefining, Molten Salt Extraction)	Water Leach	180	5.8	105
Pyro Salts (Electrorefining, Molten Salt Extraction)	Pyrox->LANL distill	84	3.1	26
Pyro Salts (Direct Oxide Reduction)	Pyro-Oxidize	2	3.1	1
Pyro Salts (Direct Oxide Reduction)	Blending	34	4.2	14
Pyro Salts (Direct Oxide Reduction)	Salt Scrub->Purex at F-Canyon	10	3.1	3
Pyro Salts (Direct Oxide Reduction)	Salt Scrub->Purex at H-Canyon	10	3.1	3
Pyro Salts (Direct Oxide Reduction)	Water Leach	25	5.8	15

Material	Process	Exposure-Years	Multiplier	Labor Costs
Pyro Salts (Direct Oxide Reduction)	Pyrox->LANL W Leach	12	3.1	4
Combustibles (Aqueous)	Neutralize/Dry	3	5.8	2
Combustibles (Aqueous)	Blending	1	4.2	1
Combustibles (Aqueous)	Mediated Electrochemical Oxidation	3	5.8	2
Combustibles (Aqueous)	Sonic Washing	4	5.8	2
Combustibles (Aqueous)	Incineration	3	4.2	1
Combustibles (Aqueous)	Catalytic Chemical Oxidation	12	5.8	7
Combustibles (Organic)	Thermal Desorption	6	5.8	3
Combustibles (Organic)	Blending	1	4.2	0
Combustibles (Organic)	Mediated Electrochemical Oxidation	2	5.8	1
Combustibles (Organic)	Sonic Washing	3	5.8	2
Combustibles (Organic)	Incineration	2	4.2	1
Combustibles (Organic)	Catalytic Chemical Oxidation	9	5.8	5
Combustibles (Dry)	Repackage	1	1.1	0
Combustibles (Dry)	Blending	0	4.2	0
Combustibles (Dry)	Mediated Electrochemical Oxidation	2	5.8	1
Combustibles (Dry)	Sonic Washing	2	5.8	1
Combustibles (Dry)	Incineration	2	4.2	1
Combustibles (Dry)	Catalytic Chemical Oxidation	7	5.8	4
Fluorides	Acid Dissolution	22	5.8	13
Fluorides	Blending	56	4.2	23
Fluorides	Pack->Purex at F-Canyon	4	1.1	0
Fluorides	Pack->Purex at H-Canyon	4	1.1	0
Filter Media (HEPA)	Neutralize/Dry	12	5.8	7
Filter Media (HEPA)	Furnace Vitrification	10	4.2	4
Filter Media (HEPA)	Mediated Electrochemical Oxidation	14	5.8	8
Filter Media (HEPA)	Sonic Washing	36	5.8	21
Filter Media (HEPA)	Incineration	26	4.2	11
Filter Media (Ful Flo)	Neutralize/Dry	2	5.8	1
Filter Media (Ful Flo)	Mediated Electrochemical Oxidation	3	5.8	2
Filter Media (Ful Flo)	Sonic Washing	8	5.8	4
Filter Media (Ful Flo)	Incineration	6	4.2	3
Filter Media (All)	Blending	14	4.2	6
Sludge	Filter/Dry	5	5.8	3
Sludge	Blending	3	4.2	1
Sludge	Furnace Vitrification	3	4.2	1
Sludge	Acid Dissolution	24	5.8	14
Glass	Neutralize/Dry	1	5.8	0
Glass	Blending	1	4.2	0
Glass	Furnace Vitrification	0	4.2	0
Glass	Mediated Electrochemical Oxidation	1	5.8	0
Glass	Sonic Washing	1	5.8	1
Graphite	Repackage	9	1.1	1
Graphite	Blending	9	4.2	4
Graphite	Furnace Vitrification	9	4.2	4
Graphite	Mediated Electrochemical Oxidation	14	5.8	8
Graphite	Pack->Mediated Electrochemical Oxidation at F-Canyon	8	1.1	1
Graphite	Pack->Mediated Electrochemical Oxidation at H-Canyon	8	1.1	1

Material	Process	Exposure-Years	Multiplier	Labor Costs
Graphite	Cement	20	5.8	12
Inorganic Residues	Repackage	2	1.1	0
Inorganic Residues	Blending	2	4.2	1
Inorganic Residues	Furnace Vitrification	2	4.2	1
Inorganic Residues	Mediated Electrochemical Oxidation	3	5.8	2
Inorganic Residues	Pack->Mediated Electrochemical Oxidation at F-Canyon	1	1.1	0
Inorganic Residues	Pack->Mediated Electrochemical Oxidation at H-Canyon	1	1.1	0
Scrub Alloy	Repackage	3	1.1	0
Scrub Alloy	Calcine, Vitrify	99	4.2	41
Scrub Alloy	Pack->Purex at F-Canyon	4	1.1	0
Scrub Alloy	Pack->Purex at H-Canyon	4	1.1	0

Table G–4 Exposure-Years, Person-Year Multiplier, Allocable Labor Costs ($M) at Savannah River Site

Material	Process	Exposure Years	Multiplier	Labor Costs
Incinerator Ash	Purex at F-Canyon	223	5.8	129
Incinerator Ash	Purex at H-Canyon	652	5.8	378
Incinerator Ash, Graphite Fines	Mediated Electrochemical Oxidation at F-Canyon	145	5.8	84
Incinerator Ash, Graphite Fines	Mediated Electrochemical Oxidation at H-Canyon	138	5.8	80
Sand, Slag & Crucible	Purex at F-Canyon	33	5.8	19
Sand, Slag & Crucible	Purex at H-Canyon	90	5.8	52
Salt Scrub—Electrorefining & Molten Salt Extraction Salts	Purex at F-Canyon	71	5.8	41
Salt Scrub—Electrorefining & Molten Salt Extraction Salts	Purex at H-Canyon	98	5.8	57
Salt Scrub—Direct Oxide Reduction Salts	Purex at F-Canyon	9	5.8	5
Salt Scrub—Direct Oxide Reduction Salts	Purex at H-Canyon	12	5.8	7
Fluorides	Purex at F-Canyon	29	5.8	17
Fluorides	Purex at H-Canyon	60	5.8	35
Graphite	Mediated Electrochemical Oxidation at F-Canyon	23	5.8	13
Graphite	Mediated Electrochemical Oxidation at H-Canyon	21	5.8	12
Inorganic Residues	Mediated Electrochemical Oxidation at F-Canyon	5	5.8	3
Inorganic Residues	Mediated Electrochemical Oxidation at H-Canyon	5	5.8	3
Scrub Alloy	Purex at F-Canyon	18	5.8	11
Scrub Alloy	Purex at H-Canyon	25	5.8	15

As a practical matter, the only processing options for which the differences in *incremental* labor costs to DOE are likely to be significant are those with much higher exposure-years than the others. For example, Table G-3 shows that duration of exposures at Rocky Flats to calcine and cement incinerator ash is more than double that to furnace vitrify the ash or fuse the ash for Purex processing at the Savannah River Site. This difference is outside the range of uncertainty in the processing technologies and the cost estimating approaches. On the other hand, exposure durations for furnace vitrifying ash and fusing ash differ by about 10 percent. This exposure duration is within the level of uncertainty in the cost estimating procedures.

Also, the labor multipliers for the individual processing options are unlikely to differ to the degree implied by the table once a complete management alternative is costed and scheduled in detail (to which is beyond the scope of an EIS). Although the basis for multipliers as high as 5.8 and as low as 1.1 for individual processing options was established earlier in this section, three important caveats attach to these estimates. First, they are based on a very small sample. Four processes provide four very different multipliers. Increasing the sampling basis would probably narrow the range of multipliers. Second, they are applied to broadly similar processes without any adjustments. Third, regardless of the true (but unknown) multiplier for a single processing option, detailed costing and scheduling for a complete management alternative will force the multipliers towards a much narrower range than 1.1 to 5.8. This narrower range will arise because of the relative fixity of many indirect and support costs; e.g., security and site administration. This is particularly true at the Savannah River Site, where all of the individual options are assigned a 5.8 labor multiplier based on their similarity to high-multiplier processing options at Rocky Flats, rather than direct or indirect costs at the Savannah River Site. Each of these three factors suggests that for decisionmaking, greater weight should be given to exposure-hours as a criterion than to the implied labor costs.

G.1.3 Transuranic-Related Costs

Costs related to packaging, characterizing, and shipping transuranic waste make up the largest cost element in a substantial minority of the processing options. The generation of transuranic waste is a function of both the mass of the residue and the processing technology. Transuranic waste mass is discussed in Chapter 4. Transuranic-related costs are estimated on a unit cost basis, as shown on **Table G–5.** The number of drums of transuranic waste is the sum of the number of drums of primary transuranic wastes (from the residue matrix in a particular processing option) and the number of drums of secondary transuranic waste (from the processing activities). **Table G–6** shows the number of transuranic waste drums and total cost for acquiring the drums, characterizing the waste, shipping the waste to the Waste Isolation Pilot Plant (WIPP), and so forth, in millions of dollars.

Table G–5 Transuranic Waste—Cost Factors

Cost Factor	*Description*	*Value*	*Ref.*
Transuranic Drum		$150/drum	1
Transuranic Pipe	TRUPACT-II pipe (2,800 fissile gram equivalent)	$2,000/drum	4
Interim Storage at Rocky Flats	Transuranic drums prior to the WIPP shipping	$100/drum/yr for 3 years	3,2
Transuranic Shipping	14 drums per TRUPACT-II 3 TRUPACT IIs per carrier 2,800 Fissile gram equivalent per TRUPACT-II		1
Transuranic Shipping Cost	1408 miles round-trip Rocky Flats to WIPP at $4,630 plus $10.87 per mile for each shipment	$687/drum	1
Transuranic Characterization Cost for WIPP	• Headspace gas sampling and analysis ($1,200/drum) • Real-time radiography and radioassay ($2,500/drum) • Data reporting and project management ($1,000/drum) • Resource Conservation and Recovery Act characterization ($1,000/drum) • Visual examination and inner bag gas sampling ($1,000/drum)	$6,700/drum	3
WIPP Disposal Cost		$7,018/drum (average) or $0/drum (incremental up to Rocky Flats baseline at WIPP)	3

References:
1. DOE 1996c.
2. SAIC 1997c.
3. DOE 1996a.
4. DOE 1997a.

Table G–6 Transuranic Waste Drums—Number and Cost ($M)

Material	*Process*	*Rocky Flats*	*Savannah River Site*	*Los Alamos National Laboratory*	*Cost*
Incinerator Ash	Calcine & Cement	1,310			13
Incinerator Ash	Blending	6,430			63
Incinerator Ash	Furnace Vitrification	5,428			53
Incinerator Ash	Fusion->Purex at F-Canyon	593	150		6
Incinerator Ash	Fusion->Purex at H-Canyon	593	150		6
Incinerator Ash, Graphite Fines	Pack->Mediated Electrochemical Oxidation at F-Canyon	634	190		6
Incinerator Ash, Graphite Fines	Pack->Mediated Electrochemical Oxidation at H-Canyon	634	190		6
Sand, Slag & Crucible	Calcine & Cement	286			3
Sand, Slag & Crucible	Blending	1,402			14
Sand, Slag & Crucible	Furnace Vitrification	1,183			12
Sand, Slag & Crucible	Pack without Calc->Purex at F-Canyon	130	12		1
Sand, Slag & Crucible	Pack without Calc->Purex at H-Canyon	130	12		1
Inorganic Ash	Calcine & Cement	130	0		1
Inorganic Ash	Blending	130	0		7
Inorganic Ash	Furnace Vitrification	130	0		6
Graphite Fines	Cement	87			1
Graphite Fines	Furnace Vitrification	350			3
Graphite Fines	Blending	650			4
Pyro Salts (Electrorefining, Molten Salt Extraction)	Pyro-Oxidize	577			5
Pyro Salts (Electrorefining, Molten Salt Extraction)	Blending	12,667			125
Pyro Salts (Electrorefining, Molten Salt Extraction)	Salt Scrub->Purex at F-Canyon	1,386	100		12
Pyro Salts (Electrorefining, Molten Salt Extraction)	Salt Scrub->Purex at H-Canyon	1,386	100		12
Pyro Salts (Electrorefining, Molten Salt Extraction)	Distillation	641			5
Pyro Salts (Electrorefining, Molten Salt Extraction)	Water Leach	13,807			108
Pyro Salts (Electrorefining, Molten Salt Extraction)	Pyrox->LANL distill	577		64	5
Pyro Salts (Direct Oxide Reduction)	Pyro-Oxidize	723			6
Pyro Salts (Direct Oxide Reduction)	Blending	1,673			16
Pyro Salts (Direct Oxide Reduction)	Salt Scrub->Purex at F-Canyon	175	12		1
Pyro Salts (Direct Oxide Reduction)	Salt Scrub->Purex at H-Canyon	175	12		1

Material	Process	Rocky Flats	Savannah River Site	Los Alamos National Laboratory	Cost
Pyro Salts (Direct Oxide Reduction)	Water Leach	1,744			14
Pyro Salts (Direct Oxide Reduction)	Pyrox->LANL W Leach	723		3,858	36
Combustibles (Aqueous)	Neutralize/Dry	54			1
Combustibles (Aqueous)	Blending	128			1
Combustibles (Aqueous)	Mediated Electrochemical Oxidation	710			6
Combustibles (Aqueous)	Sonic Washing	246			2
Combustibles (Aqueous)	Incineration	128			1
Combustibles (Aqueous)	Catalytic Chemical Oxidation	743			6
Combustibles (Organic)	Thermal Desorption	6			0
Combustibles (Organic)	Blending	15			0
Combustibles (Organic)	Mediated Electrochemical Oxidation	83			1
Combustibles (Organic)	Sonic Washing	29			0
Combustibles (Organic)	Incineration	15			0
Combustibles (Organic)	Catalytic Chemical Oxidation	87			1
Combustibles (Dry)	Repackage	32			0
Combustibles (Dry)	Blending	77			1
Combustibles (Dry)	Mediated Electrochemical Oxidation	427			3
Combustibles (Dry)	Sonic Washing	148			1
Combustibles (Dry)	Incineration	76			1
Combustibles (Dry)	Catalytic Chemical Oxidation	447			4
Fluorides	Acid Dissolution	333			3
Fluorides	Blending	3,293			32
Fluorides	Pack->Purex at F-Canyon	28	12		0
Fluorides	Pack->Purex at H-Canyon	28	12		0
Filter Media (HEPA)	Neutralize/Dry	147			1
Filter Media (HEPA)	Furnace Vitrification	702			7
Filter Media (HEPA)	Mediated Electrochemical Oxidation	1,956			15
Filter Media (HEPA)	Sonic Washing	781			8
Filter Media (HEPA)	Incineration	604			6
Filter Media (Ful Flo)	Neutralize/Dry	165			2
Filter Media (Ful Flo)	Mediated Electrochemical Oxidation	880			7
Filter Media (Ful Flo)	Sonic Washing	345			3
Filter Media (Ful Flo)	Incineration	267			3
Filter Media (All)	Blending	270			3
Sludge	Filter/Dry	60			1
Sludge	Blending	218			2
Sludge	Furnace Vitrification	218			2
Sludge	Acid Dissolution	661			5
Glass	Neutralize/Dry	11			0
Glass	Blending	41			0
Glass	Furnace Vitrification	41			0
Glass	Mediated Electrochemical Oxidation	145			1
Glass	Sonic Washing	48			0
Graphite	Repackage	171			2

Material	Process	Rocky Flats	Savannah River Site	Los Alamos National Laboratory	Cost
Graphite	Blending	650			6
Graphite	Furnace Vitrification	650			6
Graphite	Mediated Electrochemical Oxidation	2,056			16
Graphite	Pack->Mediated Electrochemical Oxidation at F-Canyon	75	44		1
Graphite	Pack->Mediated Electrochemical Oxidation at H-Canyon	75	44		1
Graphite	Cement	756			7
Inorganic Residues	Repackage	37			0
Inorganic Residues	Blending	120			1
Inorganic Residues	Furnace Vitrification	119			1
Inorganic Residues	Mediated Electrochemical Oxidation	485			4
Inorganic Residues	Pack->Mediated Electrochemical Oxidation at F-Canyon	14	10		0
Inorganic Residues	Pack->Mediated Electrochemical Oxidation at H-Canyon	14	10		0
Scrub Alloy	Repackage	59			1
Scrub Alloy	Calcine, Vitrify	2,809			28
Scrub Alloy	Pack->Purex at F-Canyon	58	23		1
Scrub Alloy	Pack->Purex at H-Canyon	58	23		1

LANL = Los Alamos National Laboratory HEPA = High-Efficiency Particulate Air

Transuranic waste drums are shipped in TRUPACT-II containers. For a shipment from Rocky Flats to WIPP containing three TRUPACT IIs with 14 drums per TRUPACT II, the total cost of characterization, shipment, and disposal is approximately $17,000 per drum, including a pipe component in each drum and 3 years of onsite storage at Rocky Flats prior to shipping. The major components of this cost are $6,700 per drum for characterization, $2,000 per drum for the pipe component, and about $7,000 per drum for disposal. Other costs relate to the drums, transportation, and so forth.

The incremental cost to the Rocky Flats program is not necessarily the total cost of characterizing, shipping, and disposing of a drum. The key uncertainty is disposal cost. The National Transuranic Waste Management Plan specifies that WIPP will accept 1,949 shipments of transuranic waste from Rocky Flats (DOE 1996d). At three TRUPACT-IIs per shipment with 14 drums per TRUPACT-II, this implies 81,858 drums for the transuranic wastes under this EIS. This is the cost baseline for the EIS. Recent estimates from Rocky Flats translate into about 36,000 drums, or 850 to 1,000 shipments, depending on the TRUPACT-II loading, thus providing considerable spare capacity in case the wastes in this EIS or in other Rocky Flats programs (e.g., plutonium solutions or highly enriched uranium) exceed expectations (DOE 1997b). Although WIPP costs are fixed, the reduction in drums and TRUPACT-II shipments reduces costs.

The incremental cost to Rocky Flats depends on whether the WIPP waste acceptance criteria are modified to allow disposal of 2,800 fissile gram equivalent per TRUPACT II. The current limit is 325 fissile gram equivalent. At 325 fissile gram equivalence, nonseparation processing options generate so many drums that shipping and disposing at WIPP becomes prohibitive. For example, if the blending processing options are selected (except for scrub alloy, where calcination and vitrification is selected) the 325 fissile gram equivalence limit generates approximately 244,000 drums. This is three times the Rocky Flats baseline at WIPP. The

excess over the Rocky Flats baseline is almost eight times the spare capacity of WIPP for the entire DOE complex. The incremental cost to the Rocky Flats program under this scenario would exceed $2.5 billion.[1]

In the cases where the shipments of transuranic waste from Rocky Flats to WIPP are less than or equal to the baseline WIPP plan for Rocky Flats, the incremental disposal cost for the Rocky Flats program is zero. There are two ways for the residues management program to achieve this. The first way is for DOE to select some plutonium separation processing options for the Rocky Flats program. The separated plutonium would become part of a separate program for disposition of fissile materials. The disposition of these separated materials will be decided by DOE at a later date. Costs related to the ultimate disposition of refined plutonium are: (1) the cost to store the plutonium at Rocky Flats, the Savannah River Site, or Los Alamos National Laboratory until the fissile materials disposition program takes responsibility; (2) the costs to ship the plutonium to an appropriate site (assumed to be the Savannah River Site for materials at Rocky Flats); and (3) the minimum costs for fissile materials disposition. Minimum costs for fissile materials disposition are included in the Rocky Flats EIS to ensure that the endpoints among the processing options are consistent. Disposal of the nonfissile separated residues at WIPP generates a small fraction of the total number of drums as in the nonseparation cases.

The second way for DOE to incur zero incremental costs for disposal of Rocky Flats transuranic waste at WIPP is to increase the allowable fissile gram equivalent in each TRUPACT-II. On February 20, 1997, the Nuclear Regulatory Commission approved an increase in the loading of a TRUPACT-II from 325 fissile gram equivalent to 2,800 fissile gram equivalence with the inclusion of a pipe component (NRC 1997). The pipe component ensures the absence of criticality in worst-case accidents. In September 1997, DOE released the WIPP SEIS II, which says that the WIPP Waste Acceptance Criteria will be revised to allow a 2,800 fissile gram equivalence loading. Because Nuclear Regulatory Commission approval and the WIPP SEIS II make the acceptance of 2,800 fissile gram equivalence probable and because this acceptance would precede shipments under the present EIS, it is reasonable to estimate incremental disposal costs at WIPP under the assumption of 2,800 fissile gram equivalent loading. At 2,800 fissile gram equivalence, the worst-case nonseparation processing options take up less than half of the WIPP capacity currently allocated to Rocky Flats. Even assuming transuranic wastes from other programs equal to those in the present program, Rocky Flats would not require all the WIPP capacity currently allocated to it. Thus, DOE can reasonably assume that the incremental cost to dispose of Rocky Flats transuranic waste at WIPP is zero.

G.1.4 Low-Level Waste Costs

Low-level waste costs and cost factors for Rocky Flats and the Los Alamos National Laboratory are estimated on a unit cost basis, as shown on **Table G–7**. The total cost of shipping and disposal is just over $1,050 per drum. Low-level waste volumes are discussed in Chapter 4. Low-level waste characterization, shipping, and disposal costs are significant only for water leach ($34 million for electrorefining and molten salt extraction salts, $4 million for direct oxide reduction salts), high-efficiency particulate air filter media mediated electrochemical oxidation ($5 million), graphite mediated electrochemical oxidation ($5 million), and calcining and cementing incinerator ash ($3 million). As discussed in the following section, no activity at the Savannah River Site generates economically significant quantities of low-level waste.

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[1]*The full cost of $16,000 per drum multiplied by the roughly 160,000 excess drums. This assumes that WIPP could and would be expanded at a marginal cost equal to its average cost.*

Table G–7 Low-Level Waste Costs and Cost Factors (Rocky Flats and the Los Alamos National Laboratory)

Cost Factor	*Description*	*Cost*	*Reference*
Drum		$150/drum	1
Interim Storage at Rocky Flats		$50/year for 1 year	2
Characterization	Real-time radiography and radioassay ($133/drum) NDA ($116/drum) Data reporting, movement and management ($439/drum)	$688/drum	3
Shipping		$30/drum	4
Disposal		$150/drum	5

References:
1. Same drum as for transuranic waste.
2. SAIC estimate.
3. SAIC 1997c.
4. SAIC 1997b.
5. DOE 1996a.

G.1.5 Other Waste, Storage, and Shipping Costs

Processing wastes generated at the Savannah River Site are disposed as low-level waste at the Savannah River Site, intermediate-level waste as saltstone at the Savannah River Site, transuranic waste at WIPP, and high-level waste as vitrified glass logs (Defense Waste Processing Facility logs) at the as-yet unspecified geologic repository. **Table G–8** shows unit costs for these wastes. The combined costs to dispose of low-level and intermediate-level wastes from processes at the Savannah River Site exceed $1 million only for Purex processing of fused incinerator ash ($1.8 million). Total costs related to transuranic waste disposal exceed $1 million only for the ash Purex processing ($1.2 million) and the ash mediated electrochemical oxidation processing ($1.5 million). The costs to manufacture and dispose of Defense Waste Processing Facility logs are significant for the following processes: mediated electrochemical oxidation of incinerator ash and graphite fines ($56 million), mediated electrochemical oxidation of graphite ($16 million), Purex processing of fused incinerator ash ($11 million), and Purex processing of sand, slag, and crucible without inorganics ($8 million). Costs for other residues are insignificant. Costs for disposing of wastes generated at H-Canyon are comparable to the F-Canyon costs. In the case of mediated electrochemical oxidation at the Savannah River Site H-Canyon, decontamination and decommissioning of contaminated equipment at HB-Line would generate 1,800 cubic feet (about 250 drums) of transuranic waste, 2,000 cubic feet of low-level waste, and 20 cubic feet of mixed transuranic waste. Disposal costs for this amount of waste would be about $2 million.

Certain processing options generate residues (e.g., americium) or refined plutonium that must be stored onsite for some period of time before shipment in special canisters (e.g., 3013 containers) and special transports (e.g., Safe, Secure Trailers). Costs for these functions are estimated in Table G–8. Plutonium storage costs are based on a long-run average of $3,500/position/year in the Savannah River Site's modified 235F or FB-Line vaults and $1,000/position/year in the New Plutonium Storage Vault, scheduled to start May 2002. Each 3013 container is assumed to contain 4 kg (8.8 lbs) of refined plutonium. A Safe, Secure Trailer is assumed to carry twenty-four 3013 containers. In practice, the amount of refined plutonium in a 3013 container may be more or less than 4 kg (8.8 lbs) (up to 4.99 kg [11 lbs] in some cases), depending on the batch size of the processes. The cost impact of batches in the 2- to 4-kg (4.4- to 8.8-lb) range is small. The cost impact of increasing the Safe, Secure Trailer loading to the maximum of thirty 3013 containers is also insignificant. At 4 kg (8.8 lbs), the costs of 3013 storage only exceeds $0.5 million for separation of plutonium from one residue category (electrorefining and molten salt extraction salts). In this case, the cost is roughly $3 million for refined plutonium produced at Rocky Flats and half as much for refined plutonium produced at the Savannah River Site or the Los Alamos National Laboratory. The difference in costs is a function of

the shipping requirements from Rocky Flats to the Savannah River Site versus the onsite storage at the Savannah River Site or the Los Alamos National Laboratory. The cost for plutonium disposition is based on DOE's current life-cycle cost estimate of $1.83 billion (undiscounted 1996$) to dispose of 50 metric tons of plutonium.

Table G–8 Other Storage and Shipping Costs

Cost Factor	*Description*	*Cost*	*Reference*
3013 Container Storage	Facility cost	$1,500/container/year for 5 years	2
3013 Container Transfer	To secure storage	$3,000/container	1
Safe, Secure Trailer Shipping	Rocky Flats to Los Alamos National Laboratory	$18;000/Safe Secure Trailer	1
	Rocky Flats to the Savannah River Site	$66,800/Safe Secure Trailer	1
Low-Level Waste at the Savannah River Site	Onsite storage	$2.50/cubic feet	1
Low-Level Waste Saltstone at the Savannah River Site	Onsite storage	$675/cubic yard	1
High-Level Waste Glass	Defense Waste Processing Facility and Repository	$2M/log	1
Fissile Materials Disposition	Can-in-canister immobilization	$36,600/kilogram	3

References:
1. DOE 1996a.
2. Assuming 5 years' storage prior to acceptance by the fissile materials disposition program.
3. DOE 1996b.

G.1.6 Costs Related to Delaying the Closure of Rocky Flats

DOE estimates that if any of the No Action processing options were selected, stabilized residues that could not be shipped to WIPP would have to be stored on-site on an interim basis. The cost to store treated residues at an otherwise shutdown site would be $23 million per year. These residues would be stored in Building 371. Activities under other EISs at Rocky Flats (e.g., plutonium solutions, highly enriched uranium) and at other sites (e.g., WIPP, the Savannah River Site, and Los Alamos National Laboratory) are assumed to not affect the Rocky Flats closure schedule. Similarly, activities in this EIS that would accelerate the removal of particular residues from particular facilities compared to the baseline shutdown years (2001 for Building 776, 2003 for Building 707, and 2006 for Building 371) are excluded (DOE 1997b). The EIS allocates storage costs for 8 years, starting when DOE would otherwise expect to have closed the site (about 2007) and ending when DOE has committed to remove all plutonium residues from the site (no later than 2015). An additional $23 million is added to transport the materials to some other DOE site (excluding WIPP). The total estimated cost of the delay is thus $207 million (undiscounted). This cost is incremental and decisional. It excludes processing for disposal.

G.2 SCHEDULES

The following facilities at Rocky Flats are candidates for use under this EIS: Building 707, Modules A, B, D, E, F, and J; Building 776; and Building 371, Rooms 3701 and 3305. The only facilities that could be on the critical path for Rocky Flats closure are 707A, 707E, and 371-3701.

Table G–9 shows the longest duration processing options individually for the activities at 707A, 707E, and 371-3701 that could affect Rocky Flats closure. For each processing option, the value on Table G–9 is the duration (in years) of the longest phase of the processing options at the specified facility. At Rocky Flats, the duration of the longest phase is based on processing constraints related to plutonium throughput, not residue

mass or nonprocessing steps (e.g., unloading, loading).[2] All phases include estimated down-time for maintenance, facility availability, unscheduled down-time, and so forth. **Table G–10** shows the duration of the longest phase of each processing option (in weeks), regardless of facility.

Table G–9 Long-Duration Activities, Years for Longest Phase at Critical Path Facilities

Processing option	*Building 707A*	*Building 707E*	*Building 371-3701*
Blend electrorefining and molten salt extraction salts	10.4		
Distill electrorefining and molten salt extraction salts	2.4		
Pyro-Oxidize electrorefining and molten salt extraction salts for shipment to the Los Alamos National Laboratory	2.4		2.0
Scrub electrorefining and molten salt extraction salts for shipment to the Savannah River Site	1.4		
Blend incinerator ash and firebrick fines		2.5	
Calcine and vitrify scrub alloy		2.2	
Furnace vitrify incinerator ash and firebrick fines		2.2	
Water Leach electrorefining and molten salt extraction salts			2.3
Calcine and Cement Incinerator Ash			3.0

Table G–10 Duration of Longest Phase at Primary and Secondary Facility, by Material (Same Phase, Potential Critical Path Secondary Facilities Only)

Material	*Process*	*Duration (weeks)*	*Primary Facility*	*Duration (weeks)*	*Secondary Facility*
Incinerator Ash	Calcine & Cement	156	3701	0	0
Incinerator Ash	Blending	130	707	0	0
Incinerator Ash	Furnace Vitrification	114	707	0	0
Incinerator Ash	Fusion->Purex at F-Canyon	77	707	0	0
Incinerator Ash	Fusion->Purex at H-Canyon	77	707	0	0
Incinerator Ash, Graphite Fines	Pack->Mediated Electrochemical Oxidation at F-Canyon	61	707	0	0
Incinerator Ash, Graphite Fines	Pack->Mediated Electrochemical Oxidation at H-Canyon	61	707	0	0
Sand, Slag & Crucible	Calcine & Cement	22	3701	0	0
Sand, Slag & Crucible	Blending	85	707	0	0
Sand, Slag & Crucible	Furnace Vitrification	16	707	0	0
Sand, Slag & Crucible	Pack without Calc->Purex at F-Canyon	17	707	0	0
Sand, Slag & Crucible	Pack without Calc->Purex at H-Canyon	17	707	0	0
Inorganic Ash	Calcine & Cement	9	3701	0	0
Inorganic Ash	Blending	33	707	0	0
Inorganic Ash	Furnace Vitrification	6	707	0	0
Graphite Fines	Cement	13	3701	0	0
Graphite Fines	Furnace Vitrification	9	707	0	0
Graphite Fines	Blending	11	707	0	0
Pyro Salts (Electrorefining, Molten Salt Extraction)	Pyro-Oxidize	68	707A	0	0

[2] *Processing time at Los Alamos National Laboratory is also a function of plutonium throughput. Processing time at the Savannah River Site is a function of total residue mass.*

Material	Process	Duration (weeks)	Primary Facility	Duration (weeks)	Secondary Facility
Pyro Salts (Electrorefining, Molten Salt Extraction)	Blending	539	707A	0	0
Pyro Salts (Electrorefining, Molten Salt Extraction)	Salt Scrub->Purex at F-Canyon	74	707A	0	0
Pyro Salts (Electrorefining, Molten Salt Extraction)	Salt Scrub->Purex at H-Canyon	74	707A	0	0
Pyro Salts (Electrorefining, Molten Salt Extraction)	Distillation	125	707A	0	0
Pyro Salts (Electrorefining, Molten Salt Extraction)	Water Leach	122	3701	0	0
Pyro Salts (Electrorefining, Molten Salt Extraction)	Pyrox->LANL distill	125	707A	104	3701
Pyro Salts (Direct Oxide Reduction)	Pyro-Oxidize	9	707A	0	0
Pyro Salts (Direct Oxide Reduction)	Blending	68	707A	0	0
Pyro Salts (Direct Oxide Reduction)	Salt Scrub->Purex at F-Canyon	9	707A	0	0
Pyro Salts (Direct Oxide Reduction)	Salt Scrub->Purex at H-Canyon	9	707A	0	0
Pyro Salts (Direct Oxide Reduction)	Water Leach	17	3701	0	0
Pyro Salts (Direct Oxide Reduction)	Pyrox->LANL W Leach	18	707A	15	3701
Combustibles (Aqueous)	Neutralize/Dry	8	3701	0	0
Combustibles (Aqueous)	Blending	1	3701	0	0
Combustibles (Aqueous)	Mediated Electrochemical Oxidation	18	3701	0	0
Combustibles (Aqueous)	Sonic Washing	7	3701	0	0
Combustibles (Aqueous)	Incineration	8	776	0	0
Combustibles (Aqueous)	Catalytic Chemical Oxidation	25	3701	0	0
Combustibles (Organic)	Thermal Desorption	25	3701	0	0
Combustibles (Organic)	Blending	1	3701	0	0
Combustibles (Organic)	Mediated Electrochemical Oxidation	12	3701	0	0
Combustibles (Organic)	Sonic Washing	5	3701	0	0
Combustibles (Organic)	Incineration	6	776	0	0
Combustibles (Organic)	Catalytic Chemical Oxidation	17	3701	0	0
Combustibles (Dry)	Repackage	1	707D	0	0
Combustibles (Dry)	Blending	1	3701	0	0
Combustibles (Dry)	Mediated Electrochemical Oxidation	10	3701	0	0
Combustibles (Dry)	Sonic Washing	4	3701	0	0
Combustibles (Dry)	Incineration	5	776	0	0
Combustibles (Dry)	Catalytic Chemical Oxidation	14	3701	0	0
Fluorides	Acid Dissolution	25	3701	0	0
Fluorides	Blending	82	707	0	0
Fluorides	Pack->Purex at F-Canyon	9	371	0	0
Fluorides	Pack->Purex at H-Canyon	9	371	0	0
Filter Media (HEPA)	Neutralize/Dry	32	3701	0	0

Material	Process	Duration (weeks)	Primary Facility	Duration (weeks)	Secondary Facility
Filter Media (HEPA)	Furnace Vitrification	12	707	0	0
Filter Media (HEPA)	Mediated Electrochemical Oxidation	22	3701	0	0
Filter Media (HEPA)	Sonic Washing	54	3701	0	0
Filter Media (HEPA)	Incineration	78	776	0	0
Filter Media (Ful Flo)	Neutralize/Dry	7	3701	0	0
Filter Media (Ful Flo)	Mediated Electrochemical Oxidation	5	3701	0	0
Filter Media (Ful Flo)	Sonic Washing	11	3701	0	0
Filter Media (Ful Flo)	Incineration	16	776	0	0
Filter Media (All)	Blending	16	3701	0	0
Sludge	Filter/Dry	22	3701	0	0
Sludge	Blending	3	707	0	0
Sludge	Furnace Vitrification	3	707	0	0
Sludge	Acid Dissolution	46	3701	0	0
Glass	Neutralize/Dry	2	3701	0	0
Glass	Blending	1	3701	0	0
Glass	Furnace Vitrification	1	707	0	0
Glass	Mediated Electrochemical Oxidation	1	3701	0	0
Glass	Sonic Washing	2	3701	0	0
Graphite	Repackage	12	707	0	0
Graphite	Blending	12	707	0	0
Graphite	Furnace Vitrification	12	707	0	0
Graphite	Mediated Electrochemical Oxidation	24	3701	0	0
Graphite	Pack->Mediated Electrochemical Oxidation at F-Canyon	22	3701	10	707
Graphite	Pack->Mediated Electrochemical Oxidation at H-Canyon	22	3701	10	707
Graphite	Cement	17	3701	0	0
Inorganic Residues	Repackage	2	707	0	0
Inorganic Residues	Blending	2	707	0	0
Inorganic Residues	Furnace Vitrification	2	707	0	0
Inorganic Residues	Mediated Electrochemical Oxidation	3	3701	0	0
Inorganic Residues	Pack->Mediated Electrochemical Oxidation at F-Canyon	3	3701	0	0
Inorganic Residues	Pack->Mediated Electrochemical Oxidation at H-Canyon	3	3701	0	0
Scrub Alloy	Repackage	6	707	0	0
Scrub Alloy	Calcine, Vitrify	115	707	0	0
Scrub Alloy	Pack->Purex at F-Canyon	6	3701	0	0
Scrub Alloy	Pack->Purex at H-Canyon	6	3701	0	0

LANL = Los Alamos National Laboratory HEPA = high-efficiency particulate air

Because all activities have multiple phases (e.g., unload, bag-in, feed preparation, treatment, nondestructive analysis, bag-out, load transport), the duration of a processing option at a facility is longer than that of the single longest phase. Also, because facilities will be down while the transition is made from one residue or processing option to the next, the duration of time associated with a series of processing options is longer than the sum of the individual processing options. Combining these two timing factors, DOE estimates that the actual time required for processing a residue is about 15 percent greater than the time for the single longest phase of the processing option. The 15 percent adder is an approximation for use in estimating the impacts

from a series of processing options where multiple phases, batch sizes, facilities, and transitions are involved. **Table G–11** summarizes these issues for several boundary cases. The same approach was used to generate the durations on the summary table of strategic management alternatives (Table 4–14).

Table G–11 Potential Critical Path Scenarios at Rocky Flats, Years to Complete, Including 15 Percent Time Premium

Scenario	*Case*	*707A*	*707E*	*371-3701*
Blend all, except calcine and vitrify scrub alloy	Blend	13.4	10.5	
Pyro-oxidize and distill salts. No other residues, except residues to be blended affect 707A	Longest at 707A	3.2		
Furnace vitrify ash, sand, slag and crucible, graphite fines, high-efficiency particulate air filters, sludge, glass, graphite, and inorganics; calcine and vitrify scrub alloy. No other residues, except residues to be blended affect 707E	Longest at 707E		6.4	
Pyro-oxidize/water leach salts; acid dissolve plutonium fluorides and sludge; mediated electrochemical oxidation graphite, glass, and inorganics; cement graphite fines; calcine and cement other ash; neutralize/dry filters; pack and ship scrub alloy to the Savannah River Site; catalytic chemical oxidation combustibles	Longest at 3701			11.9
Pyro-oxidize/water leach salts; package and ship plutonium fluorides, and scrub alloy to the Savannah River Site; acid dissolve sludge; mediated electrochemical oxidation graphite, glass, and inorganics, sonic wash inorganics; catalytic chemical oxidation combustibles. No other residues affect 3701.	Longest at 3701 excluding No Action			7.5
Pyro-oxidize salts; neutralize/dry glass and filters; filter/dry sludge; direct repackage combustibles, scrub alloy, inorganics, and graphite; acid dissolve plutonium fluorides; cement graphite fines; calcine and cement other ash	No Action[a]	1.7	0.4	7.1
Scrub salts for shipment to the Savannah River Site; package ash, (excluding inorganics), graphite, inorganics, plutonium fluorides, and scrub alloy for shipment to the Savannah River Site; cement graphite; blend combustibles and filters; vitrify glass, inorganic ash, and sludge.	Shortest integrated	1.8	2.5[b]	0.6

[a] Direct activities only. Onsite storage after processing is not included.
[b] To comply with processing schedules at the Savannah River Site, combustibles processing at 707E would be interrupted for plutonium fluorides packaging. Without this interruption, the processing duration at Rocky Flats would be closer to 2.2 years.

The following inferences from Table G–11 are important:

- The time required for blending is longer than that for any other approach to managing the same material. The blend-all scenario (except for scrub alloy, which is calcined and vitrified) requires more than 13 years at 707A and more than 10 years at 707E.

- Excluding blending, the longest duration scenarios at Buildings 707A and 707E are 3.2 years and 6.4 years, respectively. Under these circumstances, the 707 area can be decommissioned (excluding other programs) within the critical path for Rocky Flats closure.

- Excluding blending, the longest duration scenario at 371-3701 is about 12 years. The principal processing options in this scenario (including the 15 percent time adder described above) are water leaching of all salts (2.7 years) and calcining and cementing of all ash residues (3.8 years). If the blending processing options and the No Action processing options at Building 371-3701 are eliminated, the maximum duration scenario is about 7.5 years.

- The No Action Alternative requires more than 7 years at Building 371-3701 and relatively small amounts of time at other critical path facilities. Interim on-site storage is not included.

- The shortest integrated schedule requires about 2.5 years at Rocky Flats. This schedule features short-duration activities, the use of multiple facilities, the use of facilities off the critical path, and the use of other sites. For example, if incinerator ash, graphite fines, sand, slag and crucible, graphite, and inorganics are packaged and shipped to the Savannah River Site, the treatment and packaging take place in 707D and 707E and the shipping takes place from Building 371, but not from room 3701. None of these facilities, including the shipping facilities at 371, are on the critical path. Thermal destruction of combustibles and filters is not part of the shortest integrated schedule due to siting and permitting issues. Cementation of graphite residues is not part of the shortest integrated schedule due to technology development scheduling issues. These scheduling constraints are discussed in Section G.3.2.

- The shortest integrated schedule that excludes mediated electrochemical oxidation at the Savannah River Site (not shown on Table G–11) requires about 3 years. It substitutes ash fusion incinerator ash and shipment to the Savannah River Site for Purex processing, furnace vitrification of graphite fines, and furnace vitrification of inorganics. It is also less expensive than using mediated electrochemical oxidation at the Savannah River Site.

Variations on the critical path scenarios on Table G–11 can be generated by substituting individual processing options from Table G–10 (including the 15 percent time premium). For example, the last line on Table G–11 shows that the shortest integrated schedule requires 1.8 years at 707A. This scenario includes salt scrub at 707A for shipment to the Savannah River Site. The duration of this activity is 74 weeks, plus 15 percent. Substituting pyro-oxidation and distillation of electrorefining and molten salt extraction salts (125 weeks + 15 percent) generates 3.2 years of additional processing time at 707A. This is the longest duration scenario at 707A, as shown on the second line of Table G–11.

The No Action Alternative includes costs for interim on-site storage from the date the site is assumed to otherwise close (2007) to the date when DOE has promised to remove all plutonium residues (2015). This eight-year period generates $184 million in incremental costs. An additional $23 million is added for offsite shipping. This incremental cost of $207 million excludes processing for disposal.

G.3 Major Cost Risks

Cost and schedule risks are summarized in the following subsections.

G.3.1 Technical Risk

Table G–12 shows the processing options for the major residue categories according to their technical risk. The low-risk processing options are nearly free of technical risk. The moderate-risk processing options are significantly riskier than the low-risk processing options, though still within DOE bounds. The high-risk processing options are at the boundary of technical acceptability and carry very substantial costs if they are implemented and subsequently fail. Technology risks discussed in this section should be considered in the light of schedule risks summarized in Section G.3.2 and site capabilities summarized in Section G.3.3.

Table G–12 Technical Risks for Major Categories of Processing Options

Residue	*Low Risk*	*Moderate Risk*	*High Risk*
Ash	Blending, Purex at the Savannah River Site	Vitrification, Mediated Electrochemical Oxidation at the Savannah River Site, Calcine and Cement, Cement	
Salt	Blending, Purex at the Savannah River Site	Pyro-oxidize (electrorefining salts), Water Leach, Salt Scrub in preparation for Purex at the Savannah River Site	Pyro-oxidize (molten salt extraction and direct oxide reduction salts), distillation (electrorefining, molten salt extraction salts)
Combustibles	Blending, Neutralize/Dry, Repackage, Incinerate	Mediated Electrochemical Oxidation, Sonic Wash, Thermal Desorption, Catalytic Chemical Oxidation	
Fluoride	Blending, Purex at the Savannah River Site	Acid Dissolution	
Filter Media	Blending, Neutralize/Dry, Incinerate	Vitrification, Mediated Electrochemical Oxidation, Sonic Wash	
Sludge	Blending, Filter/Dry	Vitrification, Sonic Wash, Acid Dissolution	
Glass	Blending, Neutralize/Dry	Vitrification, Mediated Electrochemical Oxidation	
Graphite	Blending, Repackage	Vitrification, Mediated Electrochemical Oxidation at the Savannah River Site, Cement	
Inorganics	Blending, Repackage	Vitrification, Mediated Electrochemical Oxidation, Mediated Electrochemical Oxidation at the Savannah River Site, Sonic Wash	
Scrub Alloy	Purex at the Savannah River Site, Repackage	Calcine and Vitrify	

Among the preferred processing options, distillation of molten salt extraction salts carries the highest technical and economic risk. Distillation produces americium-rich transuranic oxides. These oxides would likely be designated for shipment to the Savannah River Site under future programs for the disposition of fissile materials. Standard 3013 containers and existing facilities at the Savannah River Site cannot adequately shield the gamma radiation from the americium. The result could be a requirement to construct costly remote-handling and storage facilities. Alternatively, the salts could be scrubbed at Rocky Flats for Purex processing at the Savannah River Site. Although salt scrub is a low-risk process in general, scrubbing of less pure salts or salts that have absorbed moisture during storage creates moderate to high technical risks. A small but non-trivial portion of the salts at Rocky Flats is likely to be in these categories. Development work on scrubbing off-specification salts would be required prior to or in parallel with the scrubbing operations. Finally, if the salts are pyro-oxidized in preparation for distillation, the option to scrub for Purex processing is foreclosed. Thus, short-term stabilization (i.e., pyro-oxidation) may limit the processing path to distillation or blend down. Blend down is technically proven, but would add more than $150 million to total costs and extend processing operations at Rocky Flats to around 2010.

Of the other processing options, pyro-oxidation of direct oxide reduction salts and distillation of electrorefining salts also carry high risks. Pyro-oxidation of direct oxide reduction salts as a precursor to distillation (not pyro-oxidation as a stand-alone process) is unproven using the existing technologies at Rocky Flats. Salt distillation (for all three salt categories) is unproven at the scale proposed for the residues in this program. Ash vitrification is among the more uncertain of the moderate risk options, but is not a high risk option. The proposed approach to ash vitrification includes a calcination stage ahead of the vitrification stage. This increases the cost of vitrification, but reduces the risk. Optimization studies are underway to determine if

calcination can be bypassed without affecting the acceptability of the waste form. With the possible exception of the americium issue related to distillation of molten salt extraction salts, the other relatively high technical risk processes are considered within acceptable bounds by DOE.

G.3.2 Schedule Risk

Certain processing technologies have low or moderate technical risk but significant schedule risk. Schedule risks of significance are outlined below. For each risk category, the estimated time beyond the Record of Decision is provided. No schedule delays due to general facilities or equipment upgrades are envisioned.

- **Cementation**—Rocky Flats would have to install or remodel gloveboxes to provide additional area for the curing stage. The time required to be fully operational is estimated at one year.

- **Catalytic Chemical Oxidation**—Catalytic chemical oxidation has been demonstrated commercially but not as a production process at the scale or characteristics required for the plutonium residues. The time required to demonstrate a consistent process and develop procedures and supporting analyses is estimated at four years.

- **Thermal Destruction**—Thermal destruction (i.e., fluidized bed incineration), while demonstrated in previous Rocky Flats operations and at other sites, has not been demonstrated under current Clean Air Act standards. Additionally, the designated building (Building 776) has significant programmatic risk due to its condition and schedule for decommissioning. Because of the requirement to identify and permit a new or restarted facility at Rocky Flats and develop procedures and supporting analyses, the process would not be available for an estimated four years.

- **Sonic Wash**—Sonic washing has been demonstrated with residue-type material at a bench scale. The time required to demonstrate a consistent full-scale process and develop the procedures and supporting analyses is estimated at two years.

- **Acid Dissolution**—Acid dissolution for processing plutonium fluorides or sludges is a proven process, but the capabilities for it are not currently available at Rocky Flats. Also, this process would take place in the same area of Building 371 as the neutralize/dry process for combustibles (including combustibles below Safeguard Termination Limits). Because the acid dissolution of fluorides or sludges would be required to follow all combustibles processing, it might not be able to start for four years.

- **Mediated Electrochemical Oxidation (Rocky Flats)**—The mediated electrochemical oxidation technology has been demonstrated for radioactive materials, although not in DOE production operations. Equipment would have to be installed in Building 371 adjacent to the liquid treatment facilities. Requirements for these treatment facilities by higher priority residues (e.g., combustibles) would delay the start of operations by at least four years.

- **Mediated Electrochemical Oxidation (Savannah River Site)**—Installation of the new dissolvers, start-up tests, etc. are estimated to require three years from the Record of Decision at the Savannah River Site. In the case of H-Canyon, decontamination and decommissioning of existing equipment and facilities prior to installation of the mediated electrochemical oxidation equipment is estimated to require an additional two years.

- **Salt Distillation**—Salt distillation has been demonstrated at a pilot scale at the Los Alamos National Laboratory with residue materials. Optimization studies are ongoing and final designs are not yet available. Capabilities for production-scale distillation could be available in two to four years at the Los Alamos National Laboratory and two years at Rocky Flats.

- **Water Leach (Rocky Flats)**—Water leaching is a well-demonstrated technology for dissolving chloride salts. The equipment required for water leaching would have to be installed in Building 371 adjacent to the liquid treatment facilities. Requirements for these treatment facilities by higher priority residues (e.g., combustibles) would delay the start of operations by at least four years.

- **Water Leach (Los Alamos National Laboratory)**—The capability for water leaching is installed and operational at Los Alamos National Laboratory on a limited scale. Additional capabilities are available using a similar aqueous dissolution process. If any other capabilities were necessary they could be available in two to four years.

Ideally, all processes requiring liquid processing at Rocky Flats would follow the processing of combustibles (including combustibles below Safeguard Termination Limits) in Building 371. If the selected approach for managing plutonium fluoride residues is packaging at Rocky Flats for shipment to the Savannah River Site, fluoride packaging would follow the processing of wet combustibles, but precede the processing of dry combustibles. This insertion of fluoride packaging into the Building 371 time-line adds three to six months to the total length of operations at Rocky Flats compared to processing all the combustibles followed by fluoride packaging. The interruption is necessary, however, to coordinate the processing windows of Rocky Flats and the Savannah River Site. Other processes that use the liquid processing capabilities of Building 371 would follow both the fluoride and the combustibles processes. Certain sequences could thus add time to the total processing duration at Rocky Flats. Depending on the selected processing options, other integration issues and shipment constraints could be expected to result in additional extensions to the total processing duration.

G.3.3 Availability and Capability of DOE Facilities

This section summarizes the availability and capability of Rocky Flats, the Savannah River Site, and Los Alamos National Laboratory to process the plutonium residues. These capabilities should be considered in the light of the technical risk issues discussed in Section G.3.1 and the schedule risk issues discussed in Section G.3.2.

G.3.3.1 Availability and Capability of Rocky Flats

Different materials processes at Rocky Flats require different facilities and technologies. To vitrify incinerator ash, graphite fines, and inorganic ash will require Rocky Flats to buy and install furnaces in new or modified gloveboxes. Ash vitrification has never been performed at Rocky Flats. If technical issues related to vitrification cannot be resolved, it is likely that calcination/cementation will be selected. Purex processing of ash at the Savannah River Site is problematic because of Resource Conservation and Recovery Act permitting issues (Section G.3.4). Blending ash generates an extremely large number of transuranic waste drums and carries very high costs. Calcination and cementation of incinerator ash has been previously conducted at Rocky Flats.

Distillation of electrorefining salts and molten salt extraction salts has never been performed at Rocky Flats. All new equipment will need to be purchased and installed, and start-up issues will need to be resolved before processing. As discussed in Sections G.3.1 and G.3.3.2, the only non-Purex option remaining if distillation is not available is blending, which creates very large waste quantities and incurs very high costs.

Pyro-oxidation at Rocky Flats is the front-end process for the preferred processing options for electrorefining salts, molten salt extraction salts, and direct oxide reduction salts. All new equipment will need to be purchased and installed, and start-up issues will need to be resolved before processing. Since pyro-oxidation has been identified as a stabilization technology to be used prior to storage or shipment, it is possible that distillation (the end process for the preferred processing options for electrorefining salts and molten salt

extraction salts) could still be performed without pyro-oxidation with little impact on the final product. However, since pyro-oxidation is required for transportation, non-pyro-oxidized direct oxide reduction salts could not be sent to Los Alamos National Laboratory for water leaching. The next alternative for front-end processing at Rocky Flats would likely be salt scrub, which generates scrub alloy that can be Purex-processed at the Savannah River Site. The salt scrub process is, however, in question for some portion of the salts that have oxidized or absorbed moisture over time. The only remaining option for pyro-oxidized direct oxide reduction salts is blending, which creates large quantities of transuranic waste. Pyro-oxidized salts cannot be Purex-processed.

With respect to aqueous combustibles and glass residues, Rocky Flats has both the availability and the capability in place to neutralize/dry these residues, with no increase in capital expenditures. With respect to dry combustibles, graphite, and inorganics, Rocky Flats has both the availability and the capability in place to repackage these residues, with no increase in capital expenditures. With respect to organic-contaminated combustibles, Rocky Flats has never performed the preferred thermal desorption/steam passivation process. If thermal desorption/steam passivation is not feasible, Rocky Flats could select from several other options, including mediated electrochemical oxidation, sonic wash, catalytic chemical oxidation, and blending. Fluidized bed incineration is the least likely choice due to siting and permitting issues.

G.3.3.2 Availability and Capability of the Savannah River Site

Purex processing at the Savannah River Site's F-Canyon is part of the preferred alternative for sand, slag, and crucible; plutonium fluorides; and scrub alloy. If F-Canyon is shut down before it can complete processing of all scheduled shipments from Rocky Flats, or if residues scheduled for some other form of management (especially salts and ash) ultimately cannot be processed as planned, the costs for management outside of F-Canyon Purex could be extremely high. The Savannah River Site's H-Canyon is technically suited to Purex processing of the Rocky Flats residues, but requires more time and has higher costs.

Similarly, although F-Canyon and H-Canyon could also complete the mediated electrochemical oxidation process on suitable residues, and in about the same processing time, mediated electrochemical oxidation at H-Canyon would require an up-front expenditure of $20 million for decontamination and decommissioning of contaminated equipment. The decontamination and decommissioning process at H-Canyon would take 2 years, generate 60 rem, and generate additional transuranic and low-level waste (WSRC 1997). Installation of two Silver II electrochemical dissolvers (at either F-Canyon or H-Canyon) for mediated electrochemical oxidation would require 3 years.

While the Savannah River Site could Purex-process all of the Rocky Flats salts if they were scrubbed (subject to the concern over purity and moisture content), it could not Purex-process any of them if they were pyro-oxidized. The pyro-oxidation issue is particularly acute for molten salt extraction salts (because of the americium). In this case, it is conceivable that if post-oxidation distillation or water leaching fails, the only remaining non-Purex processing option would be blending.

G.3.3.3 Availability and Capability of the Los Alamos National Laboratory Facilities

The only preferred processing option using facilities at Los Alamos National Laboratory is water leach of direct oxide reduction salts. Water leach has been tested at the bench scale at Los Alamos National Laboratory and equipment is already available to perform the processing. Start-up issues still need to be resolved before full-scale processing can begin. Although acid dissolution has been suggested as an alternative, it has not been evaluated in this EIS due to current processing constraints at Los Alamos. Therefore, if water leach is not available for direct oxide reduction salts, the only other non-Purex alternative is blending, which creates large quantities of transuranic waste and has very high costs.

G.3.4 Resource Conservation and Recovery Act Designation

Some materials, such as ash, have Resource Conservation and Recovery Act designation. Processing of Resource Conservation and Recovery Act materials requires treatment permits. Unless the Savannah River Site gets a Resource Conservation and Recovery Act treatment, storage, and disposal permit, it cannot accept ash for temporary storage, treatment, or final disposition. WIPP is qualified to handle the Resource Conservation and Recovery Act wastes generated from the plutonium processing activities at Rocky Flats, but the proposed high-level geologic repository is not planned as a Resource Conservation and Recovery Act-qualified site. This raises certain issues regarding the ability of the Savannah River Site to accept certain residues and the disposition of Resource Conservation and Recovery Act wastes in high-level waste generated by the Savannah River Site's Defense Waste Processing Facility. No cost or schedule impacts for this issue have been determined.

G.4 Estimated Absolute and Incremental Costs for Each Processing Option

Table G–13 and **Table G–14** show the undiscounted absolute and incremental costs, respectively, in 1997 dollars for each processing option. Absolute costs at each site are the sum of direct and indirect labor (including site overheads) for processing and waste management; high-level waste, low-level waste, and transuranic waste packaging, shipping, and disposal; Safe, Secure Trailer shipping (if required), and 3013 packaging and on-site storage (if required). Costs for itemized equipment (in the options that include pyro-oxidation, distillation, or mediated electrochemical oxidation) must be added separately, depending on how many options that could share a piece of itemized equipment are included in a particular management approach. These itemized equipment costs are listed in the second paragraph of Section G.1.1. Costs for common facilities and equipment and research and development are excluded. Costs for disposal at WIPP are estimated at zero since they are already part of the Rocky Flats baseline. Costs for disposal of vitrified high-level waste from the Savannah River Site are included. Values in the column entitled "MD" (material disposition) represent costs to dispose of separated fissile materials. No particular site is associated with these costs. Processing options under the No Action Alternative do not include a charge for delaying the closure of Rocky Flats.

Incremental costs are determined by subtracting the absolute costs for individual processing options from the absolute cost for the No Action Alternative processing option. (Costs for itemized pieces of equipment, summarized in the second paragraph of Section G.1.1, must be added separately.) The cost of interim onsite storage is excluded.

Absolute and incremental costs should be viewed in the light of the discussions on common facilities costs in Section G.1.1 and labor multipliers in Section G.1.2.

Table G–13 Absolute Costs, Millions of Undiscounted 1997 Dollars[a]

Material	*Process*	*Rocky Flats*	*Savannah River Site*	*LANL*	*MD*	*Total*
Incinerator Ash	Calcine & Cement	126	0	0	0	126
Incinerator Ash	Blending	116	0	0	0	116
Incinerator Ash	Furnace Vitrification	89	0	0	0	89
Incinerator Ash	Fusion->Purex at F-Canyon	21	145	0	33	199
Incinerator Ash	Fusion->Purex at H-Canyon	21	389	0	33	444
Incinerator Ash, Graphite Fines	Pack->Mediated Electrochemical Oxidation at F-Canyon	19	144	0	36	199
Incinerator Ash, Graphite Fines	Pack->Mediated Electrochemical Oxidation at H-Canyon	19	140	0	36	195
Sand, Slag & Crucible	Calcine & Cement	19	0	0	0	19

Material	Process	Rocky Flats	Savannah River Site	LANL	MD	Total
Scrub Alloy	Repackage	1	0	0	0	1
Scrub Alloy	Calcine, Vitrify	69	0	0	0	69
Scrub Alloy	Pack->Purex at F-Canyon	1	12	0	7	21
Scrub Alloy	Pack->Purex at H-Canyon	1	16	0	7	25

LANL = Los Alamos National Laboratory MD = costs to dispose of separated fissile materials
HEPA = high efficiency particulate air
[a] See Sections G.1.1 and G.1.2 for important issues regarding interpretation of the costs.

Table G–14 Incremental Costs, Millions of Undiscounted 1997 Dollars[a]

Material	Process	No Action Cost	Incremental Cost
Incinerator Ash	Calcine & Cement	126	
Incinerator Ash	Blending		-10
Incinerator Ash	Furnace Vitrification		-37
Incinerator Ash	Fusion->Purex at F-Canyon		73
Incinerator Ash	Fusion->Purex at H-Canyon		318
Incinerator Ash, Graphite Fines	Pack->Mediated Electrochemical Oxidation at F-Canyon		73
Incinerator Ash, Graphite Fines	Pack->Mediated Electrochemical Oxidation at H-Canyon		68
Sand, Slag & Crucible	Calcine & Cement	19	
Sand, Slag & Crucible	Blending		25
Sand, Slag & Crucible	Furnace Vitrification		-2
Sand, Slag & Crucible	Pack without Calc->Purex at F-Canyon		17
Sand, Slag & Crucible	Pack without Calc->Purex at H-Canyon		48
Inorganic Ash	Calcine & Cement	8	
Inorganic Ash	Blending		11
Inorganic Ash	Furnace Vitrification		0
Graphite Fines	Cement	10	
Graphite Fines	Furnace Vitrification		-4
Graphite Fines	Blending		-2
Pyro Salts (Electrorefining, Molten Salt Extraction)	Pyro-Oxidize	24	
Pyro Salts (Electrorefining, Molten Salt Extraction)	Blending		214
Pyro Salts (Electrorefining, Molten Salt Extraction)	Salt Scrub->Purex at F-Canyon		59
Pyro Salts (Electrorefining, Molten Salt Extraction)	Salt Scrub->Purex at H-Canyon		107
Pyro Salts (Electrorefining, Molten Salt Extraction)	Distillation		45
Pyro Salts (Electrorefining, Molten Salt Extraction)	Water Leach		258
Pyro Salts (Electrorefining, Molten Salt Extraction)	Pyrox->LANL distill		56
Pyro Salts (Direct Oxide Reduction)	Pyro-Oxidize	8	
Pyro Salts (Direct Oxide Reduction)	Blending		23
Pyro Salts (Direct Oxide Reduction)	Salt Scrub->Purex at F-Canyon		6

Material	Process	No Action Cost	Incremental Cost
Pyro Salts (Direct Oxide Reduction)	Salt Scrub->Purex at H-Canyon		9
Pyro Salts (Direct Oxide Reduction)	Water Leach		29
Pyro Salts (Direct Oxide Reduction)	Pyrox->LANL W Leach		20
Combustibles (Aqueous)	Neutralize/Dry	2	
Combustibles (Aqueous)	Blending		0
Combustibles (Aqueous)	Mediated Electrochemical Oxidation		7
Combustibles (Aqueous)	Sonic Washing		2
Combustibles (Aqueous)	Incineration		0
Combustibles (Aqueous)	Catalytic Chemical Oxidation		13
Combustibles (Organic)	Thermal Desorption	3	
Combustibles (Organic)	Blending		-3
Combustibles (Organic)	Mediated Electrochemical Oxidation		-1
Combustibles (Organic)	Sonic Washing		-2
Combustibles (Organic)	Incineration		-2
Combustibles (Organic)	Catalytic Chemical Oxidation		3
Combustibles (Dry)	Repackage	0	
Combustibles (Dry)	Blending		1
Combustibles (Dry)	Mediated Electrochemical Oxidation		5
Combustibles (Dry)	Sonic Washing		2
Combustibles (Dry)	Incineration		1
Combustibles (Dry)	Catalytic Chemical Oxidation		8
Fluorides	Acid Dissolution	22	
Fluorides	Blending		34
Fluorides	Pack->Purex at F-Canyon		2
Fluorides	Pack->Purex at H-Canyon		20
Filter Media (HEPA)	Neutralize/Dry	9	
Filter Media (HEPA)	Furnace Vitrification		3
Filter Media (HEPA)	Mediated Electrochemical Oxidation		23
Filter Media (HEPA)	Sonic Washing		20
Filter Media (HEPA)	Incineration		9
Filter Media (Ful Flo)	Neutralize/Dry	3	
Filter Media (Ful Flo)	Mediated Electrochemical Oxidation		8
Filter Media (Ful Flo)	Sonic Washing		5
Filter Media (Ful Flo)	Incineration		2
Filter Media (All)	Blending		-3
Sludge	Filter/Dry	3	
Sludge	Blending		0
Sludge	Furnace Vitrification		0
Sludge	Acid Dissolution		18
Glass	Neutralize/Dry	0	
Glass	Blending		0
Glass	Furnace Vitrification		0
Glass	Mediated Electrochemical Oxidation		2
Glass	Sonic Washing		1
Graphite	Repackage	3	
Graphite	Blending		7

Material	Process	No Action Cost	Incremental Cost
Graphite	Furnace Vitrification		7
Graphite	Mediated Electrochemical Oxidation		30
Graphite	Pack->Mediated Electrochemical Oxidation at F-Canyon		33
Graphite	Pack->Mediated Electrochemical Oxidation at H-Canyon		32
Graphite	Cement		16
Inorganic Residues	Repackage	1	
Inorganic Residues	Blending		1
Inorganic Residues	Furnace Vitrification		1
Inorganic Residues	Mediated Electrochemical Oxidation		7
Inorganic Residues	Pack->Mediated Electrochemical Oxidation at F-Canyon		7
Inorganic Residues	Pack->Mediated Electrochemical Oxidation at H-Canyon		7
Scrub Alloy	Repackage	1	
Scrub Alloy	Calcine, Vitrify		68
Scrub Alloy	Pack->Purex at F-Canyon		20
Scrub Alloy	Pack->Purex at H-Canyon		24

LANL = Los Alamos National Laboratory HEPA = high efficiency particulate air
[a] See Sections G.1.1 and G.1.2 for important issues regarding interpretation of the costs.

In some cases, an apparent or real discrepancy appears between the costs for processing options under the No Action Alternative and under other management approaches. These are as follows:

- The processing option to ship incinerator ash and graphite fines to the Savannah River Site is equivalent in mass to the sum of the No Action processing options for incinerator ash without graphite fines (calcine and cement) and graphite fines (cement). For incremental cost purposes, the shipment processing option is compared to the cost for the sum of the two No Action processing options.

- The costs for salt pyro-oxidation as a No Action processing option exceed the costs for the pyro-oxidation phase of the distillation processing options. The reason is that pyro-oxidation as a No Action processing option requires different and more expensive processing for stabilization than for production of an input to the distillation or water leaching processing options.

- The processing option to ship scrub alloy to the Savannah River Site includes the packaging of 452 kg (996 lbs) of residue mass and the shipping of 700 kg (1,543 lbs) of residue mass. Approximately 248 kg (547 lbs) of residue mass are stored in containers that are ready to ship. Processing options at Rocky Flats and at the Savannah River Site cover the full 700 kg (1,543 lbs) of residue mass. The cost difference between packaging 452 kg (996 lbs) for shipment and packaging 700 kg (1,543 lbs) (if it were required) is insignificant.

G.5 References

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DOE/EIS - 0277D
November 1997

Draft Environmental Impact Statement

on Management of Certain Plutonium Residues and Scrub Alloy Stored at the Rocky Flats Environmental Technology Site

Summary

U.S. Department of Energy
Assistant Secretary for
Environmental Management
Washington, DC 20585

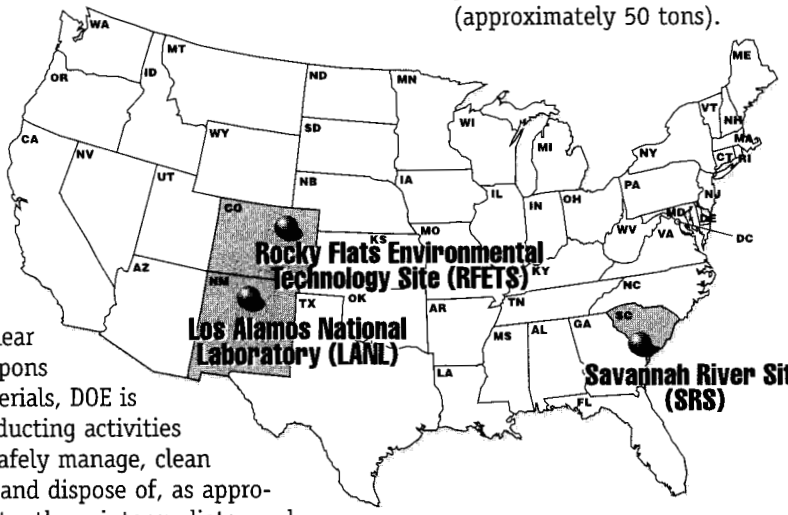
DRAFT ENVIRONMENTAL IMPACT STATEMENT ON MANAGEMENT OF CERTAIN PLUTONIUM RESIDUES AND SCRUB ALLOY STORED AT THE ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

The National Environmental Policy Act of 1969 (NEPA) requires the preparation of an Environmental Impact Statement (EIS) for major Federal actions that may significantly affect the quality of the environment. An Environmental Impact Statement looks at both the shortterm and long term effects of the proposed actions.

The Department of Energy has prepared a *Draft Environmental Impact Statement on Management of Certain Plutonium Residues and Scrub Alloy Stored at the Rocky Flats Environmental Technology Site*. This document analyzes alternatives for processing these plutonium bearing materials to address health and safety issues raised by the Defense Nuclear Facilities Safety Board, and to prepare the materials for disposal or other disposition. Some alternatives would involve transporting some of the plutonium residues and scrub alloy to the Savannah River Site in South Carolina and/or to the Los Alamos National Laboratory in New Mexico during the 1998-2004 timeframe.

Background

During the Cold War era, the Department of Energy (DOE) and its predecessor agencies produced materials for use in nuclear weapons. During these manufacturing and production activities, several intermediate products were generated, some of which remain in storage at various DOE sites. Now that the Cold War is over and the United States has ceased production of nuclear weapons materials, DOE is conducting activities to safely manage, clean up, and dispose of, as appropriate, these intermediate products and byproducts.



Sites where certain Rocky Flats plutonium residues and scrub alloy could be processed

Among the intermediate products requiring proper management and preparation for disposal or other disposition are the plutonium residues and scrub alloy currently stored at the Rocky Flats Environmental Technology Site (Rocky Flats), located near Golden, Colorado. Approximately 42,200 kilograms (kg) of plutonium residues (containing 2,600 kg of plutonium) and 700 kg of scrub alloy (containing 200 kg of plutonium) require processing prior to disposal as transuranic waste at the Waste Isolation Pilot Plant, located in Carlsbad, New Mexico, or other disposition to address health and safety issues raised by the Defense Nuclear Facilities Safety Board in their Recommendation 94-1. This is equivalent to about 95,000 pounds of plutonium residues and scrub alloy (approximately 50 tons).

Although these stored materials are not directly usable in nuclear weapons, they remain a potential target for theft as a source of plutonium for use in nuclear weapons or other devices. Processing is also required to convert these materials into a form that is suitable for disposal or other disposition.

Management Alternatives Analyzed in the Draft EIS

The processing alternatives evaluated for the various types of plutonium residues and the scrub alloy include:

- **No action**—*continue current stabilization activities at Rocky Flats for continued onsite storage. However, the residues and scrub alloy may be left in a form that is unsuitable for disposal or other disposition.*
- **Processing without separating the plutonium from the residues and scrub alloy**—*includes immobilization and dilution technologies, with all processing taking place at Rocky Flats. The materials would then be suitable for disposal at the Waste Isolation Pilot Plant.*
- **Processing with separation of the plutonium from the residues and scrub alloy**—*includes various plutonium separation techniques. Onsite processing is evaluated at Rocky Flats for most of the residues and scrub alloy; offsite processing is evaluated at the Savannah River Site and at Los Alamos National Laboratory for certain types of*

(Alternatives continued on page 2)

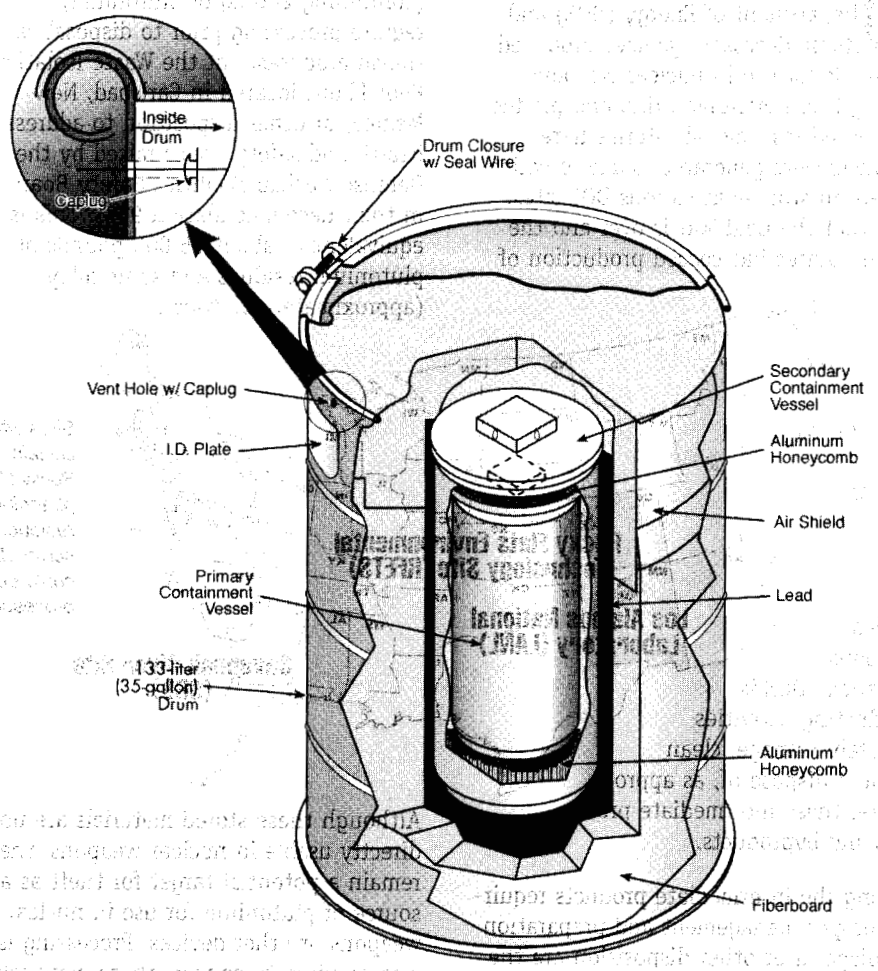
Alternatives
(continued from page 1)

residues and the scrub alloy. Any plutonium separated from residues and scrub alloy would be stored pending disposition in compliance with decisions to be made after completion of the Surplus Plutonium Disposition Environmental Impact Statement described in a Notice of Intent issued in the Federal Register on May 22, 1997 (62 FR 28009). During storage, any separated plutonium would be protected through use of the same safeguards and security measures being used to protect the much larger amount of plutonium already in DOE's inventory. In accordance with existing DOE policy, any plutonium separated under this EIS would not be used in nuclear weapons.

Containment and Shipment of Plutonium Residues and Scrub Alloy

The alternatives evaluated in the EIS include possible shipments from Rocky Flats to the Savannah River Site and/or the Los Alamos National Laboratory from approximately 1998 to 2004. Offsite shipments of plutonium residues and scrub alloy would be made using "Type B" containers, which are authorized by DOE and used in accordance with Department of Transportation regulations. Type B containers have been designed to minimize the possibility of dispersal, radiation, and criticality, and are tested under normal and accident conditions.

Prior to shipment, preprocessing and repackaging will occur at Rocky Flats. Under all of the alternatives evaluated in the Draft EIS, the maximum number of shipments to the Savannah River Site between 1998-2004 would be 208. The maximum number of shipments to the Los Alamos National Laboratory would be 62 during the 1998-2004 timeframe. Under the "preferred alternative" identified in the Draft EIS, the number of shipments would be significantly lower (up to 39 highway shipments could be made to the Savannah River Site, and up to 13 highway shipments could be made to the Los Alamos National Laboratory during the 1998-2004 timeframe).



A typical Type B container for shipments of plutonium residues and scrub alloy

Written Comments on the Draft Environmental Impact Statement on Certain Plutonium Residues and Scrub Alloy Stored at the Rocky Flats Environmental Technology Site

If you would like to give us written comments, please feel free to use this page and drop it off at the registration table when you leave. Alternatively, you may mail your comments to the Department of Energy at the address listed below. Also, please provide us with your name, address, and telephone number for any follow-up information or any questions concerning the intent of your comments. This will also allow us to properly indicate the source of the comments in the comment response document. Thank you.

Name: _____ **Phone:** _____

Title and Organization: _____

Address: _____

City: _____ **State** _____ **Zip** _____

*** *COMMENTS* ***

_____

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To Mail in Comments, Address Correspondence to:

Mr. Charles R. Head
Office of Nuclear Material and Facility Stabilization
Office of Environmental Management, EM-67
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585-0001

All comments are due by January 5, 1998, and those received by that date will be considered by DOE in preparation of the final EIS. Comments received after the close of the comment period will be considered to the extent practicable.

Characteristics of Plutonium Residues and Scrub Alloy

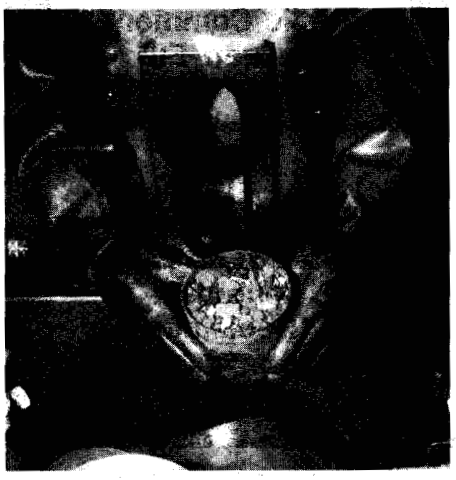
Plutonium residues and scrub alloy are "plutonium-bearing" materials. Plutonium residues are primarily in the form of salts, ash, sludge, and contamination on rags, glass, and metal pieces. Scrub alloy is a metal mixture created as an interim step in plutonium recovery, and is primarily composed of magnesium, aluminum, americium, and plutonium.

Plutonium is a solid, heavy metal that is not readily dispersed in the air. It is not very water soluble or highly chemically reactive. Plutonium's physical characteristics allow for little absorption into the human body through ingestion or skin exposure. The most significant potential exposure is by inhalation of plutonium compounds. Once inhaled, plutonium particles stick to the lung tissue. Then the alpha radiation from the plutonium can cause lung cancer.

The overall human health risk to the public from plutonium during transportation is very low. The preprocessing/repackaging safeguards undertaken prior to shipment and the multiple layers of containment provided by containers severely limit the potential for inhalation.

Packaged residues

Residues from processing



Drums in storage

Safe Transportation of Radioactive Materials

DOE has safely transported radioactive materials for over 40 years. Over the past 25 years, approximately 70 shipments of plutonium residues and scrub alloy have been safely transported from Rocky Flats to the Savannah River Site. These shipments were made using the same Safe Secure Trailer System that is normally used to transport nuclear weapons and weapons components.

Safe Secure Trailer System

The Safe Secure Trailer System uses a specially designed, 18-wheel tractor/trailer that incorporates various detectents to prevent unauthorized removal of cargo. The Trailer has superior structural characteristics, has enhanced communications monitoring to ensure in-transit safety and security, adheres to maintenance standards significantly more stringent than those applied to similar commercial transport vehicles, and employs specially trained and equipped personnel. DOE conducts periodic and unannounced audits/surveys during transport operations to monitor compliance with approved procedures.

DOE Wants Your Input

The Draft EIS will be available for public review and comment during a public comment period which ends January 5, 1998. Comments will be considered and responded to in the Final EIS. Once the public comment period on the Draft EIS is completed, a Final EIS will be published and distributed. The Final EIS will reflect consideration of all comments received during the public comment period, written and oral, and will contain the responses to those comments, as well as revised EIS text. Once the Final EIS is published, a minimum 30-day waiting period is required before a Record of Decision (ROD) can be issued. The ROD will notify the public of the decision made on the proposed action and the reasons for that decision. After the ROD is published, DOE will begin implementing any action that may be decided upon.

The public is encouraged to participate in the decision making process by submitting comments on the Draft EIS. There are several ways to participate:

- *Review the Draft EIS at Reading Room locations across the United States. Call DOE's Center for Environmental Management Information at 1-800-7-EM-DATA (1-800-736-3282) or in Washington DC at 202-863-5084 for the nearest Reading Room location.*
- *Attend a public meeting held during the public comment period at Rocky Flats, Los Alamos National Laboratory, and the Savannah River Site. Call 1-800-7-EM-DATA for meeting dates, times, and locations.*
- *Request a copy of the Draft EIS (900 pages), Draft EIS Summary (80 pages), or other information by calling DOE's Center for Environmental Management Information at 1-800-7-EM-DATA.*
- *Written comments may be sent to Charles R. Head, Office of Nuclear Materials and Facility Stabilization (EM-60), U.S. Department of Energy, 1000 Independence Avenue, SW, Washington, DC 20585.*
- *Questions about NEPA may be sent to Carol M. Borgstrom, Director, Office of NEPA Oversight (EH-25), U.S. Department of Energy, 1000 Independence Avenue, SW, Washington, DC 20585.*

NEPA Process

Notice of Intent for EIS

↓

Scoping Process

↓

Draft EIS

↓

Public Comment on Draft EIS

↓

Final EIS

↓

Record of Decision

If you are interested in receiving the Draft EIS (available now) or the Final EIS when it is issued, please fill out the form below.

- ☐ Draft Summary Only (one volume, approximately 80 pages)
- ☐ Draft Full EIS (three volumes, approximately 900 pages)
- ☐ Final Summary Only
- ☐ Final Full EIS
- ☐ Record of Decision (one volume, approximately 50 pages)

NAME: _____

ORGANIZATION: _____

ADDRESS: _____

CITY: _____ STATE: _____ ZIP: _____

Please fax this form to:
Charles R. Head
202-586-5393

Mail to:
Charles R. Head
U.S. Department of Energy, EM-60
1000 Independence Avenue, SW
Washington, DC 20585

For more information:
Center for Environmental Management Information
1-800-7-EM-DATA (1-800-736-3282) or in Washington DC at 202-863-5084

Department of Energy

Washington, DC 20585
November 12, 1997

Dear Interested Party:

Enclosed is the *Summary* of the *Draft Environmental Impact Statement on Management of Certain Plutonium Residues and Scrub Alloy Stored at the Rocky Flats Environmental Technology Site*. This environmental impact statement has been prepared in accordance with the National Environmental Policy Act to consider the potential impacts from alternative means of processing certain plutonium residues and all of the scrub alloy stored at the Rocky Flats Environmental Technology Site. The processing could be accomplished at Rocky Flats near Golden, Colorado, the Savannah River Site, near Aiken, South Carolina and/or the Los Alamos National Laboratory in Los Alamos, New Mexico.

You are invited to comment on the draft environmental impact statement. Comments may be submitted on any portion of the document, and should be forwarded to:

Mr. Charles R. Head
U.S. Department of Energy
Office of Environmental Management, EM-60
1000 Independence Avenue, SW
Washington, D.C. 20585-0001

or E-mail to RFPR.EIS@EM.DOE.GOV
FAX to 202-586-5393

Written comments should be submitted no later than January 5, 1998. Comments submitted after that date will be considered to the extent practicable. Comments may also be presented at public hearings to be held at the times and locations listed in the *Federal Register* notice announcing the availability of the draft environmental impact statement for public review and comment. We will carefully consider all comments in preparing the final environmental impact statement, scheduled to be issued next year.

You may review the complete draft environmental impact statement in public reading rooms at the addresses listed at the end of the *Summary*. In addition, you may request a copy of the entire document by telephoning the Center for Environmental Management Information at 1-800-736-3282 (or in Washington, D.C. at 202-863-5084).

Sincerely,

Alvin L. Alm
Assistant Secretary for
Environmental Management

Enclosure

Printed with soy ink on recycled paper

DOE/EIS - 0277D
November 1997

Draft Environmental Impact Statement

on Management of Certain Plutonium Residues and Scrub Alloy Stored at the Rocky Flats Environmental Technology Site

Summary

U.S. Department of Energy
Assistant Secretary for
Environmental Management
Washington, DC 20585

COVER SHEET

Responsible Agency: United States Department of Energy (DOE)

Title: Draft Environmental Impact Statement on Management of Certain Plutonium Residues and Scrub Alloy Stored at the Rocky Flats Environmental Technology Site

Contact: For further information, or to submit comments concerning this Draft Environmental Impact Statement (EIS), contact:

Charles Head, Senior Technical Advisor
Office of Nuclear Material and Facility Stabilization (EM-60)
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1000 Independence Avenue, SW
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For general information on DOE's National Environmental Policy Act (NEPA) process, contact:

Carol Borgstrom, Director
Office of NEPA Policy and Assistance (EH-42)
U.S. Department of Energy
1000 Independence Avenue, SW
Washington, DC 20585
Telephone: 202-586-4600 or leave a message at 1-800-472-2756

Abstract: DOE proposes to process certain plutonium-bearing materials being stored at the Rocky Flats Environmental Technology Site (Rocky Flats) located near Golden, Colorado. These materials are plutonium residues and scrub alloy remaining from nuclear weapons manufacturing operations formerly conducted by DOE at this site. In their present forms, these materials cannot be disposed of or otherwise dispositioned because they contain plutonium in concentrations exceeding DOE safeguards termination requirements. Defense Nuclear Facilities Safety Board Recommendation 94-1 addressed health and safety concerns with the management of plutonium residues and scrub alloy at Rocky Flats. The proposed processing will address the concerns raised by the Board and also will prepare the plutonium residues and scrub alloy for disposal or other disposition.

DOE has identified and assessed three technical alternatives for processing these plutonium-bearing materials: (1) *No Action*, (2) *Processing without Plutonium Separation*, and (3) *Processing with Plutonium Separation*. Under the No Action Alternative, DOE would stabilize the materials for safe storage at Rocky Flats for the indefinite future or for disposal if safeguards termination limit variances can be applied. Under the Processing without Plutonium Separation Alternative, DOE would conduct more extensive operations at Rocky Flats to process the materials for disposal. Under the Processing with Plutonium Separation Alternative, DOE would remove most of the plutonium from the plutonium-bearing materials in preparation for disposal or other disposition. Rocky Flats, the Savannah River Site, and Los Alamos National Laboratory are the reasonable sites for processing with plutonium separation. Any plutonium resulting from separation processes would be placed in safe and secure storage pending disposition in accordance with decisions to be reached after completion of the Surplus Plutonium Disposition Environmental Impact Statement. The remaining material would be prepared for disposal.

Public Comment: Comments on this Draft EIS may be submitted through the end of the 45-day comment period, which will commence with the issuance of a Notice of Availability from the U.S. Environmental Protection Agency. Comments received after the end of the comment period will be considered to the extent practicable. Comments may be submitted in writing to DOE at the address indicated above. Oral or written comments may also be submitted at public meetings to be held during the comment period on dates and locations to be announced in the *Federal Register* and via other public media shortly after issuance of the Draft EIS. All comments will be considered in the preparation of the Final EIS.

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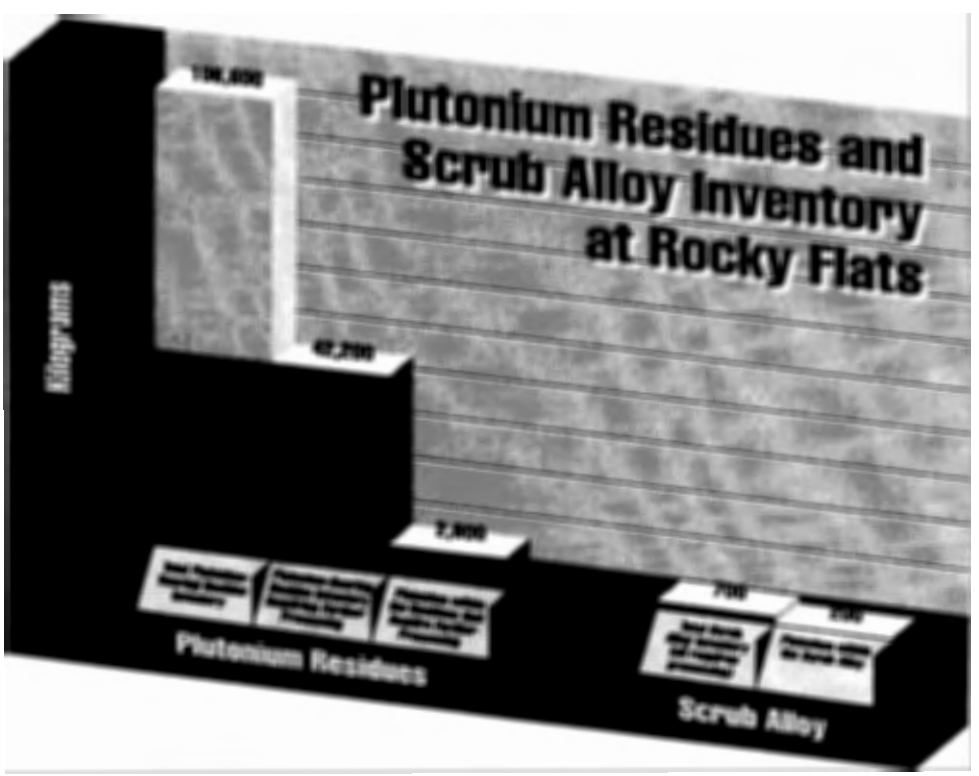
1.0 INTRODUCTION

This Draft Environmental Impact Statement (EIS) identifies potential alternatives and impacts associated with a proposed action to process certain plutonium residues and all of the scrub alloy currently stored at the Rocky Flats Environmental Technology Site (Rocky Flats). Processing of these materials is needed to prepare them for disposal as transuranic waste or for other disposition. The Department of Energy (DOE) has prepared this Draft EIS in accordance with the National Environmental Policy Act (NEPA), as amended.

1.1 BACKGROUND

Plutonium residues and scrub alloy stored at Rocky Flats were generated as intermediate products or byproducts resulting from the manufacture of components for nuclear weapons. Now that nuclear weapons manufacturing and processing activities have ceased, plutonium residues and scrub alloy are being stored pending disposition. Although these materials have been, or are currently being, stabilized for interim storage and disposal, some of these materials require further processing to meet requirements for disposal. The proposed action would involve the use of a selected group of processing technologies to prepare each of the residue categories and scrub alloy for disposal or other disposition. The materials covered by this EIS include:

- **Plutonium residues**, primarily in the form of salts, ash, sludge, and contamination on rags, glass, and metal pieces; and
- **Scrub alloy**, a magnesium/aluminum/americium/plutonium metal mixture created as an interim step in plutonium recovery (and placed into the form of metal).



Defense Nuclear Facility Safety Board (the Board) Recommendation 94-1 addressed health and safety concerns regarding various materials at Rocky Flats, including plutonium residues and scrub alloy. The Board concluded that hazards could arise from continued storage of these materials in their current form and recommended that they be stabilized. Although stabilization of the plutonium residues was addressed in the Rocky Flats Solid Residues Environmental Assessment, the processing analyzed in the Environmental Assessment would leave approximately 40 percent of the Rocky Flats plutonium residues (i.e., the plutonium residues covered by this EIS) in a form that could not be disposed of. In addition, the Environmental Assessment did not address stabilization of the scrub alloy. Since less than 1 percent of these Rocky Flats plutonium residues and none of the scrub alloy have been stabilized to date using the processes analyzed in the Rocky Flats Solid Residues Environmental Assessment, DOE considers it prudent to consider in this EIS processing alternatives that would not only stabilize the remaining plutonium residues and the scrub alloy to address the health and safety concerns raised by Board Recommendation 94-1, but would also convert them into forms that would allow for their disposal or other disposition. The proposed action includes processing with and without plutonium separation.

1.2 PURPOSE AND NEED FOR AGENCY ACTION

***Transuranic Waste** is contaminated with radioactive elements heavier than uranium (e.g., isotopes of plutonium) with half-lives longer than 20 years in concentrations greater than 100 nanocuries per gram of waste.*

Most of the transuranic waste (about 97 percent by volume) is alpha-emitting and can be safely handled in its packaging (alpha particles can be stopped by shielding as thin as a sheet of paper).

A small percentage of transuranic waste emits sufficient penetrating radiation (gamma rays) to require more shielding (i.e., lead-shielded casks) if it is to be transported for processing or disposal.

The purpose and need for agency action is to process certain plutonium residues and scrub alloy currently in storage at Rocky Flats to address health and safety concerns raised by the Defense Nuclear Facilities Safety Board in Recommendation 94-1, and to prepare them for offsite disposal or other disposition, while supporting site closure and limiting worker exposure and waste production. The proposed action includes processing options that would separate plutonium from the residues and scrub alloy, as well as processing options that exclude plutonium separation. Any plutonium separated from the plutonium residues or scrub alloy as a result of the proposed action would be placed into safe and secure storage pending disposition by immobilization or conversion to mixed-oxide fuel in accordance with decisions to be made under DOE's Surplus Plutonium Disposition Environmental Impact Statement.

Stabilization and repackaging efforts have been completed, or are currently underway, for the Rocky Flats plutonium residues[1]. However, even after the stabilization and repackaging efforts are completed, some of the residues and all of the Rocky Flats scrub alloy still potentially would not meet the safeguards termination limits requirements for disposal at the Waste Isolation Pilot Plant (WIPP)[2]. In particular, these residues and scrub alloy would remain in forms that could be attractive as a source of plutonium for use in nuclear weapons or other terrorist devices. Safeguards controls (defined in the box below) are used to ensure that such materials cannot be diverted for illicit purposes.

Because the WIPP disposal facility was not designed to accommodate safeguards controls, requirements for terminating the safeguards controls must be satisfied before the plutonium residues or scrub alloy could be disposed of in WIPP[2]. This means that the materials must be placed in a physical form that would make extraction of the plutonium very difficult, or be processed to reduce the plutonium concentration. This EIS identifies and analyzes alternative technologies that process the residues and scrub alloy into forms which could be disposed of or otherwise dispositioned.

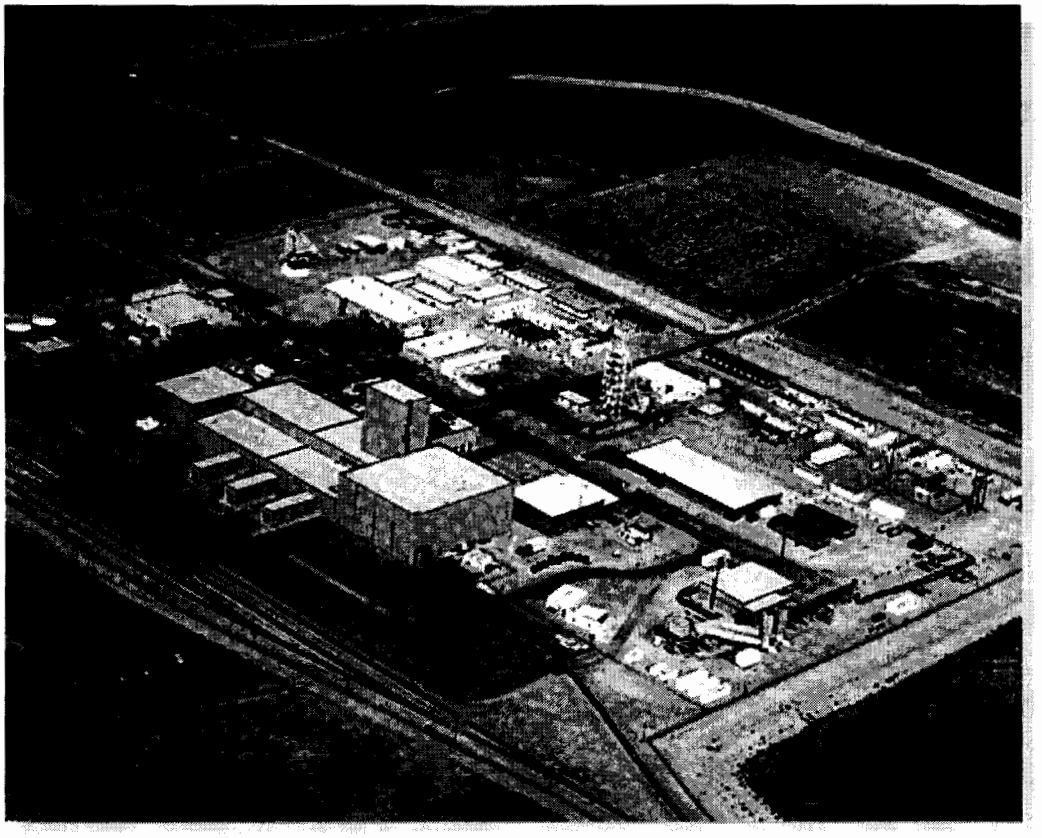
***Safeguards controls** are those measures (e.g., record keeping, monitoring, and physical protection) that DOE and other organizations holding nuclear materials take to ensure that the materials are not stolen or diverted for illicit purposes. The safeguards controls are applicable to nuclear materials held by DOE are specified in DOE Order 5633.3B, "Control and Accountability of Nuclear Materials," dated September 7, 1994.*

***Safeguards termination limits requirements** are those steps that must be taken, or conditions that must exist, in order for nuclear materials to be no longer attractive as a source of fissile material and that can be exempted from further safeguards controls. These steps include:*

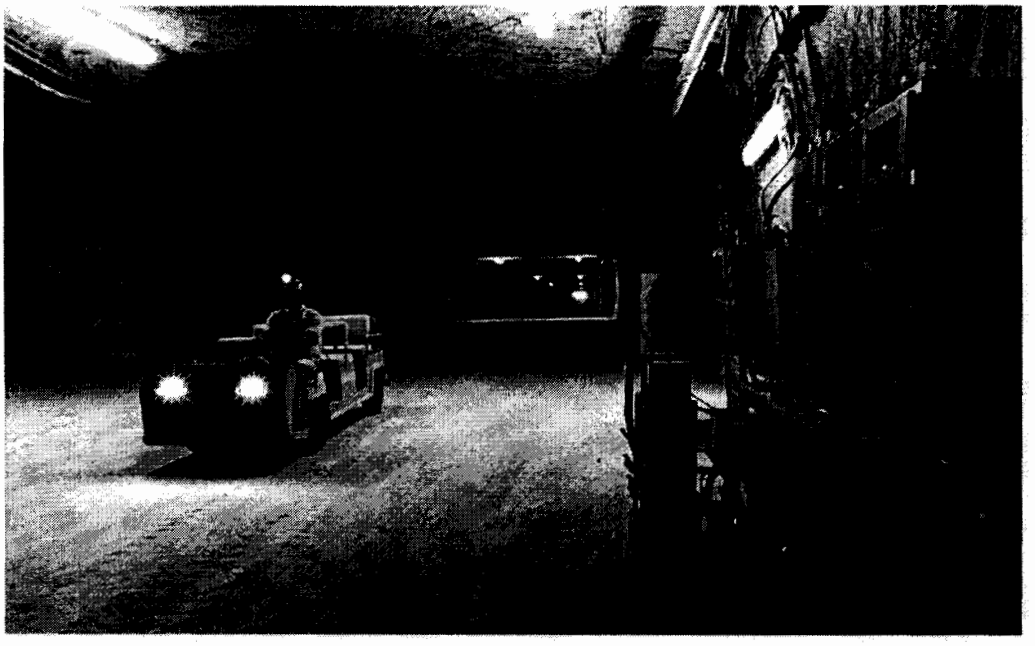
- *reducing the concentration of plutonium or other fissile elements to meet certain limits established by DOE's Office of Safeguards and Security (by either diluting the residues with materials that are similar or removing some or all of the plutonium), or*
- *immobilizing the materials by converting them into glass or ceramic forms from which it would be difficult to extract the plutonium or other fissile elements.*

[1] *Current stabilization and repackaging activities for all of the Rocky Flats plutonium residues are addressed in a separate NEPA document, entitled Solid Residue Treatment, Repackaging, and Storage Environment Assessment/Finding of No Significant Impact, DOE/EA-1120, Rocky Flats Field Office, April 1996 (hereafter referred to as the "Solid Residue Environmental Assessment").*

[2] *Disposal in WIPP of transuranic waste generated from processing scrub alloy will require additional NEPA review. Such disposal may also require changes to current legal limits on WIPP.*



The Waste Isolation Pilot Plant (WIPP), located near Carlsbad, New Mexico, is a geologic repository in ancient salt beds proposed to be used for disposal of DOE's transuranic waste. WIPP is currently scheduled to open in May 1998.



1.3 SCOPE OF EIS

1 kilogram (kg) equals 2.2 pounds (lb).

1.3.1 SCOPE OF MATERIALS COVERED IN EIS

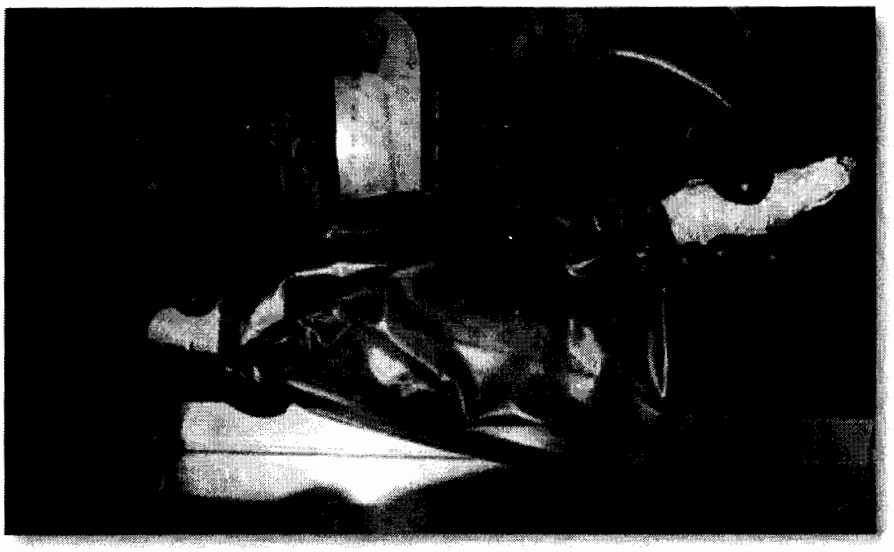
The materials covered under this EIS include approximately 40 percent of the 106,600 kg (235,000 lb) existing inventory of Rocky Flats plutonium residues, and also the entire inventory of Rocky Flats scrub alloy. The covered material consists of 42,200 kg (93,000 lb) of plutonium residues [containing 2,600 kg (5,730 lb) of plutonium] and 700 kg (1,540 lb) of scrub alloy [containing 200 kg (440 lb) of plutonium]. The remaining Rocky Flats plutonium residues will meet the requirements for disposal after being processed as discussed in the Solid Residues Environmental Assessment, and are not addressed in this EIS.

The materials covered in the EIS are described in more detail below.

ROCKY FLATS PLUTONIUM RESIDUES AND SCRUB ALLOY*	
1. **Ash Residues**** (1) incinerator ash, firebrick fines, and soot; (2) pulverized sand, slag, and crucible; and (3) graphite fines.	• ~ 27,900 kg (61,500 lb) of material containing about 1,250 kg (2,760 lb) of plutonium. • Approximately 72 percent (~20,100 kg or 44,300 lb) would require additional processing to meet requirements for disposal at WIPP or for other disposition.
2. **Pyrochemical Salt Residues**** (1) electrorefining salts, (2) molten salt extraction salts, and (3) direct oxide reduction salts.	• ~ 16,000 kg (35,300 lb) of material containing about 1,000 kg (2,200 lb) of plutonium. • Salts consist primarily of sodium chloride, calcium chloride, potassium chloride, and magnesium chloride. • Approximately 93 percent (~14,900 kg or 32,800 lb) would require additional processing to meet requirements for disposal at WIPP or for other disposition.
3. **Wet Residues**** Comprised of materials such as wet (aqueous and organic contaminated) combustibles, plutonium fluorides, high-efficiency particulate air filter media, sludges, and Raschig (glass) rings.	• ~ 16,500 kg (36,400 lb) of material containing about 340 kg (750 lb) of plutonium. • Approximately 26 percent (~4,300 kg or 9,500 lb) would require additional processing to meet requirements for disposal at WIPP or for other disposition.
4. **Direct Repackage Residues**** Consists of paper, rags, cloth, plastic, personal protective equipment, and gaskets.	• ~ 39,300 kg (86,600 lb) of material containing about 340 kg (750 lb) of plutonium. • Approximately 8 percent (~2,900 kg or 6,400 lb) would require additional processing to meet requirements for disposal at WIPP or for other disposition.
5. **Scrub Alloy**	• Magnesium/aluminum/americium/plutonium metal mixture created as an interim step in plutonium recovery. • Entire scrub alloy inventory of approximately 700 kg (1,540 lb) containing about 200 kg (440 lb) of plutonium would require additional processing to meet requirements for disposal at WIPP or for other disposition.

* *This table characterizes the residues and scrub alloy as presented in the Notice of Intent (see Appendix A). For evaluation purposes these five categories were reorganized into 10 new categories as shown in Table S-1 in Section 2.2.*

** *Safeguards termination limit variances may be applied to certain residues within these categories, which would allow disposal at WIPP without further processing beyond current stabilization and repackaging activities. Table S-1 in Section 2.2 identifies the residues for which variances may be applied.*



Packaged Residues

Drums in Storage

1.3.2 SCOPE OF ALTERNATIVES EVALUATED IN EIS

The alternatives evaluated in this EIS are summarized below.

ALTERNATIVES EVALUATED IN EIS		
Alternative 1 **No Action**	**Alternative 2** **Processing without Plutonium Separation**	**Alternative 3** **Processing with Plutonium Separation**
Stabilization to prepare the residues for interim storage, as described in the Solid Residue Environmental Assessment, and repackaging of the scrub alloy to allow for its interim storage. This is referred to as the "No Action" Alternative. This includes processes such as calcination, cementation, and direct repackaging. *Note: DOE is considering use of variances from certain safeguards termination limits that would allow disposal of some plutonium residues under this alternative. See Section 1.4 for more discussion of this subject.*	Processing that converts the material into a form that meets safeguards termination limits for disposal at WIPP. This would include technologies such as blend down and immobilization (e.g., vitrification or cementation). These technologies would be implemented onsite at Rocky Flats.	Processing that separates the plutonium from the material and concentrates it so that the residual material meets the safeguards termination limits for disposal at WIPP, while the separated and concentrated plutonium is placed in safe and secure storage pending ultimate disposition by immobilization or conversion to mixed-oxide fuel in accordance with decisions to be reached under the Surplus Plutonium Disposition Environmental Impact Statement. This alternative would include separation technologies such as acid dissolution and plutonium oxide recovery, Purex, and mediated electrochemical oxidation. These technologies would be implemented either onsite at Rocky Flats or offsite at the Savannah River Site and/or the Los Alamos National Laboratory.

For this EIS, the "proposed action" is to process the plutonium residues and scrub alloy to prepare them for disposal as transuranic waste or other disposition. The proposed action could be accomplished by either Alternative 2 or 3, or some combination of them. The environmental and human health impacts associated with the processing options that are available for these two alternatives, as well as those processes under the No Action Alternative, are evaluated in this EIS.

The processing technologies for the No Action Alternative are as given in the Solid Residue Environmental Assessment. Alternatives 2 and 3 processing technologies were selected for detailed evaluation by DOE. DOE screened and selected candidate processing technologies for specific categories of residues (e.g., ash, pyrochemical salts, wet residues, and direct repackage residues) and for scrub alloy. Only those processing technologies that are mature enough for near-term implementation were selected for detailed evaluation. These technologies are described in more detail in Section 2 of this Summary and in Chapter 2 and Appendix C of the EIS. Potential environmental impacts from the alternatives discussed above are described in Section 4 of this Summary and in detail in Chapter 4 and Appendices D and E of the full EIS.

1.4 PROLIFERATION RISK

For over 40 years, the United States has supported international efforts to prevent the spread of nuclear weapons to states that do not already have them. Although the cold war has ended, national support for the nonproliferation of nuclear weapons remains undiminished. As one of its fundamental nonproliferation strategies, the United States seeks to prevent the unauthorized acquisition of materials, such as plutonium, that could be used to manufacture nuclear weapons. U.S. efforts to prevent unauthorized access to plutonium are based on longstanding national policies, as well as on our obligations under the Nuclear Nonproliferation Treaty and the Treaty on the Physical Protection of Nuclear Material. The material covered by this EIS (approximately 40 percent of the plutonium residues and all of the scrub alloy stored at Rocky Flats) contains nearly 2,800 kg (6,200 lb) of plutonium that could be used in nuclear weapons, if diverted.

The nonproliferation consequences of each alternative for management of these materials are discussed below.

- ***Alternative 1 (No Action Alternative)*** — Under the No Action Alternative, the entire Rocky Flats inventory of plutonium residues and scrub alloy would be stabilized and stored there pending disposition. Materials containing nearly 2,800 kg (6,200 lb) of plutonium would remain an attractive target for theft by those interested in the manufacture of nuclear weapons. Theft would be prevented by continued operation of the physical security system at Rocky Flats. From the viewpoint of nuclear weapons nonproliferation, the No Action Alternative has no clearly defined endpoint. The stabilization efforts under the No Action Alternative would result in a very small reduction in proliferation risk.

  Several residue categories have been granted variances from safeguard termination limits and could be disposed of in WIPP without further processing beyond that included in the No Action Alternative. Variances from safeguards termination limits can be obtained if the residue would not be in a form that is attractive for theft as a source of plutonium for use in nuclear weapons or terrorist activities after it is stabilized. Variances have been approved by the DOE Office of Safeguards and Security for the combustible, glass and graphite residues, most inorganic residues, and some salts and filter residues[1]. DOE is also currently considering additional variances for ash and sludge residues, molten salt extraction and electrorefining salt residues, and high-efficiency particulate air filter residues. If safeguards termination limit variances are applied to any of the Rocky Flats residues assessed in this EIS, the impacts from the stabilization activities that would occur would be the same as or less than those for the No Action Alternative. As a result, the processing impacts would be the same.

> ***Safeguards Termination Limits***
>
> "Safeguards" are part of the process of ensuring that unauthorized persons or organizations do not obtain materials (e.g., uranium or, for this EIS, plutonium) that could be used to manufacture nuclear weapons. Safeguards termination limits are limits on the maximum concentration of plutonium that may exist in a material without causing the material to be subject to the strict material control and accountability requirements applied under "safeguards" requirements. These concentration limits are established based on a determination of how low the plutonium concentration must be for any given material form to make the material unattractive as a source of plutonium. DOE granted a variance to the safeguards termination limits for certain residues when evaluations demonstrated that the proposed processing method for the material, the controls in place for normal handling of transuranic waste, and the limited quantity of special nuclear material present in any particular place and time preclude the need to take additional measures to address threats of diversion and theft. When safeguards termination limit variances are given, the residue material is no longer subject to strict material control and accountability as special nuclear material. The materials, however, are still controlled and guarded based on DOE's management practices and physical security procedures.

[1] *Although DOE has already determined that safeguards termination limit variances are applicable for combustible, glass and graphite residues, most inorganic residues, and some direct oxide reduction salt and filter residues, action to apply these variances is on hold pending issuance of the Record of Decision to follow completion of this EIS.*

- ***Alternative 2 (Process without Plutonium Separation)*** — Implementation of Alternative 2 would render the Rocky Flats plutonium residues and scrub alloy unattractive as a source of plutonium for the manufacture of nuclear weapons. From the viewpoint of nuclear weapons nonproliferation, the endpoint is clearly defined as completion of processing for the entire inventory, at which time the resulting materials would pose a greatly reduced proliferation risk. Under this alternative, the high level of physical security required under Alternatives 1 and 3 would no longer be required for the processed plutonium residues and scrub alloy. This alternative would cause the largest reduction in the risk of proliferation in the near term.

- ***Alternative 3 (Process with Plutonium Separation[1])*** — Under this alternative, plutonium separated from the Rocky Flats plutonium residues and scrub alloy would be stored pending disposition in accordance with decisions to be reached under the *Surplus Plutonium Disposition Environmental Impact Statement*. Waste resulting from the separation process would not pose a proliferation risk; however, the separated plutonium would remain a potential target for theft until its disposition. Physical security to prevent theft would be required for the separated plutonium during the interim storage period. Pending publication of the Record of Decision for the Surplus Plutonium Disposition Environmental Statement, scheduled to occur in late 1998, Alternative 3 has no clearly defined point for termination of the nuclear weapons proliferation risk. Nevertheless, once final disposition of the plutonium was completed, this alternative would cause a reduction in the risk of proliferation. Sites under consideration for managing this surplus plutonium are all currently storing large quantities of plutonium. Physical security is already in place at these sites and is expected to continue. The additional storage of separated plutonium from residues and scrub alloy would not substantially increase the proliferation risk at these sites.

  This alternative would also reduce the amount of transuranic waste that would have to be sent to WIPP.

1.5 DECISIONS TO BE MADE BASED ON THIS EIS

To ensure that the plutonium residues and scrub alloy addressed in this EIS are properly prepared for disposal or other disposition and are stored safely before disposal or disposition, the following decisions must be made:

- Whether any further processing of the plutonium residues or scrub alloy should occur, and if so:
  - how much of the plutonium residues and scrub alloy should be processed; and
  - what processing approach should be used for each of the plutonium residue categories and for the scrub alloy.
- The locations at which further processing and subsequent management of the plutonium residues and scrub alloy should occur. It is possible that different sites could be chosen for management of different residues and the scrub alloy, or even for different portions of a single residue category if differences in the weight percent of plutonium contained in a portion of a residue category (or other detailed differences in the residue chemistry) make choosing different locations desirable from a management or cost standpoint.

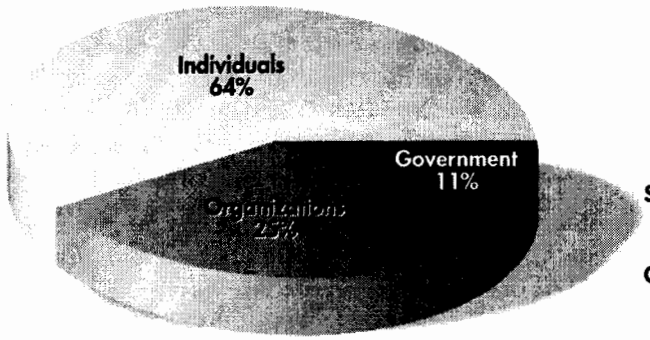
DOE's decisions will be announced in the Record of Decision for this EIS, which will be issued no less than 30 days after the Environmental Protection Agency publishes the Notice of Availability for the Final EIS.

[1] *DOE is in the process of preparing a study on the nonproliferation implications of various management alternatives, including chemical separation for spent nuclear fuel. DOE expects to complete this study by the spring of 1998. Findings of the study could be relevant to decisions to be made regarding the processing of materials considered in this EIS.*

1.6 PUBLIC SCOPING PROCESS

The preliminary scope of this EIS was described in the *Federal Register* Notice announcing DOE's intent to prepare this EIS ("Notice of Intent to Prepare an Environmental Impact Statement on Management of Certain Plutonium Residues and Scrub Alloy Stored at the Rocky Flats Environmental Technology Site," 61 FR 58866, dated November 19, 1996). This Notice of Intent announced a 30-day public scoping period (from November 19, 1996, through December 19, 1996), during which the public was invited to submit comments on the preliminary scope. During the scoping period, DOE held two public scoping meetings — one on December 3, 1996, at Rocky Flats and one on December 12, 1996, near the Savannah River Site in North Augusta, South Carolina. DOE also received written comments submitted by the public through letters and electronic mail.

DOE received comments from approximately 30 individuals and organizations as part of the scoping process. Almost half of the comments were from individuals and organizations in the Rocky Flats area and most of the remainder were from individuals in the Savannah River Site area. A few were from national organizations, such as the Natural Resources Defense Council and the Military Production Network. Comments were also received from organizations with a specific interest in Rocky Flats activities, such as American Friends Service Committee, Denver; Colorado Coalition for the Prevention of Nuclear War; Colorado Peace Action; Greenpeace, Boulder, Colorado; Physicians for Social Responsibility, Colorado Chapter; and Rocky Mountain Peace and Justice Center. (Figure S-1.)



National Level
Natural Resources Defense Council
Military Production Network

Rocky Flats Area
Individuals*
Coalition of Service Organizations
- American Friends Service Committee, Denver
- Colorado Coalition for the Prevention of Nuclear War
- Colorado Peace Action
- Greenpeace, Boulder, Colorado
- Physicians for Social Responsibility
- Rocky Mountain Peace and Justice Center

Savannah River Site Area
Individuals*
Savannah River Site Citizens Advisory Board

Government
U.S. Department of the Interior, Fish & Wildlife Service
City of Arvada (Colorado)
City of Broomfield (Colorado)

** Individuals include citizens, former site workers, and current site workers.*

Figure S-1. Commentor Affiliations

In the Savannah River Site area, comments were received (both orally at the public scoping meeting and in writing) from individual citizens and the Site's Citizens Advisory Board.

Comments were received on management alternatives, as well as on storage; safeguards and proliferation; disposal or other disposition; transportation; environmental, health, and safety issues; and costs. Key comments on the management alternatives include the following.

- ***No Action*** — Very few commentors supported the No Action Alternative as described in the Notice of Intent, i.e., maintenance of the "status quo" at Rocky Flats. Evaluation of the No Action Alternative is required by 40 CFR 1502.14 (Council on Environmental Quality's NEPA regulations) and is analyzed in this EIS.

- ***Processing without Plutonium Separation*** — Commentors from the Rocky Flats area were split, with some supporting onsite processing of the residues and scrub alloy at Rocky Flats and some supporting offsite processing to remove the materials from the site in accordance with DOE's commitments regarding cleanup of Rocky Flats. Several organizations supported vitrification, as long as the resulting form of the residues provides sufficient safeguards against theft or diversion.

Draft EIS on Management of Certain Plutonium Residues and Scrub Alloy Stored at the Rocky Flats Environmental Technology Site

Chapter 2 of this Summary presents information on:

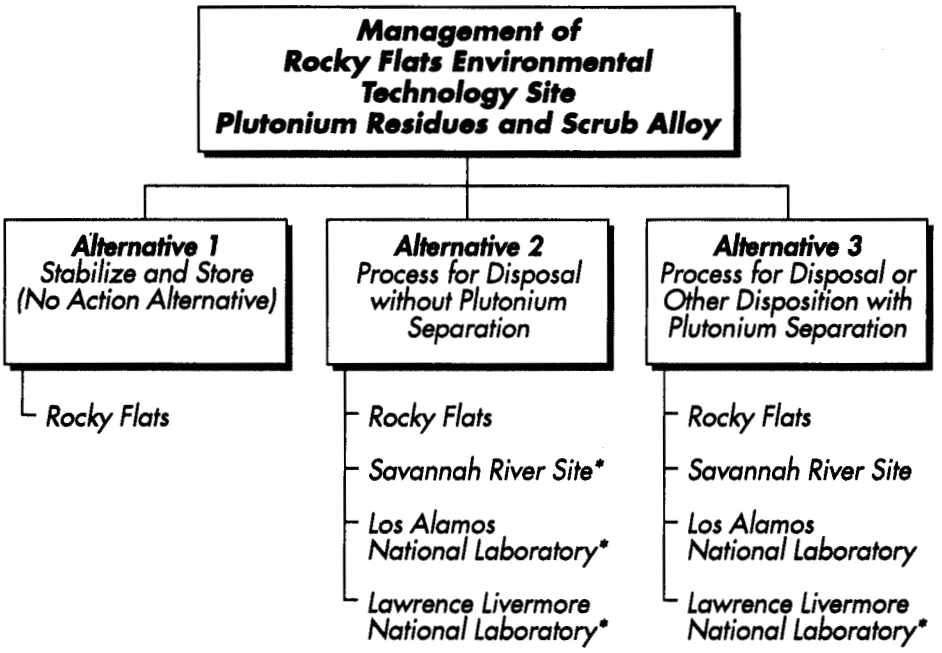
- Description of Alternatives
- Categories of Material
- DOE Sites Considered
- Technology Screening Process
- Description of Technologies
- Preferred Processing Options
- Interim Storage
- Ultimate Disposition
- Transportation

2.0 PROPOSED ACTION AND ALTERNATIVES

This chapter describes the alternatives evaluated under the two action alternatives and the "No Action" Alternative. Included is a description of the alternatives, the material categories that need further processing for disposal or other disposition, the sites being considered, the procedure used to screen and select alternative technologies for evaluation, and a summary of each processing technology evaluated. For most of the material types, a preferred processing technology has been identified and highlighted in this section. Discussions of interim storage methods, transportation of the materials, and disposition of the materials are also presented.

2.1 DESCRIPTION OF ALTERNATIVES

The alternatives evaluated in this EIS are presented below, along with the DOE sites considered for implementing the alternatives.



** Sites at which processing was considered but not analyzed in detail*

Alternative 1

This alternative consists of stabilization or repackaging to prepare the material for interim storage as described in the Solid Residue Environmental Assessment. Under this alternative, further processing would not occur to prepare the material for disposal or other disposition. This is referred to as the "No Action" Alternative. Scrub alloy was not addressed in the Environmental Assessment. The No Action Alternative for scrub alloy is defined as continued storage at Rocky Flats with repackaging, as necessary. Under this alternative, the stabilization process would leave approximately 40 percent of the Rocky Flats plutonium residues and all of the Rocky Flats scrub alloy in a form that cannot be disposed of (i.e., these materials would not meet safeguards termination limits). Some stabilized residues could be disposed based on variances from safeguards termination limits.

Depending on the material category, technologies under this alternative include calcination, cementation, pyro-oxidation, neutralization, thermal desorption, steam passivation, repackaging, acid dissolution/plutonium oxide recovery, and filtration.

Alternative 2

Under this alternative, the material would be processed to convert it into a form that meets safeguards termination limits for disposal at the WIPP. However, additional NEPA review will be required for scrub alloy since scrub alloy was not specifically addressed in the WIPP Supplemental EIS-II.

Depending on the material category, technologies that might be used include immobilization (e.g., cementation or calcination/vitrification), blend down, catalytic chemical oxidation (digestion), and sonic wash.

Alternative 3

Under this alternative, the material would be processed to separate plutonium from the material and concentrate it so that the residual material meets the safeguards termination limits for disposal at the WIPP or disposal as low-level waste or high-level waste, while the separated and concentrated plutonium is placed in safe and secure storage pending disposition by immobilization or conversion to mixed-oxide fuel in accordance with decisions to be made under the Surplus Plutonium Disposition Environmental Impact Statement.

Depending on the material category, processing technologies that might be used include acid dissolution/plutonium oxide recovery, Purex process/plutonium metal or oxide recovery, mediated electrochemical oxidation, salt distillation, salt scrub, and water leach.

Several of the *preferred* processing options involve plutonium separation (refer to Section 2.6 of this Summary). Use of these separation processes reduces the health and safety concerns associated with the higher worker radiation doses that are received from non-separation processes.

Processing plutonium residues and scrub alloy without separation would be conducted in gloveboxes at Rocky Flats. This would lead to relatively high radiation doses to workers from the high radioactivity that emanates from these materials. On the other hand, processing with plutonium separation at the Savannah River Site (sand, slag, and crucible; plutonium fluorides; and scrub alloy) would be performed using the Purex process in remote-handling facilities. The worker doses associated with the remote operations are several times smaller than from the glovebox operation. Although the preferred processing options for pyrochemical salts (salt distillation of molten salt extraction/electrorefining salt residues at Rocky Flats and water leach of direct oxide reduction salt residues at Los Alamos National Laboratory) are not conducted remotely, they require much shorter periods of worker exposure to the radioactive salts than the non-separation technology (blend down at Rocky Flats). This reduced exposure period also results in lower worker doses when employing the plutonium separation process.

In addition to the lower doses to workers, processing with plutonium separation results in a reduced amount of transuranic waste that ultimately would have to be transported to WIPP for disposal. The reduced handling of this material at WIPP would decrease radiation exposure to the operational staff.

2.2 CATEGORIES OF MATERIALS COVERED BY THE PROPOSED ACTION

Chapter 1 of this Summary identifies the five major categories of materials (residues and scrub alloy) that require further processing. These were the major categories identified in the November 1996 Notice of Intent to prepare this EIS (61 FR 58866, November 19, 1996). The residue categories are the same as those identified in the Solid Residue Environmental Assessment (April 1996), which addresses the existing Rocky Flats stabilization and repackaging efforts. Scrub alloy was not analyzed in the Solid Residues Environmental Assessment.

For the purpose of calculating potential environmental impacts for this EIS, plutonium residues and scrub alloy were reorganized into 10 new major material categories. Some of the categories are further divided into subcategories. These 10 new categories reflect material types that require similar processing technologies. Descriptions of the processing technologies and the evaluation of impacts are presented according to these categories. The 10 categories of material are:

1. Ash Residues
2. Pyrochemical Salt Residues
3. Combustible Residues
4. Plutonium Fluoride Residues
5. Filter Media Residues
6. Sludge Residues
7. Glass Residues
8. Graphite Residues
9. Inorganic Residues
10. Scrub Alloy

Table S-1 compares categories presented in the Notice of Intent with those used in the environmental evaluation. The processing technologies are described in Section 2.5. The potential environmental impacts are presented in Section 4.

Table S-1 shows how these 10 categories (and subcategories) correspond to the five categories presented in the Notice of Intent. Residues for which safeguards termination limit variances may be applied are also shown.

Table S-1. Material Categories

Notice of Intent Categories	EIS Categories
Ash Residues - Incinerator Ash, Firebrick Heels and Fines, and Soot - Sand, Slag, and Crucible - Graphite Fines	(#1) **Ash Residues (20,060 kg [44,200 lb])** - Incinerator Ash, and Ash Heels and Firebrick Fines - Sand, Slag, and Crucibles - Graphite Fines - Inorganic Ash
Salt Residues - Electrorefining Salts - Molten Salt Extraction Salts - Direct Oxide Reduction Salts	(#2) **Pyrochemical Salt Residues (14,900 kg [32,800 lb])** - Electrorefining Salts - Molten Salt Extraction Salts - Direct Oxide Reduction Salts[a]
Wet Residues - Wet Combustibles (partial)	(#3) **Combustible Residues (partial)[b]** - Aqueous/Organic-Contaminated Combustibles (685 kg [1,500 lb])
- Wet Combustibles (partial)	(#4) **Filter Media Residues (2,630 kg [5,800 lb])**
- Plutonium Fluoride	(#5) **Plutonium Fluoride Residues (315 kg [690 lb])**
- Sludge - Greases/Oily Sludge	(#6) **Sludge Residues (620 kg [1,370 lb])** - Sludge - Greases/Oily Sludge
- Raschig Rings	(#7) **Glass Residues (partial)[b]** - Raschig Rings (7 kg [15 lb])
Direct Repackage - Glass	(#7) **Glass Residues (partial)[b]** - Other Glass (126 kg [280 lb])
- Dry Combustibles	(#3) **Combustibles Residues (partial)[b]** - Dry Combustibles (455 kg [1,000 lb])
- Graphite, Firebrick	(#8) **Graphite Residues[b] (1,880 kg [4,150 lb])** - Graphite, Firebrick
- Miscellaneous	(#9) **Inorganic Residues (Metal and Others)[b] (460 kg [1,000 lb])** - Miscellaneous
Scrub Alloy	(#10) **Scrub Alloy (700 kg [1,540 lb])**

[a] Safeguards termination limit variances may be applied to a portion of this salt category, which would allow disposal at WIPP without further processing beyond current stabilization and repackaging activities.

[b] Safeguards termination limit variances may be applied to these categories, which would allow disposal at WIPP without further processing beyond current stabilization and repackaging activities.

2.3 DOE SITES CONSIDERED FOR IMPLEMENTING THE ALTERNATIVES

Processing and storage activities under Alternative 1 (No Action) would be performed at Rocky Flats as part of existing activities.

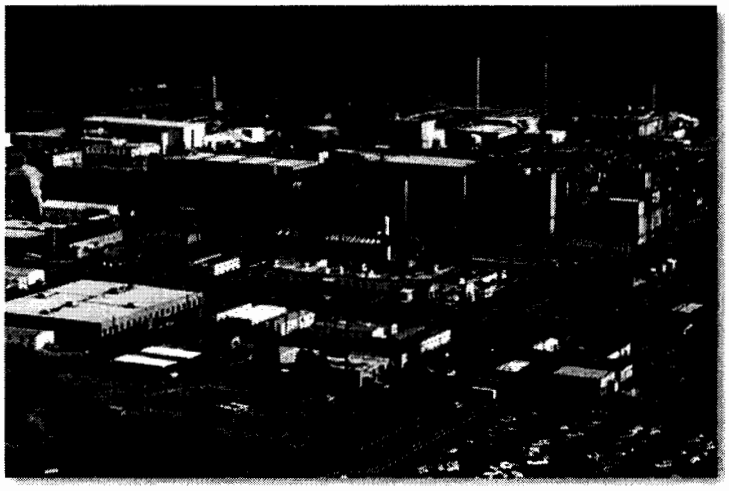
For processing and storage activities under Alternative 2, DOE initially considered four DOE sites for implementation. The sites included:

- Rocky Flats
- Savannah River Site
- Los Alamos National Laboratory
- Lawrence Livermore National Laboratory

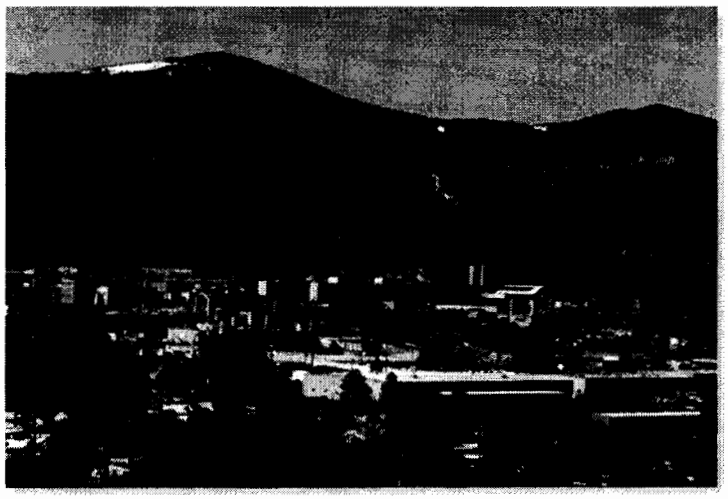
These sites were initially selected as potential processing sites because they currently manage, or have managed in the past, plutonium residues and scrub alloy. All four sites have capabilities for employing certain processing technologies, but the two national laboratories have constraints that either preclude further consideration (Lawrence Livermore National Laboratory) or limit consideration to only two processes (Los Alamos National Laboratory). Considerations for each of the four sites are given below.

Following the screening and evaluation process implemented for this EIS, DOE has limited its consideration to Rocky Flats for processes with and without plutonium separation, the Savannah River Site for processes with plutonium separation, and the Los Alamos National Laboratory for two processing technologies involving plutonium separation.

Rocky Flats
Environmental Technology Site



Savannah River Site's
F-Canyon



Los Alamos
National Laboratory

Rocky Flats Environmental Technology Site

For Alternative 2 (Processing without Plutonium Separation), DOE eliminated all sites from consideration except Rocky Flats. The transport of the materials to another site for processing would involve preprocessing at Rocky Flats, which would entail risks to the public and workers of essentially the same magnitude as the risks from doing all of the processing at Rocky Flats. Furthermore, transportation of the materials could impose additional, although small, risks to the public and transportation workers. Finally, processing the material at another site could entail risks to the public and workers at that site. The sum of the costs and risks of preprocessing, transportation, and final processing would exceed that of final processing at Rocky Flats without providing any tangible benefits. Accordingly, all processing of the plutonium residues and scrub alloy that does not involve plutonium separation would be accomplished at Rocky Flats. Rocky Flats is also being considered for processing under Alternative 3 (Processing with Plutonium Separation).

Savannah River Site

For Alternative 3 (Processing with Plutonium Separation), the Savannah River Site has unique operational facilities for the separation of plutonium. The H-Canyon, HB-Line, F-Canyon, and FB-Line were designed to separate plutonium and uranium from other materials. Because these facilities will already be in operation to stabilize corroding spent fuel and targets, it would be efficient to also use them to stabilize materials from Rocky Flats.

Los Alamos National Laboratory

Because Los Alamos National Laboratory is the site at which much of the technology used in production of the Nation's nuclear weapons stockpile was developed, it has the capability to implement essentially all of the technologies considered in this EIS. However, much of this capability is limited to laboratory bench-scale operations suitable for initial development of the technology, but not for use as a production operation. Furthermore, Los Alamos National Laboratory processing capability has been committed, for the most part, to other programs (e.g., to process the backlog of residues from Los Alamos' previous operations and to manage wastes from manufacture of plutonium components for nuclear weapons). As a result, DOE determined that most of the processing that might be performed on the Rocky Flats plutonium residues and scrub alloy could not reasonably be conducted at Los Alamos National Laboratory. Nevertheless, DOE concluded that Los Alamos National Laboratory should be considered for two processing technologies considered in this EIS (under Alternative 3). Scientists at the site developed the salt distillation technology being considered for separation of plutonium oxide from certain pyrochemical salts. The site has the experience needed to apply this processing technology and, therefore, is considered in this EIS for salt distillation. Los Alamos National Laboratory is also being considered for water leach of direct oxide reduction salts because of their experience with salt processing and Rocky Flats' limited capability for processing aqueous waste.

Lawrence Livermore National Laboratory

Lawrence Livermore National Laboratory has also developed technologies for use in the production of nuclear weapons, but the site has facility capacity and capability limitations similar to those discussed above for Los Alamos National Laboratory. In addition, Lawrence Livermore National Laboratory is subject to constraints imposed by an existing agreement with the State of California that limits the amount of plutonium that may be present at the site at any one time. This limitation would require that most, if not all, of any residues processed at Lawrence Livermore National Laboratory be shipped to another DOE site for storage prior to disposal. This requirement would result in additional shipment preparation and transportation impacts, without any advantage to offset such effects. As a result, DOE has eliminated Lawrence Livermore National Laboratory from further consideration as a site for the processing of Rocky Flats plutonium residues or scrub alloy.

2.4 PROCESS USED TO SCREEN AND SELECT PROCESSING TECHNOLOGIES FOR EVALUATION

DOE used a screening process to identify a reasonable set of processing technologies for detailed evaluation in this EIS. The screening process assessed a wide range of potential processing technologies identified in several DOE studies, including the following:

- *The Rocky Flats Environmental Technology Site: Direct Disposal Trade Study for Plutonium-Bearing Residues* (November 1995)

- A series of trade studies developed by the Office of Nuclear Material Stabilization at DOE Headquarters, in coordination with Rocky Flats, the Savannah River Site, the Lawrence Livermore National Laboratory, and the Los Alamos National Laboratory, which include the following:

  Plutonium Combustibles Trade Study (December 1996)
  Plutonium Sand, Slag, and Crucible Trade Study (January 1997)
  Plutonium Salts Trade Study (February 1996)
  Ash Residues End-State Trade Study (October 1996)
  Plutonium Scrub Alloy Trade Study (February 1996)

- *Environmental Assessment, Finding of No Significant Impact, and Response to Comments - Solid Residue Treatment, Repackaging, and Storage*, DOE/EA-1120, (April, 1996)

- *Residue Program Rebaselining: Phase I Recommendation for Rebaselining Salts, SS&C, and Graphite Fines* (the Rocky Flats Rebaselining Study) (December 1996)

- *Residue Program Rebaselining: Phase II Recommendation for Rebaselining Ash, Combustibles, Fluorides, Sludges, Glass, and Firebrick and Inorganics* (January 1997)

After identifying a preliminary set of processing technologies from these studies, DOE screened the technologies further, using a set of criteria that included the following:

- direct applicability of the technology to the particular material type,

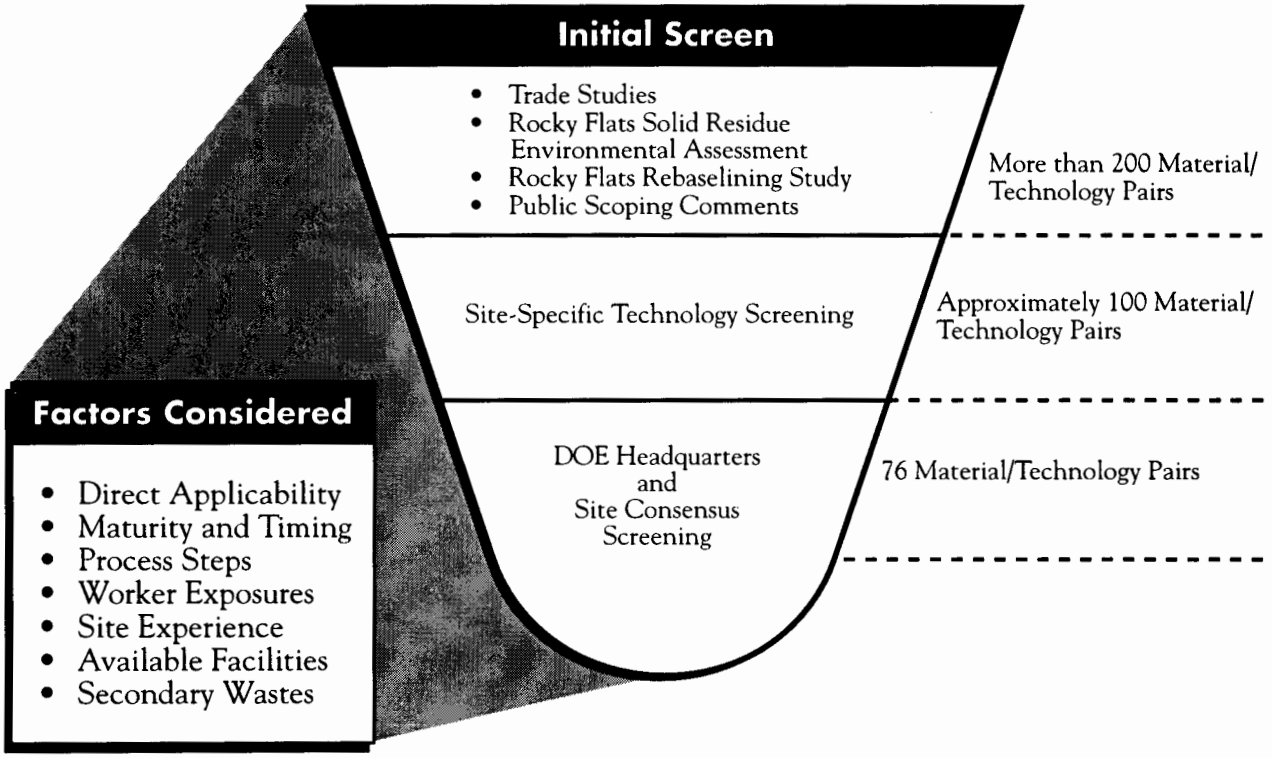
- maturity and timing of the technology so that processing could be accomplished in the 1998-2004 timeframe within reasonable cost,

- experience of the DOE site in employing the technology and availability of facilities and equipment,

- minimization of the number of process steps to minimize worker exposures, and

- amount of secondary wastes generated and appropriate secondary waste disposition methods.

Next, several working sessions were held between DOE Headquarters and site technical and management representatives to better understand the suitability of the technologies to be applied to each material type, the experience of the sites with the technologies, and the capability of the sites to implement the technologies within the desired timeframe. An attempt was made to ensure that the processes selected for evaluation in this EIS included at least one process that did not involve plutonium separation and one that included plutonium separation for each material category. These discussions were the basis for selecting the technologies included in this Draft EIS.



2.5 DESCRIPTION OF PROCESSING TECHNOLOGIES (OPTIONS)

This section presents a summary description of processing technologies evaluated in this EIS for the various material categories. Each material category was evaluated using the processes included in the No Action Alternative (i.e., those processes included in the Solid Residue Environmental Assessment), one or more processes that do not include separation of plutonium from the material, and one or more processes that include separation of plutonium from the material. Processing technologies that are applicable to each of the material categories and subcategories and DOE's preferred alternative are identified in Figure S-3. A brief overview of each of the technologies is presented in Figures S-4, S-5, and S-6. Figures S-7 through S-16 identify, for each material type, the paths from processing to ultimate disposition for the applicable processing technologies. Detailed descriptions of the processing technologies are contained in Chapter 2 and Appendix C of the EIS.

Figure S-3. Processing Technologies

MATERIAL CATEGORIES	PROCESSING TECHNOLOGIES: NO ACTION (All Stabilizations Would Occur at Rocky Flats)								WITHOUT PLUTONIUM SEPARATION* (All Processing Would Occur at Rocky Flats)						WITH PLUTONIUM SEPARATION*					
	Calcination	Cementation	Pyro-Oxidation	Neutralization/Dry	Thermal Desorption/Steam Passivation	Repackaging	Acid Dissolution/Plutonium Oxide Recovery	Filtration/Dry	Cementation	Calcination/Vitrification	Blend Down	Catalytic Chemical Oxidation	Fluidized Bed Incineration	Sonic Wash	Acid DissolutionPlutonium Oxide Recovery at Rocky Flats	Purex Process/Plutonium Metal or Oxide Recovery (would only occur at the Savannah River Site)	Mediated Electrochemical Oxidation (could occur at Rocky Flats or the Savannah River Site)	Salt Distillation (the process could occur at Rocky Flats or Los Alamos National Laboratory)	Salt Scrub (the process at Rocky Flats requires subsequent processing at the Savannah River Site)	Water Leach (the process would occur at Rocky Flats or Los Alamos National Laboratory)
ASH RESIDUES																				
Incinerator Ash Residues	●	●								■	●					●	●			
Sand, Slag, and Crucible Residues	●	●								●	●					■				
Graphite Fines Residues		●								■	●						●			
Inorganic Ash Residues	●	●								■	●									
PYROCHEMICAL SALT RESIDUES																				
Molten Salt Extraction/Electrorefining			●								●							■	●	●
Direct Oxide Reduction			●								●								●	■
COMBUSTIBLE RESIDUES																				
Aqueous-Contaminated				■							●	●	NR	●			●			
Organic-Contaminated					■						●	●	NR	●			●			
Dry						■					●	●	NR	●			●			
PLUTONIUM FLUORIDE RESIDUES							●				●				●	■				
FILTER MEDIA RESIDUES				●						●	●		NR	●			●			
SLUDGE RESIDUES								●		●	●				●					
GLASS RESIDUES				■						●	●			●			●			
GRAPHITE RESIDUES						■			●	●	●						●			
INORGANIC (Metal & Other) RESIDUES						■				●	●						●			
SCRUB ALLOY						●				N						■				

* *May also require stabilization processes included under No Action*

■ = *Preferred processing option (refer to Section 2.6 of this Summary). Preferred processing options have not yet been identified for filter media or sludge residues.*

● = *Other Technical Options*

N = *Nonpreferred Approach*

NR = *DOE considers that this option is not a reasonable alternative.*

Figure S-4. Processing Technologies for Alternative 1 (No Action)

Calcination – To provide a more chemically stable form of ash residues, calcination involves heating the ash residues in a furnace at 500°C to convert reactive metals, carbon, and organics to unreactive oxides. This step is necessary to place ash residues into a form suitable for cementation and subsequent packaging and storage. It is also a first step in preparing ash residues for processing without plutonium separation (vitrification) or for shipment to the Savannah River Site for processing with plutonium separation.

Cementation – An adaptation of the immobilization process widely used within DOE and the commercial industry and approved by the Environmental Protection Agency as a Best Demonstrated Available Technology for waste stabilization. After calcining the ash residues and crushing any oversize pieces (creating stabilized residue fines), the cementation process blends Portland cement and water with the ash residues, creating a solid material for packaging and storage.

Pyro-Oxidation – A process that converts reactive metals in salt residues to nonreactive oxides for a more chemically stable waste form. Pyrochemical salt residues and an oxidant are placed in a crucible and heated in a furnace to about 800°C. The result is a stabilized, solidified salt form ready for packaging and storage. This process would also be a first step in preparing pyrochemical salt residues for processing without plutonium separation (e.g., blending down) or for processing with plutonium separation.

Neutralization/Dry – A washing and drying process for combustible, filter media, and glass residues to remove nitrate contamination, neutralize any residual nitric acid and eliminate the potential flammability hazard. The residues are washed in potassium hydroxide to convert the acid to potassium nitrate and water. Combustible solids are separated from the nitrate solution, decanted, filtered, transferred to a drying pan, and dried under a vacuum at 80°C for 2 hours. The result is a neutralized dry solid ready for packaging and storage. The spent neutralization solution would go to the site's wastewater treatment process.

Thermal Desorption/Steam Passivation – A heating process that removes the organic solvent contaminants from combustible residues and converts plutonium fines in the residues to plutonium oxide. Batches of combustible residues are heated to 80°C for 2 hours under reduced pressure to volatilize the organic solvent contaminants. Offgases are collected on granulated activated charcoal. Then, low temperature steam is injected for 1 hour to oxidize any plutonium fines present in the residue. Upon cooling, dry absorbent is added to dry the wet matrix, and the result is a shredded combustible waste and absorbent ready for packaging and storage.

Repackaging – The direct repackaging of the dry combustible residues, graphite residues, inorganic residues, and scrub alloy that are presently in a physical or chemical form that requires repackaging, but no additional processing, to meet interim safe storage criteria. Repackaging is conducted in gloveboxes and consists of unpacking the existing storage drums and the plastic bags inside the drums, sorting the residues, and repackaging them into metal containers. If the materials require size reduction and/or compaction to minimize the volume, they will be transferred to a size reduction station for shredding or compaction. After packaging and nondestructive assay, the metal containers are loaded into pipe components, which are staged inside 208-liter (55-gallon) drums, for safe interim storage.

Acid Dissolution/Plutonium Oxide Recovery – Conducted in a glovebox, this process dissolves plutonium fluorides into a slurry, followed by precipitation and filtration of plutonium oxalate. That precipitate is then calcined and packaged as plutonium oxide. The filtrate from the oxalate precipitation is processed with magnesium hydroxide to precipitate the plutonium remaining in the solution. The magnesium hydroxide contaminated with plutonium is then removed and calcined, resulting in a stabilized form for packaging and storage.

Filter/Dry – A process used on sludge residues to remove any excess liquid and dry the remaining material by mixing with an absorbent. First, unwanted materials in the sludge (plastics, metals, or free liquids) are removed and managed appropriately. After decanting, the sludge is packed, along with absorbent for drying, into metal containers and sealed for packaging into pipe components and drums for storage.

Figure S-5. Processing Technologies for Alternative 2 — Processing without Plutonium Separation

Cementation – As a processing technology for graphite residues, this would be the same process used in Alternative 1 (No Action) for ash residues. In this case, cementation will result in an acceptable waste form for WIPP disposal for graphite molds, scarfed graphite molds, coarse graphite, and coarse firebrick.

Calcination/Vitrification – An immobilization process similar in concept to calcination in which the residues are heated in a furnace to produce a vitrified solid material. The process is conducted in gloveboxes, where a siliceous material called "frit" is added to the residues, and the material is heated in a muffle furnace at temperatures between 700°C and 1,300°C for about 4 hours. The result is a stable, glassified (vitrified) monolith that fits into an 8 x 10 inch metal can. This process could be applied to several categories of residues (ash, filter media, sludge, glass, graphite, and inorganic) and the scrub alloy. Scrub alloy is first converted to an oxide by burning and calcining at 600°C and 1,000°C, respectively. Then the calcined material is blended with sufficient glass frit to make a product that would satisfy the safeguards termination limits, and heated in a furnace to a temperature of 700°C - 1,300°C. The end product would consist of a vitrified monolith containing less than 5 percent plutonium. This technology, although technically viable, is considered by DOE to be a "non-preferred" processing option for scrub alloy at Rocky Flats. This is because the disposition of scrub alloy at WIPP has not been programmatically evaluated.

Blend Down – A process for diluting the concentration of plutonium in all categories of plutonium residues (but not scrub alloy) so that each container will meet safeguards termination limits. An inert material, such as uranium oxide, salt, or magnesium oxide, is added to create a mixture of materials with a smaller weight percentage of plutonium. Residues with a plutonium concentration below the safeguards termination limit may also be used. The dilution would initially create a larger waste mixture, which would then be reduced into smaller batches and calcined at 900°C. Calcination would eliminate water and oxidize any carbon or organic compounds into carbon dioxide.

Digestion (Catalytic Chemical Oxidation or Detox Process) – A process used to digest organic materials in combustible residues. The process uses catalysts, dissolved in acid, to oxidize organic materials and to dissolve metals associated with the residues. The metals, including plutonium, are converted to metal oxides by boiling down the solution. The residual metal oxides would be placed in containers for storage pending disposal at the WIPP.

Fluidized Bed Incineration – A two-stage flameless combustion process used as the representative technology for thermal destruction of combustible and filter media residues. This process relies upon the heat transfer characteristics of a fluidized bed to destroy combustible matrices in a controllable manner, resulting in a solid material (dry powder) containing stable oxides, which can be packaged and stored for ultimate disposal. The process involves shredding and heating the materials in a fluidized bed vessel (containing a catalyst and a sorbent) to about 500°C. Organic materials are pyrolyzed and acidic offgases are neutralized. A secondary fluidized bed converts the other gases to carbon dioxide and water, which are then passed over a catalytic converter and through high-efficiency particulate air filters before being exhausted.

DOE does not consider fluidized bed incineration a reasonable processing option. However, to provide the public a better understanding of the process, the results of the impact assessments are included in this EIS. There is no way that DOE will consider this process as acceptable for implementation.

Sonic Wash – A process to physically separate plutonium from combustible, filter media, and glass residues using sound waves. The materials are shredded, lowered into a sonic wash unit containing a weak caustic solution, and agitated by sound waves. The sonic agitation dislodges a portion of the transuranic oxides and other higher-density materials from the surfaces of the matrix. The dislodged materials would settle to the bottom, and the washed matrix would be dried and repackaged for shipment to WIPP for disposal. The settled transuranic-laden materials or sludges would be filtered from the wash, dried, and stored until they could be batched for immobilization (vitrification for combustible and filter media residues and calcining for glass residues). The immobilized settlings would be packaged for ultimate disposal. The effluent streams from the filtration and rinsing steps are evaporated and recycled back to the sonic wash unit.

Figure S-6. Processing Technologies for Alternative 3 — Processing with Plutonium Separation

Acid Dissolution/Plutonium Oxide Recovery – A process to recover plutonium from plutonium fluoride residues and sludge residues by dissolving them in nitric acid and precipitating the plutonium with oxalic acid. The resulting plutonium oxalate slurry would be filtered, precipitated, filtered again, calcined at 450°C, and packaged for interim storage and ultimate disposal at WIPP. The plutonium oxalate filter cake would be calcined at 450°C until it results in a dry plutonium oxide cake, which would be packaged and temporarily stored until it could be calcined at 1,000°C to remove volatile constituents. The recalcined plutonium oxide would then be repackaged to meet DOE standards for interim storage pending disposition in accordance with decisions reached under the Surplus Plutonium Disposition Environmental Impact Statement.

Purex Process/Plutonium Metal or Oxide Recovery – A process developed for plutonium extraction and recovery. It would use a Canyon facility at the Savannah River Site to process ash residues (except for graphite fines and inorganic ash), plutonium fluoride, and scrub alloy. These materials would be dissolved in nitric acid and separated into a waste fraction and a plutonium-bearing fraction. The waste fraction would be added to the Site's high-level waste storage system, where solids would be vitrified with other high-level wastes at the Defense Waste Processing Facility, and residual liquids would be solidified as saltstone. The plutonium-bearing fraction would be transferred to a finishing line (FB/HB), precipitated and converted to stable oxide or metal, and packaged to meet DOE standards for interim storage pending disposition in accordance with decisions reached under the Surplus Plutonium Disposition Environmental Impact Statement.

Mediated Electrochemical Oxidation – Similar to the Purex and acid dissolution/plutonium oxide recovery processes described above, but would also use oxidized silver ions generated in an electrochemical cell to catalyze the dissolution of normally unreactive plutonium compounds. Undissolved materials remaining after mediated electrochemical oxidation processing would be removed by filtration, dried, and packaged for shipment to WIPP for disposal as transuranic wastes. Plutonium dissolved in the nitric acid/silver nitrate solution would be processed differently, however, depending on the nature of the materials and the facilities available for processing it.

Plutonium from mediated electrochemical oxidation dissolution of glass and inorganic residues at the Savannah River Site, and from mediated electrochemical oxidation processing of all ash residues, would be processed through the Purex system. Here the plutonium would be reduced to metallic or oxide form and packaged to meet DOE standards for interim storage pending disposition in accordance with decisions reached under the Surplus Plutonium Disposition Environmental Impact Statement. Plutonium-bearing solutions from mediated electrochemical oxidation-treated glass and inorganic residues at Rocky Flats, as well as from mediated electrochemical oxidation-treated combustible waste, filter media, and graphite residues, would be treated with oxalic acid to precipitate the plutonium as an oxalate. This oxalate would then be calcined, recalcined, and packaged for long-term storage using the same plutonium oxide recovery process described above under the acid dissolution alternative.

Salt Distillation – A process that separates transuranic materials from a potassium chloride or sodium chloride salt matrix by using a special furnace to distill these salts away from any metal oxides in the matrix. The salt matrix would first be pyro-oxidized, as described in Alternative 1 (No Action), and then heated under vacuum in the distillation furnace to about 950°C for about 6 hours. The distilled salts would be stored for ultimate disposition at WIPP. The metal oxides and undistilled salts, such as calcium chloride, would be calcined at 1,000°C for 4 hours and packaged for interim storage pending disposition in accordance with decisions reached under the Surplus Plutonium Disposition Environmental Impact Statement. Salt distillation would be used only for salt residues from pyrochemical processing, such as electrorefining and molten salt extraction.

Salt Scrub – A process that recovers plutonium from salt residues by heating them in a crucible with magnesium and aluminum, or gallium and calcium, inside a glovebox furnace. The magnesium or calcium reduces any plutonium and americium chlorides in these residues to metallic form, allowing the metals to be extracted in an alloy with the aluminum or gallium. Heated to 800°C for 2 hours, this alloy (called scrub alloy) separates from the salts and forms a metallic button at the bottom of the crucible. After cooling, the scrub alloy button would be sent to the Savannah River Site for Purex processing, as described above, to reduce the plutonium to metal or oxide, and packaged to meet DOE standards for interim storage pending disposition in accordance with decisions reached under the Surplus Plutonium Disposition Environmental Impact Statement. The residual salts removed from the crucible would be batched to meet safeguards termination limits and pyro-oxidized as described above to stabilize any reactive metals before packaging and shipment to WIPP for disposal. Salt scrubbing could remove plutonium from calcium chloride, as well as sodium chloride/potassium residues.

Water Leach – A dissolution process to recover plutonium from pyro-oxidized pyrochemical salts using water leach. The salt is first pyro-oxidized, as discussed under Alternative 1 (No Action), then placed in a leaching vessel with water added. Because the pyro-oxidation process produces an excess of sodium oxide, the resulting solution would be alkaline. The alkaline slurry is then vacuum-filtered, leaving a damp solid filter cake of plutonium/americium oxide, which is then calcined at 1,000°C for 4 hours to remove any remaining volatile materials. The oxide material would be packaged for interim storage pending disposition in accordance with decisions reached under the Surplus Plutonium Disposition Environmental Impact Statement. The filtrate would be evaporated, leaving a lean salt that would be packaged according to WIPP waste acceptance criteria and placed in interim storage pending disposal at WIPP.

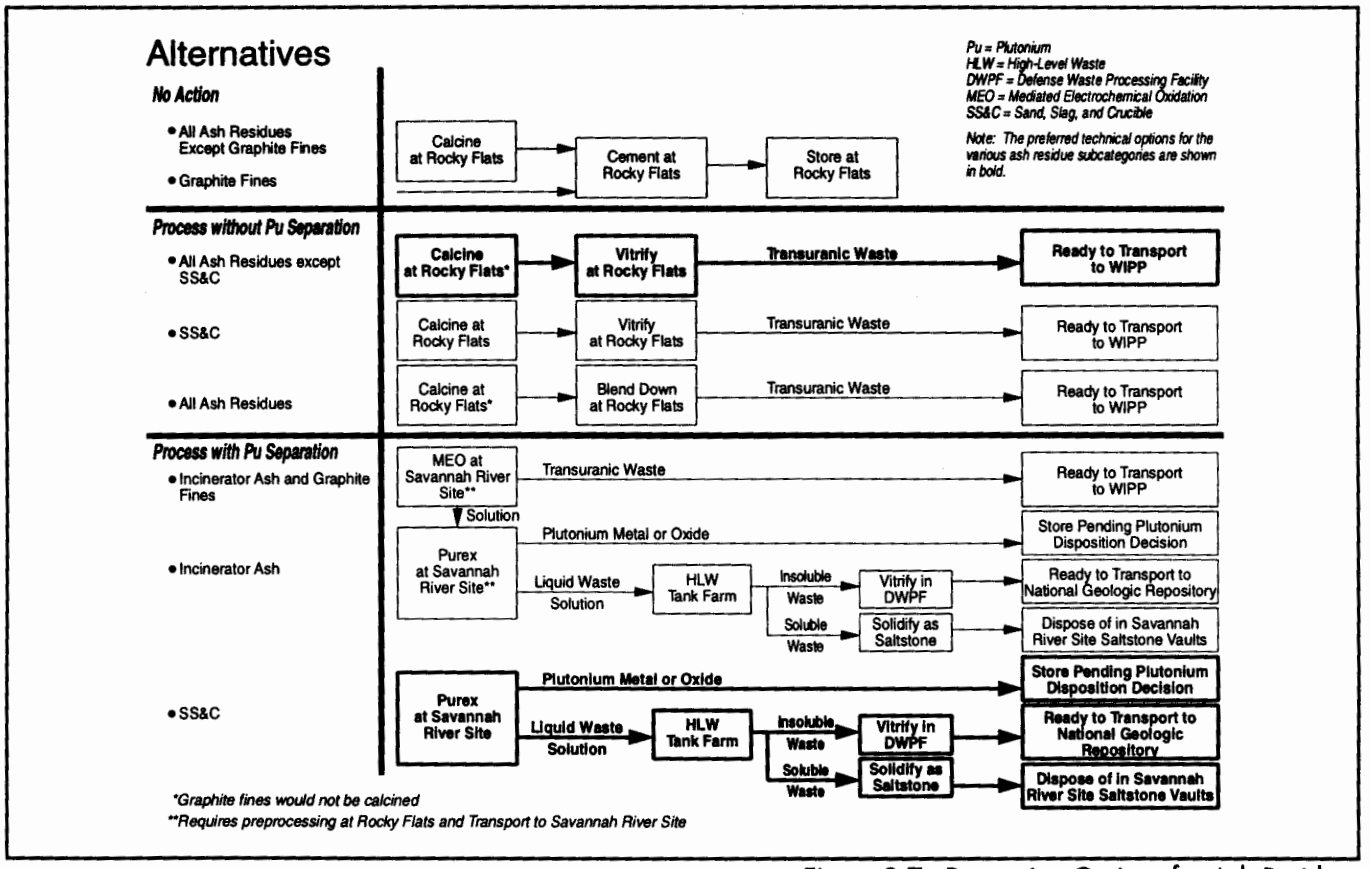


Figure S-7. Processing Options for Ash Residues

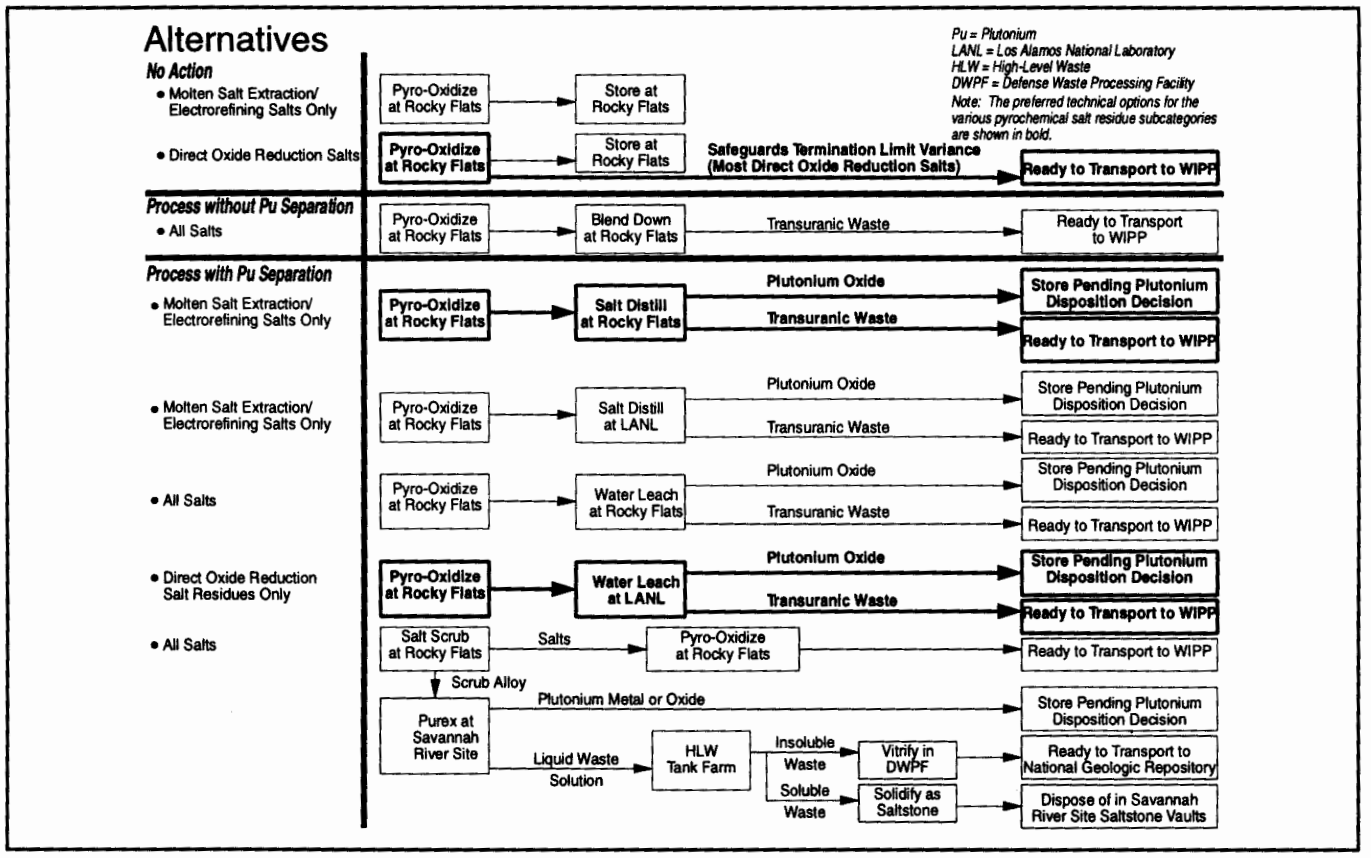


Figure S-8. Processing Options for Pyrochemical Salt Residues

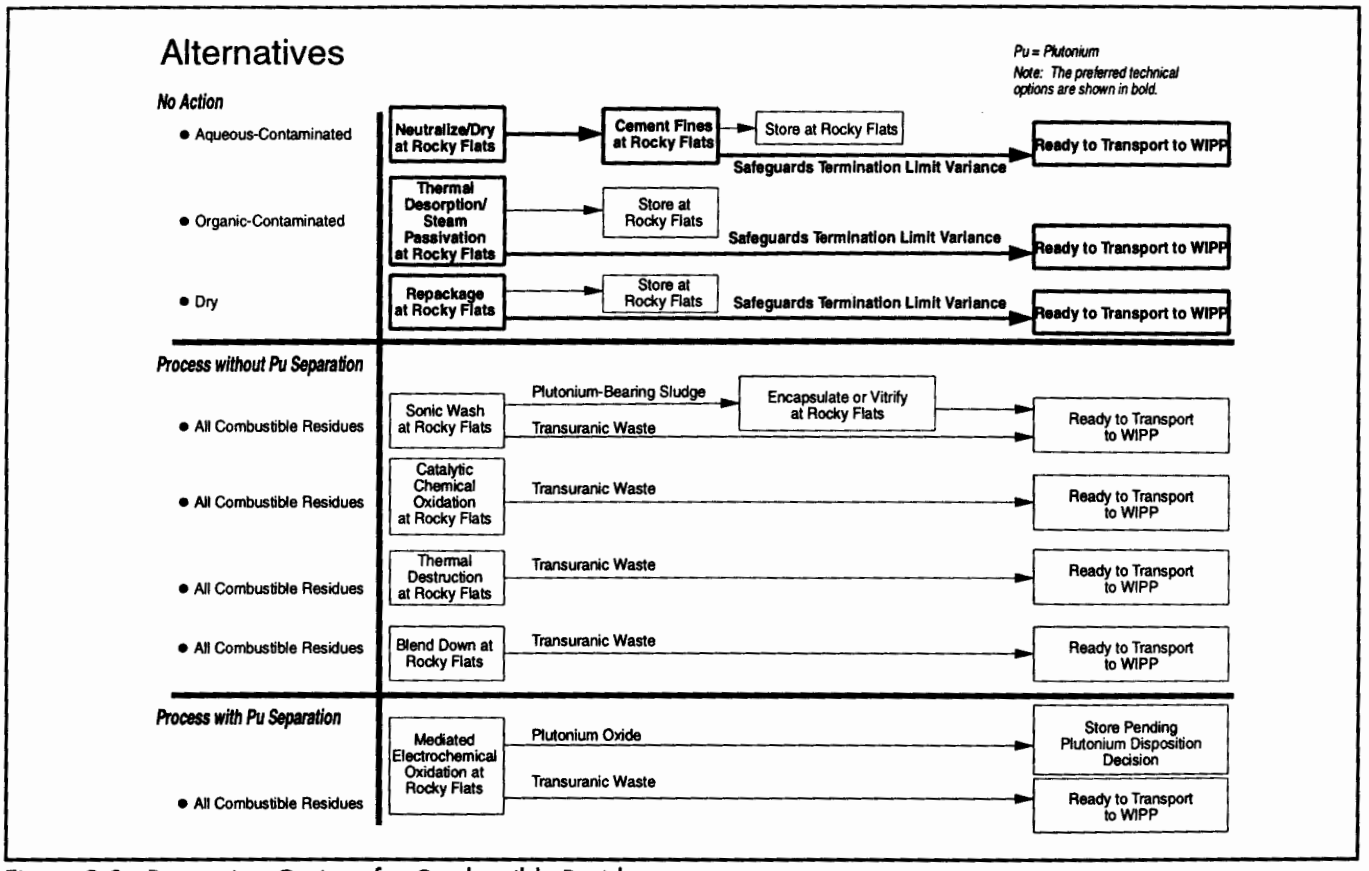


Figure S-9. Processing Options for Combustible Residues

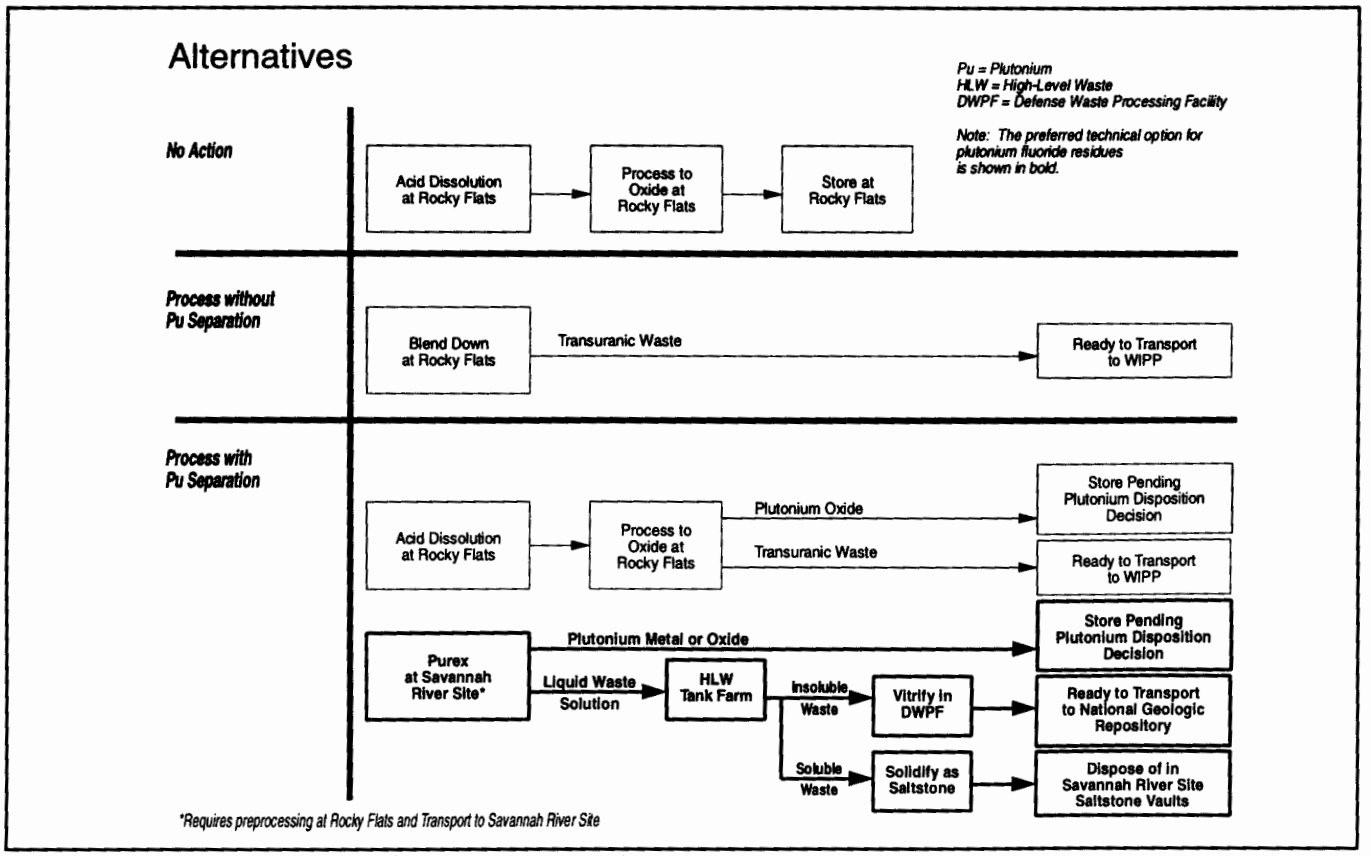


Figure S-10. Processing Options for Plutonium Fluoride Residues

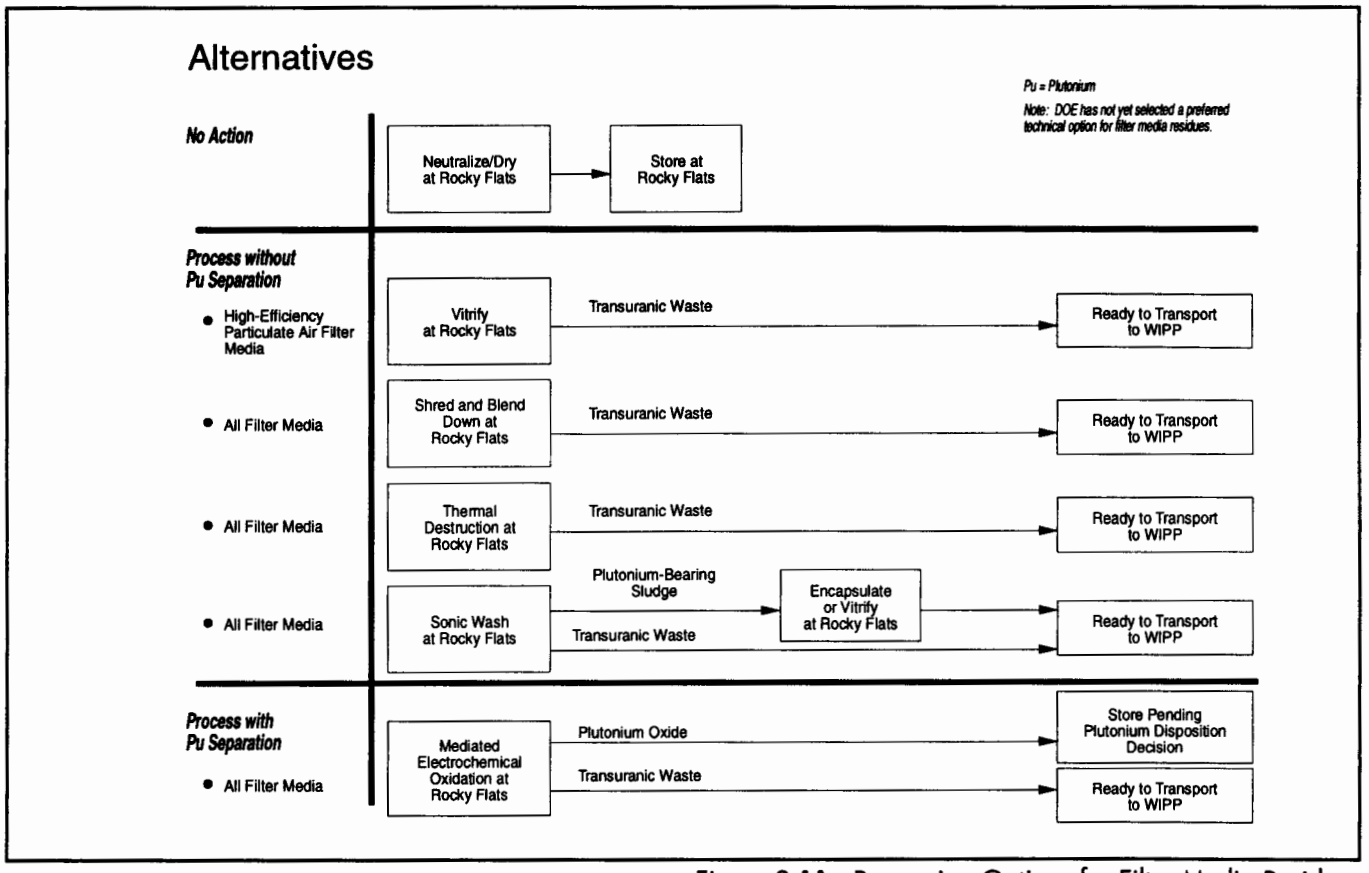


Figure S-11. Processing Options for Filter Media Residues

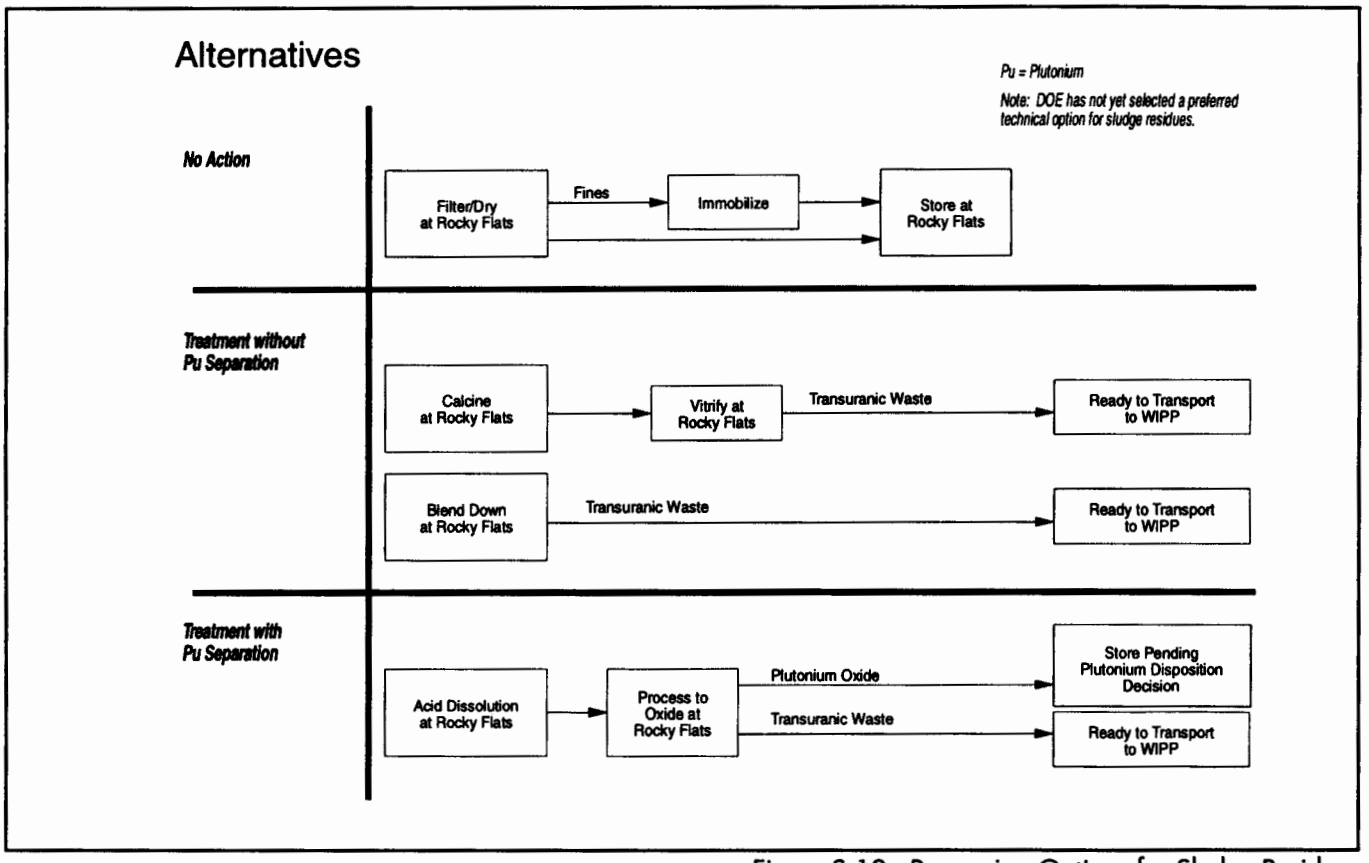


Figure S-12. Processing Options for Sludge Residues

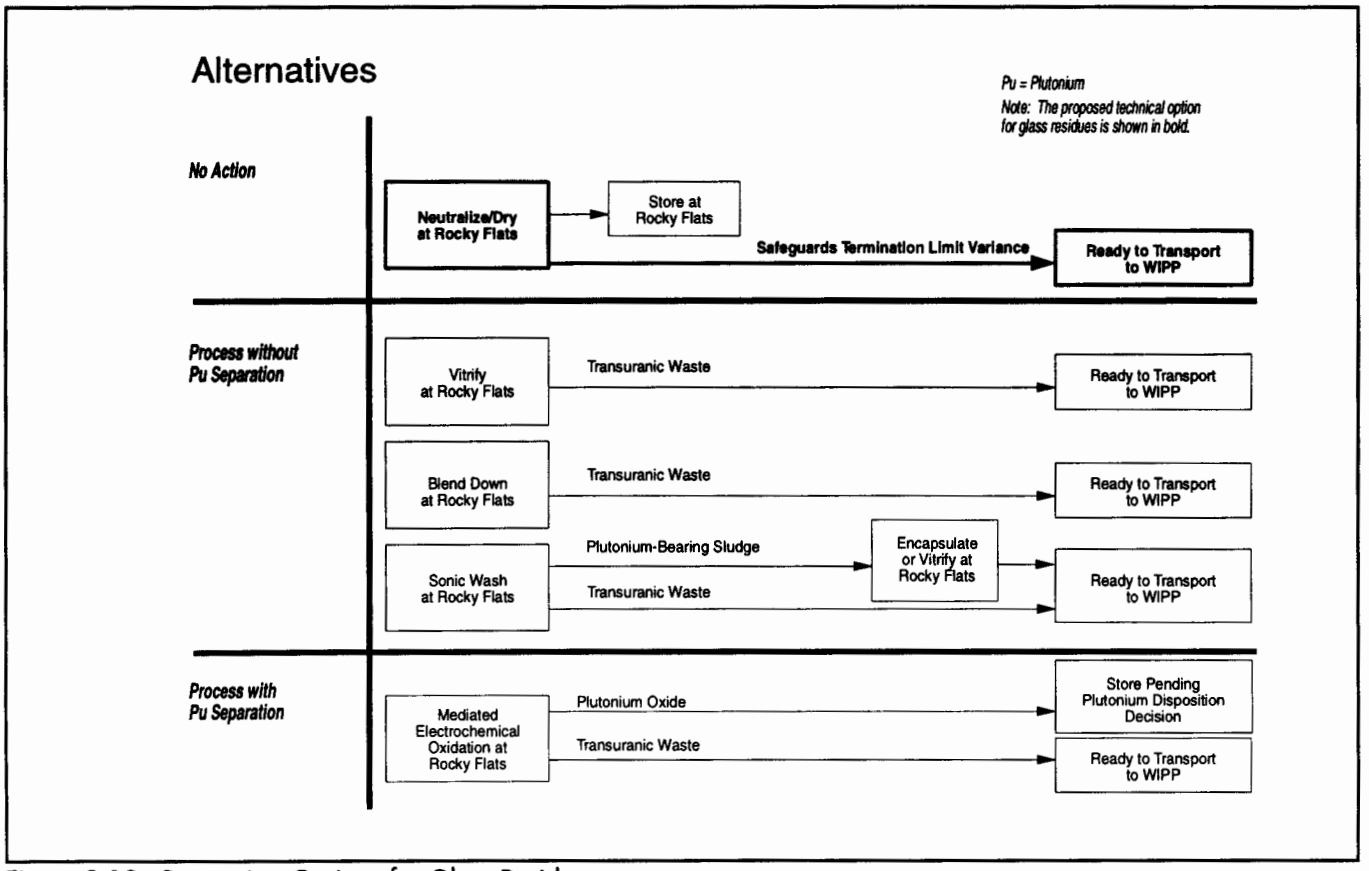


Figure S-13. Processing Options for Glass Residues

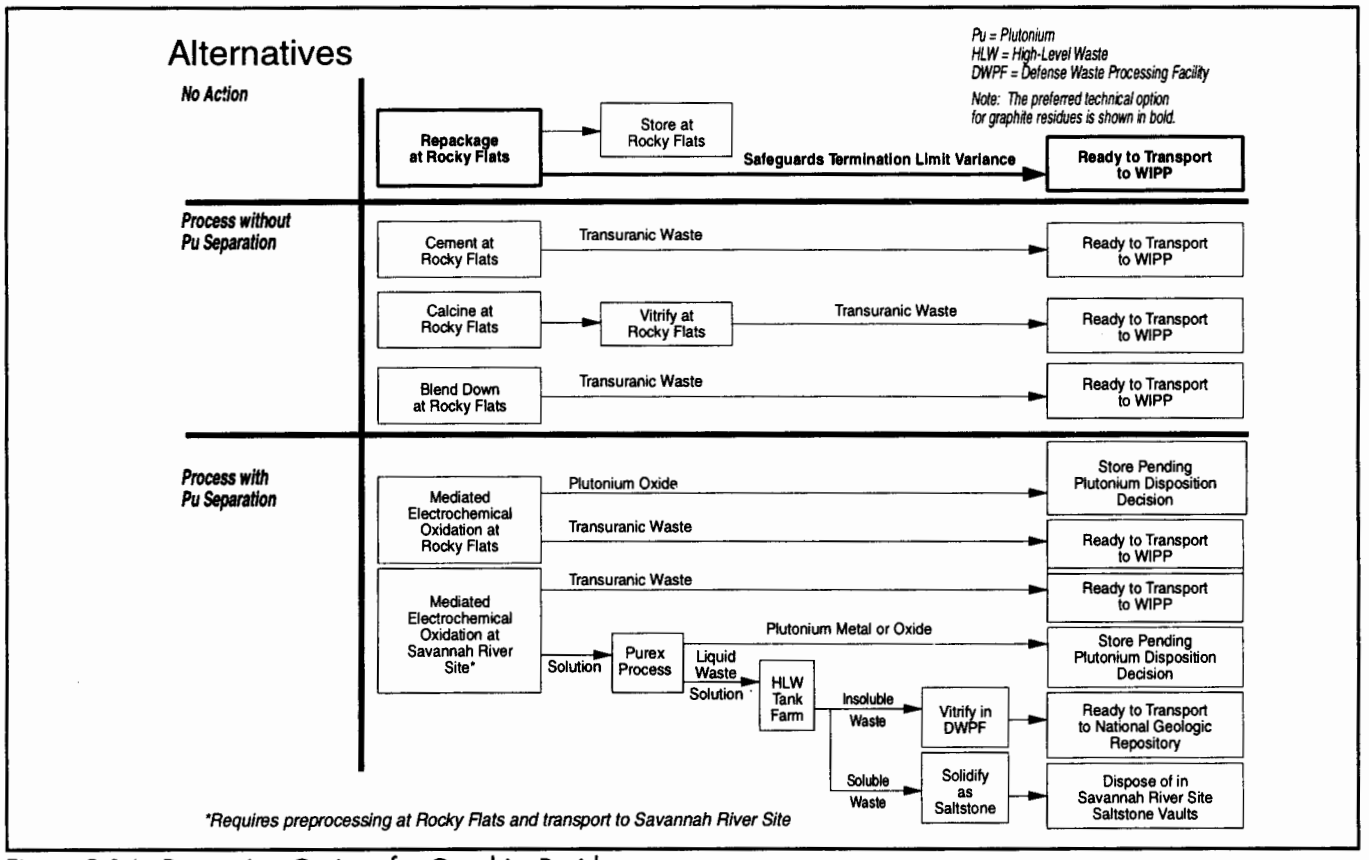


Figure S-14. Processing Options for Graphite Residues

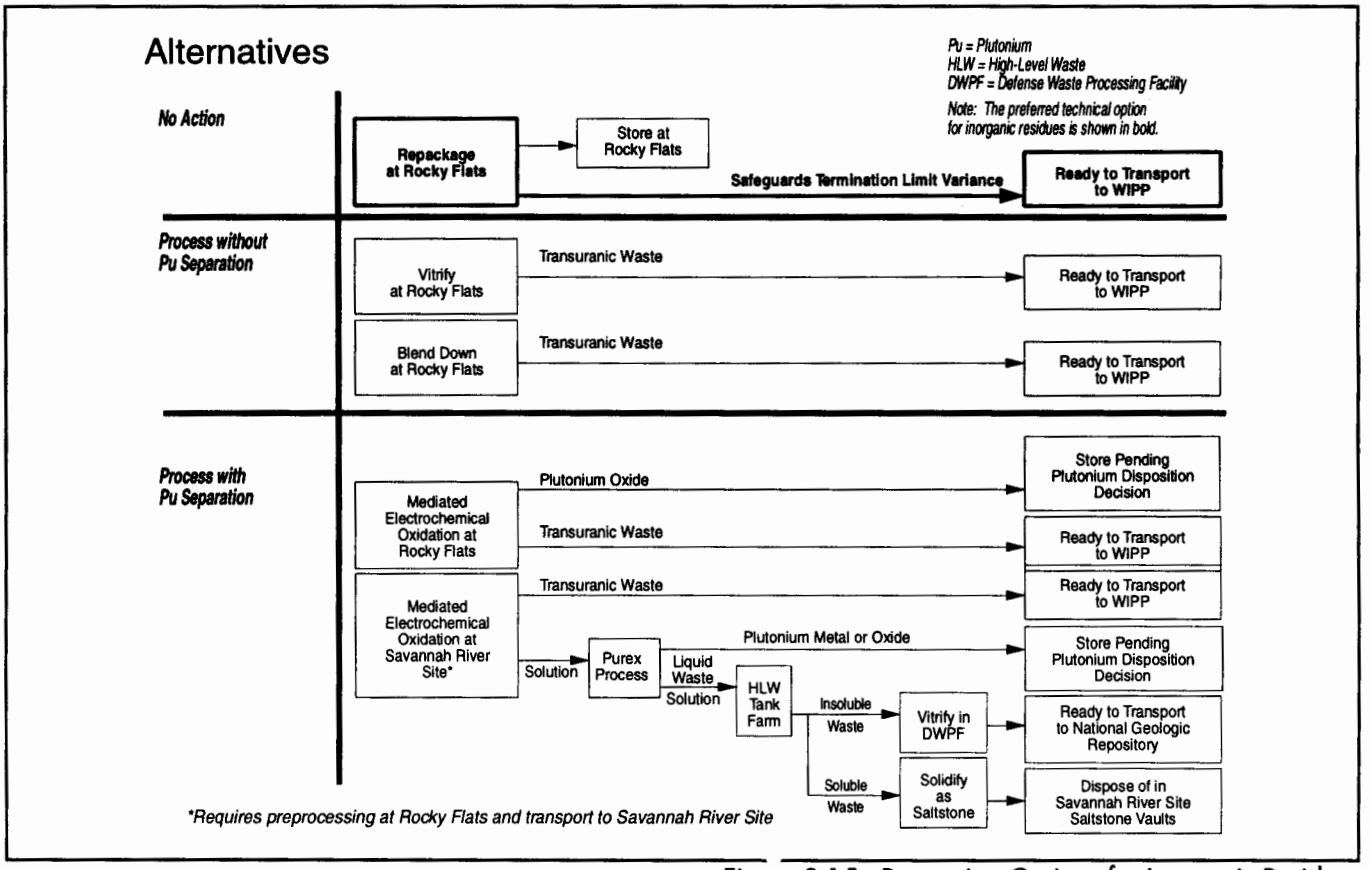


Figure S-15. Processing Options for Inorganic Residues

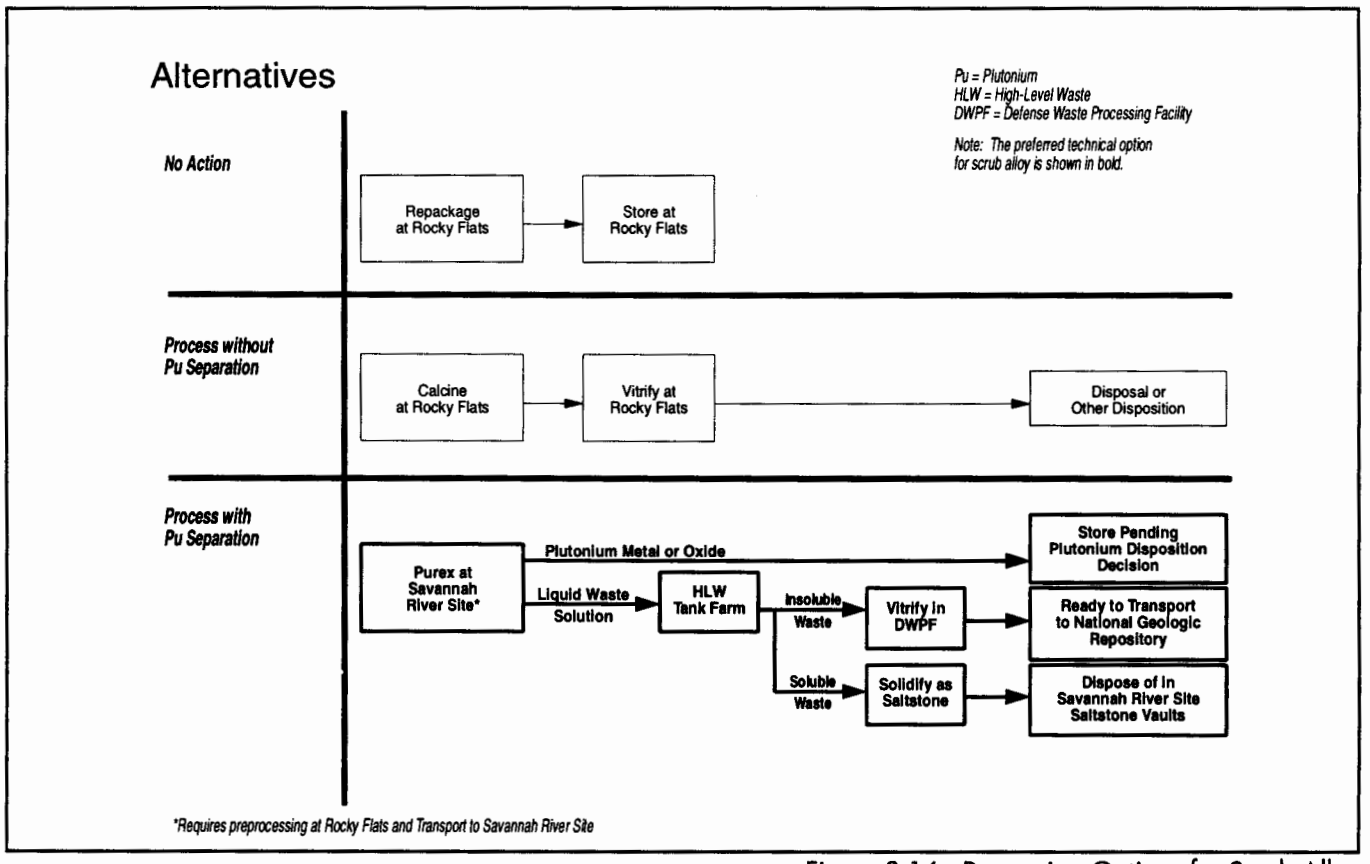


Figure S-16. Processing Options for Scrub Alloy

2.6 PREFERRED PROCESSING OPTIONS

In this EIS, DOE has identified a preferred option for processing most of the Rocky Flats plutonium residues and scrub alloy that potentially do not meet safeguards termination limits for plutonium concentrations, but not for all of the material categories. The material categories and preferred processing methods are listed in Table S-2. Taken as a group, the compilation of the preferred processing options constitutes the Preferred Strategic Management Approach for this EIS.

Table S-2. Stabilization Technology Used in the No Action Alternative of Each Material Category.

MATERIAL	PREFERRED PROCESS OPTION
Ash residues (incinerator ash)	Vitrification at Rocky Flats (See Section 2.4.1)
Ash residues (sand, slag, and crucible)	Purex processing at the Savannah River Site (See Section 2.4.1)
Ash residues (graphite fines)	Vitrification at Rocky Flats (See Section 2.4.1)
Ash residues (inorganic)	Vitrification at Rocky Flats (See Section 2.4.1)
Molten salt extraction/electrorefining salt residues (sodium chloride/potassium chloride salts)	Salt distillation at Rocky Flats (See Section 2.4.2)
Direct oxide reduction salt residues (calcium chloride salts) *	Pyro-oxidation at Rocky Flats and water leach at Los Alamos National Laboratory (No Action for some) (See Section 2.4.2)
Combustible residues (aqueous-contaminated) *	Neutralize/dry at Rocky Flats (No Action) (See Section 2.4.3)
Combustible residues (organic-contaminated) *	Wash/thermal desorption/steam passivation at Rocky Flats (No Action) (See Section 2.4.3)
Combustible residues (dry) *	Repackage at Rocky Flats (No Action) (See Section 2.4.3)
Plutonium fluoride residues	Purex processing at the Savannah River Site (See Section 2.4.4)
Filter media residues	TBD
Sludge residues	TBD
Glass residues *	Neutralize/dry at Rocky Flats (No Action) (See Section 2.4.7)
Graphite residues *	Repackage at Rocky Flats (No Action) (See Section 2.4.8)
Inorganic (metal and others) residues *	Repackage at Rocky Flats (No Action) (See Section 2.4.9)
Scrub alloy	Purex process at the Savannah River Site (See Section 2.4.10)

TBD = To be determined. DOE has not yet selected a preferred processing option.

* DOE granted safeguards termination limit variances for these categories. This allows these materials to be sent to WIPP for disposal as transuranic waste without additional processing. Only part of the direct oxide reduction salts were granted a safeguards termination limit variance.

2.7 STORAGE METHODS AND ISSUES

Because of public concerns about plutonium prior to its ultimate disposition, this EIS discusses the storage methods in detail. Storage was considered for two categories of materials: (1) plutonium residues and scrub alloy and (2) plutonium metal and oxides. Rocky Flats transuranic waste storage capacity is not explicitly addressed in this EIS; however, it may become an issue if WIPP does not open on time.

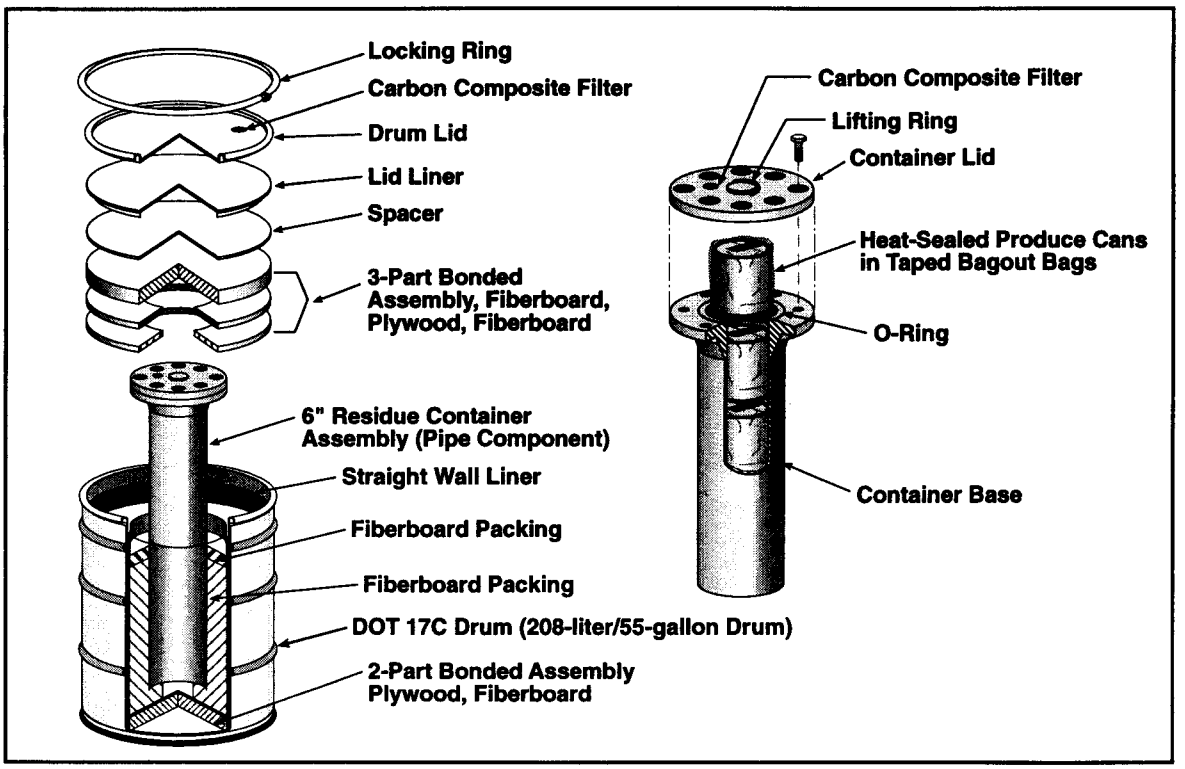
2.7.1. Storage of Plutonium Residues and Scrub Alloy

Plutonium residues and scrub alloy are stored in accordance with DOE guidance contained in *Criteria for Interim Safe Storage of Plutonium-Bearing Solid Material.* This guidance is included as an addendum to the DOE Implementation Plan for the Defense Nuclear Facilities Safety Board's Recommendation 94-1, dated February 28, 1995, which addresses remediation in the defense nuclear facilities complex.

Processed residues and scrub alloy, containing less than 50 percent plutonium by weight, are packaged in storage containers that provide multiple barriers. While in the glovebox, the material is placed into "produce cans," which are small sealed cans similar to those used for storage of food products. The "produce cans" are then sealed inside plastic "bagout bags" as they are removed from the glovebox. The next layer of containment is the "pipe component," which is a flanged stainless-steel pipe measuring 6-12 inches in diameter. A lid bolted to the flange allows the residue material to be sealed within the pipe, which is then placed inside a 208-liter (55-gallon) storage drum. (See figure below.) Processes from Alternatives 2 and 3 would produce transuranic waste that may be packaged in this way. When ready for transport to WIPP, the drums would then be placed into the TRUPACT II container, which is the Nuclear Regulatory Commission-certified and Department of Transportation-approved shipping container (Section 2.10).

Residues and scrub alloy awaiting transfer to another onsite facility or an offsite facility (Savannah River Site or Los Alamos National Laboratory) for further processing are stored temporarily in one of a number of double-containment, intrasite packagings. Prior to shipment offsite, the double-contained packages would be placed into shielded containers authorized by DOE and the Department of Transportation for shipment (Section 2.10).

Department of Transportation 17C Drum with 6" Residue Container



2.7.2. Storage of Plutonium Metal and Oxides

Processing the residues and scrub alloy under Alternative 3 would result in stabilized metals or oxides, which would be placed into safe and secure storage pending disposition in accordance with decisions reached under the Surplus Plutonium Disposition Environmental Impact Statement.

To ensure safe storage conditions, DOE has issued guidance that plutonium should not be stored in the form of plutonium solutions, metal turnings, or particles with a specific surface area greater than one square centimeter per gram (DOE 1995). Plutonium metal items should be free of hazardous or pyrophoric materials or corrosion products. Plutonium oxides should be stabilized at 1,000°C for 1 hour. In packaging, no plastic should contact plutonium metal or oxide, and metal should be packaged in as dry and inert an atmosphere as possible. Existing metal packages should be inspected for external corrosion, and packages containing more than 0.5 kg (1.1 lb) plutonium metal should be weighed annually.

Safe long-term storage of plutonium metal and oxide is addressed by DOE-STD-3013-96, *DOE Standard: Criteria for Preparing and Packaging Plutonium Metals and Oxides for Long-Term Storage* (September 1996). This standard establishes criteria for packaging plutonium metals and stabilized plutonium oxides to ensure safe storage for at least 50 years. The standard applies to packaging for storage of plutonium metals, alloys, and oxides that contain at least 50 percent plutonium by mass. To meet the standard, materials containing plutonium must be in stable forms and must be packaged in containers designed to maintain their integrity both under normal storage conditions and during handling accidents.

2.8 DISPOSAL OR OTHER DISPOSITION

This section provides an overview of the disposition paths for the processed residues and scrub alloy covered by this EIS and for any separated plutonium that would occur under Alternative 3. The impacts of disposition are evaluated in other EISs that address the disposition of transuranic waste at WIPP and disposition of surplus plutonium and, thus, are not evaluated in this EIS. However, disposal in WIPP of transuranic waste generated from processing scrub alloy will require additional NEPA review. Such disposal may also require changes to current legal limitations on WIPP.

Under the No Action Alternative, no material would be sufficiently prepared for disposition, as discussed in more detail in Section 1 of this Summary, unless safeguards termination limit variances are applied. Under implementation of the Proposed Action, materials processing would result in transuranic waste that could be transported to WIPP for disposal. The environmental impacts of shipping transuranic waste to WIPP and the impact of disposal at that site are covered in the *Waste Isolation Pilot Plant Disposal Phase, Final Supplemental Environmental Impact Statement* (DOE/EIS-0026-S-2, September 1997).

Separated plutonium (under Alternative 3) would be stored in a metal or oxide form pending decisions to be reached under the Surplus Plutonium Disposition EIS. During the process to separate plutonium, some waste streams may be produced that have the characteristics of high-level waste, low-level waste, or mixed waste. These waste streams would be managed according to the waste management practices for these waste types at the treatment site.

2.9 TRANSPORTATION FOR OFFSITE PROCESSING

If a decision is made to ship Rocky Flats plutonium residues and/or scrub alloy offsite for processing with plutonium separation, up to about 208 truck shipments to the Savannah River Site and up to about 62 shipments to the Los Alamos National Laboratory could occur during the timeframe of approximately 1998-2004 (averaging about 3 shipments per month to Savannah River Site and less than 1 shipment per month to Los Alamos National Laboratory). Because some materials could be transported to either the Savannah River Site or Los Alamos National Laboratory, but not both, the total number of shipments could not exceed 244. The shipments would be

made using a ground transport system and containers that provide a level of protection for safety and health equal to or greater than that provided by compliance with Department of Energy, Department of Transportation, and other applicable regulations.

Plutonium residues and scrub alloy have been shipped safely for 25 years. During the weapons production years (1960's to 1989), about 70 truck shipments (3,800 kg or 8,400 lb) were made from Rocky Flats to the Savannah River Site. These shipments were made using the same Transportation Safeguards System used for transporting nuclear weapons and weapon components. This same transportation system could be used in shipments of Rocky Flats plutonium residues and scrub alloy that DOE might decide to make after completion of this EIS. DOE is also evaluating the possible use of a commercial transportation system for transporting a portion of these materials. The analyses in this EIS are based on a set of assumptions that conservatively bound the impacts that would result from use of either the Transportation Safeguards System or commercial carriers.

Experience has shown that typical radiation levels for these shipments are below regulatory limits. This is due to several factors: (1) most of the radiation emitted from plutonium is alpha radiation, which cannot penetrate the container walls; (2) plutonium residues would be preprocessed/repackaged prior to shipment; and (3) the transport system, which includes the containers, transportation packaging, and special transporter, provides multiple layers of containment.

MAXIMUM TRUCK SHIPMENTS THAT COULD OCCUR UNDER ALTERNATIVE 3

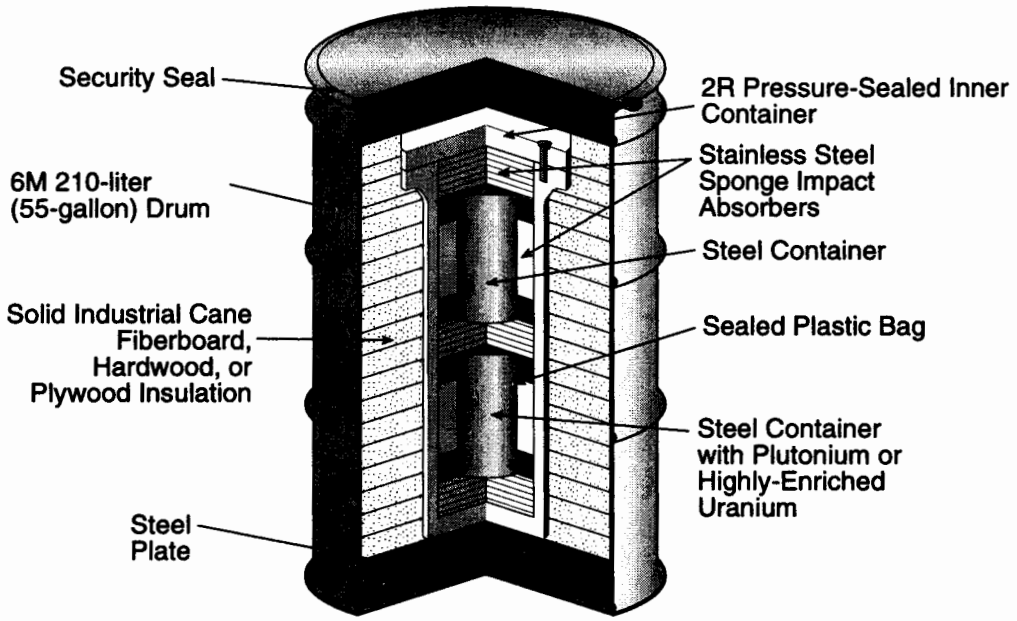
Material	Estimated Number of Shipments
Savannah River Site	
Incinerator Ash	116
Sand, Slag, and Crucible	26
Graphite Fines	7
Salts	26 [a]
Fluorides	7
Graphite	16
Inorganics	4
Scrub Alloy	6
Total	**208**
Los Alamos National Laboratory	
Electrorefining and Molten Salt Extraction Salts	52
Direct Oxide Reduction Salts	13
Total	**65** [b]

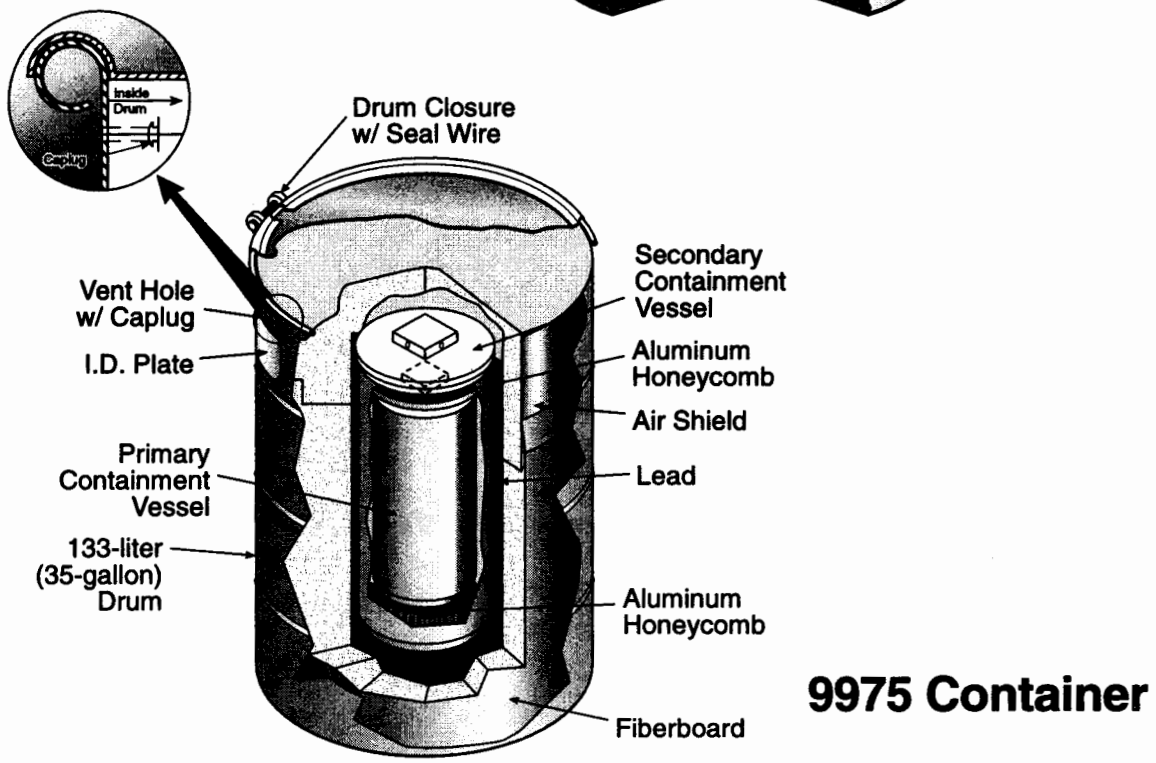
[a] *Separate shipments of molten salt extraction/electrorefining salt residues and direct oxide reduction salt residues would require 24 and 4 shipments, respectively. If shipped together, these residues require only 26 shipments.*

[b] *The actual maximum number of shipments would be 62, since some salts have conservatively been assumed to fall into both of the salt categories listed when calculating processing impacts (refer to Chapter 4 of the EIS).*

2.9.1 TRANSPORTATION PACKAGING

The containers that would be used by DOE for these shipments for offsite processing are authorized by the Department of Energy and used in accordance with Department of Transportation regulations. They are known by regulation as "Type B" packaging. The single-containment 6M container may be used to transport scrub alloy and residues containing less than 20 curies. In general, plutonium-bearing residues that are in a granular or powder form would be shipped in other Type B packaging, such as the double-containment Chalfont 9968 or 9975 containers. However, small amounts of granular or powder materials can be shipped in 6M containers where this is cost efficient. Type B packaging is made up of several components and is designed to minimize dispersal, radiation and criticality. The Type B designs have been tested under normal and accident conditions. Two typical Type B designs that would be used for shipments under this EIS are illustrated below.



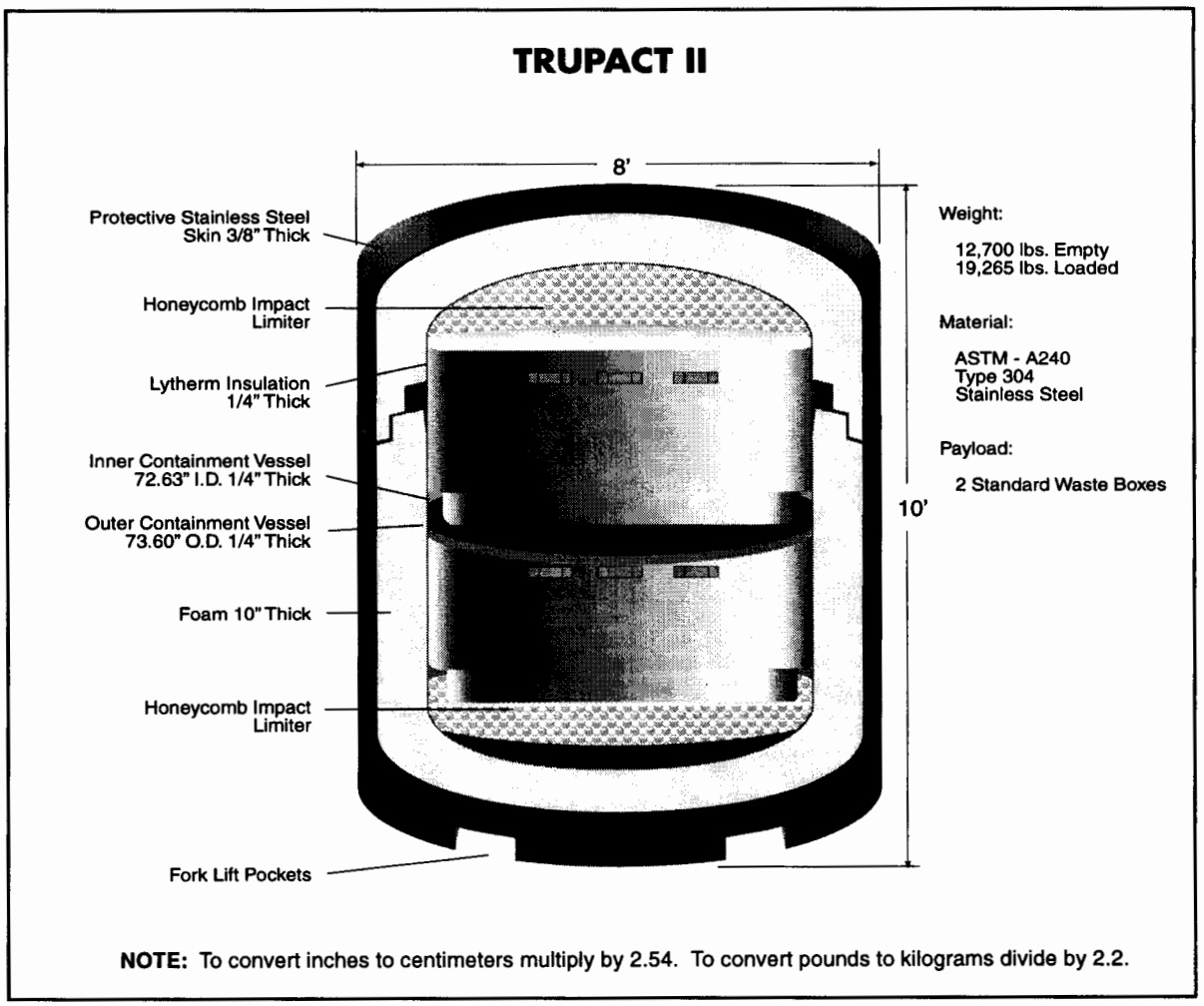


Shipments of plutonium residues and scrub alloy that meet requirements for disposal at WIPP would be transported to WIPP in TRUPACT II containers, illustrated below. This container could also be used to transport materials for offsite processing.

For the purposes of this EIS, it is assumed that the TRUPACT II shipping containers would be loaded with up to 2,800 fissile gram equivalents of plutonium-239 (up to 200 fissile gram equivalents of plutonium-239 per drum for each of 14 drums). The WIPP Waste Acceptance Criteria currently permit only 325 fissile gram equivalents of plutonium-239 to enter WIPP in a TRUPACT II . The Nuclear Regulatory Commission certified the 2,800 fissile gram equivalents loading for the TRUPACT II in February 1997. The WIPP Supplemental EIS analyzed the impacts of transporting the Rocky Flats waste utilizing the lower TRUPACT II loading. It is anticipated that the WIPP Waste Acceptance Criteria will be revised to reflect the higher TRUPACT II loading approved by the Nuclear Regulatory Commission.

In addition to meeting Nuclear Regulatory Commission-specified standards demonstrating it can withstand normal conditions of transport without loss or dispersal of its radioactive contents, the Type B container used for DOE shipments must also be designed to survive certain severe hypothetical accident conditions that demonstrate resistance to impact, puncture, fire, and water submersion. These hypothetical accident conditions do not duplicate accident environments but, rather, are defined so that they produce damage equivalent to extreme and unlikely accidents. The sequence of tests is described in more detail in Appendix B of the EIS.

TRUPACT II Shipping Container

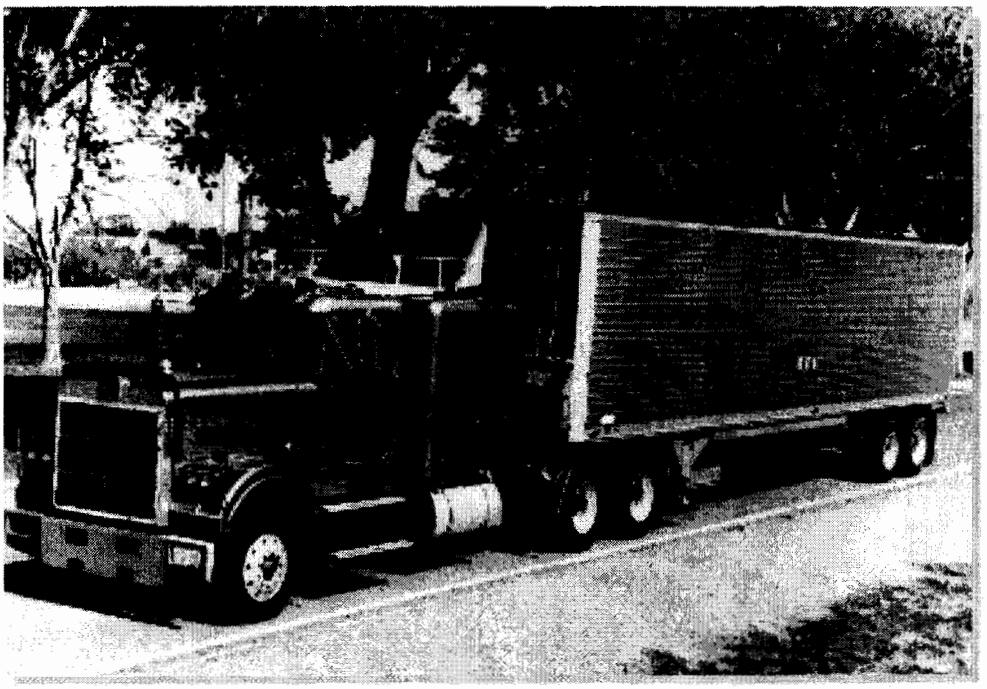


2.9.2 THE "SAFE SECURE TRAILER" SYSTEM

The Safe Secure Trailer System is an integral part of the Transportation Safeguards System operated by DOE. The Transportation Safeguards System is normally used to transport nuclear weapons, nuclear weapon components, and special nuclear materials. Since its establishment in 1975, the Transportation Safeguards Division has accumulated more than 110 million kilometers (70 million miles) of over-the-road experience transporting cargo without a fatality or radioactive release.

The Safe Secure Trailer System uses specially designed 18-wheel tractor trailers, which incorporate deterrents to prevent unauthorized removal of cargo. Key features of the system include:

- superior structural characteristics and a highly reliable cargo tiedown system;
- communications, electronic, and other equipment that further enhance in-transit safety and security;
- specially trained and equipped personnel accompanying the shipment, driving the truck and escort vehicles, and operating the communications and other equipment;
- a comprehensive maintenance program, including compliance with maintenance standards significantly more stringent than those applied to similar commercial transport vehicles; and
- periodic and unannounced audits/surveys during transport operations to ensure compliance with approved procedures.



2.9.3 ROUTE SELECTION PROCESS FOR OFFSITE TRANSPORTATION

Highway routing of nuclear material is governed by Department of Transportation regulations at 49 CFR Parts 171-179 and 49 CFR Part 397. The regulations require that shipment of a "highway route controlled quantity" of radioactive material be transported over a preferred highway network. The network includes interstate highways, with preference toward interstate system bypasses around cities, and State-designated preferred routes.

For security reasons associated with these shipments, details about routes would not be publicized before shipment. A computer code called HIGHWAY was used to select representative routes for conducting the risk assessment in this EIS. The HIGHWAY code is a computerized road atlas that provides selection of routes in compliance with the Department of Transportation preferred highway network.

2.9.4 EMERGENCY MANAGEMENT CONSIDERATIONS

DOE's Transportation Safeguards Division is responsible for the safety and security of special nuclear material shipments. The plutonium residues and scrub alloy shipments would be treated as special nuclear material shipments and would be accompanied by armed special agents who would be in constant communication with the TSD Control Center.

In the event of an incident or accident, the Transportation Safeguards Division convoy commander would notify Security Communications (SECOM), which is a nationwide communications system operated 24 hours per day by Transportation Safeguards Division. SECOM would then notify the State's emergency point of contact and would interface with emergency responders. Transportation Safeguards Division would maintain control over the immediate scene of any accident, called a "National Security Area." Beyond that, State or local officials would be in command of the scene. First on-scene responders would receive a briefing from the Transportation Safeguards Division Special Agents. The incident commander would be apprised of the security requirements and of the hazardous nature of the shipment in advance of directing the responders to begin their response.

DOE has eight regional Radiological Assistance Program teams available to respond to incidents involving plutonium residue or scrub alloy shipments.

The DOE Transportation Emergency Preparedness Program provides Federal, Tribal, State, and local responders with access to training and technical assistance necessary to safely, efficiently, and effectively respond to DOE transportation incidents involving radioactive materials.

3.0 THE AFFECTED ENVIRONMENT

The alternatives assessed in this EIS would potentially affect the environment surrounding Rocky Flats, the Savannah River Site, and Los Alamos National Laboratory. Chapter 3 of this EIS describes potentially affected environments around each of these sites. The resources that could potentially be affected are grouped into the following categories:

- Site Infrastructure
- Air Quality
- Socioeconomics
- Public and Occupational Health and Safety
- Waste Management

The resources described above are presented in detail in Chapter 3 of this EIS due to their potential to be impacted by the alternatives assessed in this EIS. Several other resources are not expected to be impacted by these alternatives, and are presented in less detail in Chapter 3. These resources are:

- Land Resources
- Noise
- Water Resources
- Geology and Soils
- Ecology
- Cultural and Paleontological Resources

4.0 ENVIRONMENTAL CONSEQUENCES

Chapter 4 of this Summary Presents:

- *Overview of Methodology for Calculating Impacts*
- *Overview of Impacts*

Chapter 4 presents an overview of the methodology used to evaluate environmental impacts and presents a summary of the environmental impacts associated with the No Action Alternative and the Action Alternatives. Chapter 2 of the Summary identifies the 10 material categories (some with further subcategories) and the set of processing options evaluated for each material category or subcategory.

- The *No Action Alternative* is a set of processing options that prepare the Rocky Flats plutonium residues and scrub alloy for indefinite storage. In addition, for any plutonium residues for which safeguards termination limit variances have been or may be obtained, this processing could be used to prepare the residues for disposal in WIPP.

- The *Action Alternatives* consist of a set of technology options for processing of these materials so that they meet requirements for disposal or other disposition (several options were evaluated for each material category and subcategory). The Proposed Action could be accomplished by a selection of technologies from Alternatives 2 or 3, identified in Section 1.3.2 of this Summary, or a combination of technologies from these two alternatives.

- The *Preferred Management Approach* is a specific selection of preferred processing technologies from the list of processing technologies applicable to each material category and subcategory.

PRIMARY FOCUS OF IMPACTS

Products & Wastes

Radiological

Chemical

4.1 METHODOLOGY FOR EVALUATING AND PRESENTING ENVIRONMENTAL IMPACTS

Each material category and subcategory was analyzed independently. For each one, every combination of material and processing option specified in Chapter 2 of this Summary was analyzed. For each combination of material and processing option, a set of impacts was assessed, including:

- Amounts of products and wastes

- Radiological health effects due to:
  - Incident-free operations and transportation
  - Accidents

- Chemical health effects due to:
  - Incident-free operations and transportation
  - Accidents (by reference to applicable documents, e.g., site-specific environmental impact statements)

DOE then calculated the total impacts of processing all the plutonium residues and scrub alloy under the No Action Alternative and under the Proposed Action. DOE also summed the lowest and highest potential impacts at each site from the processing options to obtain the range of potential impacts at each site.

The focus of the impacts is on public and occupational health and safety associated with the processing options and any associated transportation. The following sections provide an overview of how the radiological and chemical health effects were calculated for members of the public and workers.

4.1.1 INCIDENT-FREE OPERATIONS AND ACCIDENT CONDITIONS

Radiological and chemical health effects were calculated for processing options under incident-free operations and accident conditions.

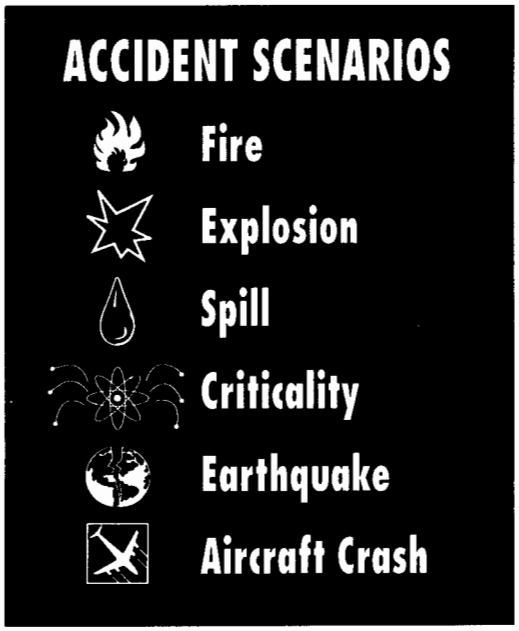
- For *incident-free operations*, the impacts are those that are anticipated to occur as a result of process operations and transportation over whatever time period is necessary to process the entire inventory of residues and scrub alloy covered under this EIS.
- For *accident conditions*, DOE analyzed a wide spectrum of potential accident scenarios, including fire, explosion, spill, criticality, earthquake, and aircraft crash. Accident scenarios with the highest consequences and risks are used in the EIS for the purpose of bounding consequences and identifying the largest contributor to total risk. The risks associated with accidents for each processing option with each residue and scrub alloy category were also computed.

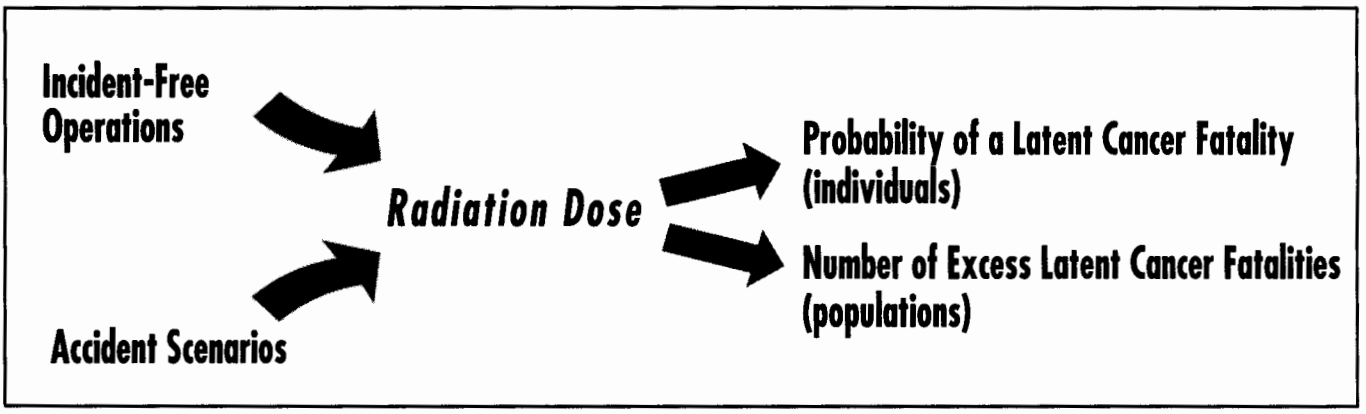
The methods used for calculating the consequences from incident-free operations and accident conditions are described in the sections that follow.

4.1.2 CALCULATING RADIOLOGICAL HEALTH EFFECTS

For each material type and processing option, radiological health effects are presented in terms of the potential radiation *dose* that a person or population would receive (based on standard computer codes used for estimating doses from releases). A risk factor is applied to the estimated dose to a *maximally exposed individual* (a worker or a member of the offsite public) to derive a *probability of a latent cancer fatality*. For the potentially exposed population (workers and the offsite public), the dose received by the receptor group is converted to the *number of estimated excess latent cancer fatalities*.

Estimated doses from incident-free operations are based on anticipated releases and direct exposures. Estimated doses from accident conditions take into account the estimated frequency of the accident, the duration of the process, and the potential release.





Health effects associated with these doses are presented for the *maximally exposed individual* (worker and member of the public), the *worker population*, the *offsite public population* living within a radius of 80 kilometers (50 miles) from the site, and the public population living and traveling along transportation routes.

For those processing options that involve transportation from Rocky Flats to the Savannah River Site and Los Alamos National Laboratory, the estimated doses and associated health effects from transportation are factored into the results for those processes. DOE uses the RADTRAN code to determine the doses potentially received by populations.

The Maximally Exposed Individual
The maximally exposed individual is an individual who receives the highest possible dose in a given situation. Under accident conditions, the dose is calculated for the individual worker located 100 meters (328 feet) or more downwind from the release point when an accidental release of radioactive material occurs; for incident-free processing operations, the dose is calculated for the hypothetical individual (member of the public) who resides at the site boundary in a downwind direction. For incident-free transportation, the dose is calculated for a hypothetical individual stuck in traffic next to a shipment for 30 minutes.

Conservatism in Estimating Health Effects
This EIS uses a conservative approach in estimating health effects to individuals and populations. Estimates are based on the linear no-threshold theory of radiation carcinogenesis, which postulates that all radiation doses, even those close to zero, are harmful. Recent studies and findings state that there is no proof or direct support for this theory. DOE uses this approach to provide an upper bound on the potential health effects.

4.1.3 CALCULATING CHEMICAL HEALTH EFFECTS

The potential impacts of exposure to hazardous chemicals released to the atmosphere as a result of the processing of plutonium residues and scrub alloy were evaluated for the routine operation of processing facilities.

Impacts for incident-free operation are presented for the maximally exposed individual worker, the maximally exposed offsite member of the public, the offsite population in an 80-kilometer (50-mile) radius, and the worker population. Health effects evaluated include excess incidences of latent cancers and a spectrum of chemical-specific cancer and noncancer health effects. The chemical health effects were based on contaminant concentrations in air and exposure duration in years, using standard exposure assessment values.

4.2 SUMMARY OF IMPACTS

This section summarizes the impacts associated with the processing options evaluated in this EIS. The following subsections cover:

- Comparison of Health and Safety Risks with Common Risks to the Public
- Impacts of the Strategic Management Approaches
- Range of Impacts at Each Site
- Range of Intersite Transportation Impacts
- Plutonium and Americium Toxicity
- Environmental Justice
- Cumulative Impacts

4.2.1 COMPARISON OF HEALTH AND SAFETY RISKS WITH COMMON RISKS TO THE PUBLIC

This section compares the increased risks to the public associated with the management of plutonium residues and scrub alloy to those of common activities, such as smoking, flying, receiving a medical x-ray, and so forth.

Radiation dose is expressed in terms of rem or millirem. One rem is 1,000 millirem. One millirem may also be expressed as 0.001 rem. The average individual in the United States receives a dose of about 300 millirem per year (or 0.3 rem per year) from natural background radiation. Millirem is abbreviated as "mrem."

- ***Risks in the Proposed Action*** — Below are highlights of the highest risks from any combination of processing activities evaluated in the EIS.

  The highest increase in the incident-free population risk to the general public living near any of the DOE management sites would be 0.00019 latent cancer fatalities. This risk occurs at the Savannah River Site. The risk would be spread among the 755,000 people who are expected to live within 80 km (50 mi) of the site, so the average risk of a latent cancer fatality to any one person among these people would be increased by less than one chance in one billion (2.5×10^{-10}).

  The highest increase in the accident population risk to the general public living near any of the DOE management sites would be 0.50 latent cancer fatalities. This risk occurs at the Rocky Flats site. The risk would be spread among the 2.4 million people who are expected to live within 80 km (50 mi) of the site, so that the average risk of a latent cancer fatality to any one person among these people would be increased by less than one chance in one million (2.1×10^{-7}).

  The highest increase in the population risk to the general public along the transportation routes due to radiation exposure during ground transport would be 0.011 latent cancer fatalities, if the maximum number of shipments is assumed (208 from Rocky Flats to the Savannah River Site).

  Nonradiological fatalities are also unlikely. The highest increases in the risk of nonradiological fatalities to the public is through a traffic accident involving a truck transporting plutonium residues or scrub alloy. Assuming the same number of shipments (208 to the Savannah River Site), the increase in the population risk to the general public along the transportation routes would be 0.02 fatalities.

- ***Risks from Common Activities*** — Every activity carries some risk. Table S-3 shows activities estimated to increase an individual's chance of death in any year by one in one million. Most of these voluntary activities would not be considered unusually risky actions, and they can be compared to the risks presented in this chapter for perspective.

Table S-3. Risks Estimated to Increase Chance of Death in Any Year by One Chance in a Million

Activity	Cause of Death
Smoking 1.4 cigarettes	Cancer; heart disease
Living 2 days in New York or Boston	Air pollution
Traveling 16 km (10 mi) by bicycle	Accident
Flying 1,600 km (1,000 mi) by jet	Accident
Living 2 months in Denver on vacation from New York	Cancer caused by cosmic radiation
One chest x-ray	Cancer caused by radiation

4.2.2 IMPACTS OF THE STRATEGIC MANAGEMENT APPROACHES

Selection of the future steps to be taken in the management of the plutonium residues and scrub alloy must be made separately for each material category and subcategory since chemical and physical differences between the material categories require that each category be handled using different methods, and possibly different management sites. Nevertheless, in an attempt to simplify presentation of this large group of processing options, DOE has assembled the separate processing options for the individual material categories into eight groups that allow the impacts of processing the plutonium residues and scrub alloy to be compared.

These groupings of processing options are referred to as Strategic Management Approaches. They include the No Action Alternative and the Preferred Management Approach discussed previously. They also include six illustrative groupings of processing options that would have the following overall effects:

- Minimization of Process Duration at Rocky Flats
- Minimization of the Cost
- All Actions Taken at Rocky Flats
- Conduct Fewest Actions at Rocky Flats
- Process with Maximum Separation of Plutonium
- Process with No Separation of Plutonium

The Strategic Management Approaches and the groupings of processing options that comprise them are shown in Table S-4.

The impacts of these various management approaches are compared in Section 4.2.2.1 of this Summary. It should be recognized that the Strategic Management Approaches, other than No Action and the Preferred Management Approach, are illustrative cases generated to assist the public in obtaining a feel for the relative impacts that could occur from various methods of dealing with the plutonium residues and scrub alloy. The material category-specific processing options that make up the illustrative Strategic Management Approaches do not necessarily represent optimum ways in which to deal with the individual material categories.

Table S-4. Strategic Management Approaches for Processing Rocky Flats Plutonium Residues and Scrub Alloy

Material Category	*No Action*	*Preferred*	*Minimize Total Process Duration at Rocky Flats* [a]	*Minimize Cost*	*Conduct All Processes at Rocky Flats*	*Conduct Fewest Actions at Rocky Flats*	*Process With Maximum Plutonium Separation*	*Process Without Plutonium Separation*
Incinerator Ash Residues	Cement at Rocky Flats	Vitrify at Rocky Flats	Preprocess at Rocky Flats and MEO at SRS	Vitrify at Rocky Flats	Vitrify at Rocky Flats	Preprocess at Rocky Flats and MEO at SRS	Preprocess at Rocky Flats and MEO at SRS	Vitrify at Rocky Flats
Graphite Fines Ash Residues	Cement at Rocky Flats	Vitrify at Rocky Flats	Preprocess at Rocky Flats and MEO at SRS	Vitrify at Rocky Flats	Vitrify at Rocky Flats	Preprocess at Rocky Flats and MEO at SRS	Preprocess at Rocky Flats and MEO at SRS	Vitrify at Rocky Flats
Sand, Slag, and Crucible Ash Residues	Cement at Rocky Flats	Preprocess at Rocky Flats and Purex at SRS	Preprocess at Rocky Flats and Purex at SRS	Vitrify at Rocky Flats	Vitrify at Rocky Flats	Preprocess at Rocky Flats and Purex at SRS	Preprocess at Rocky Flats and Purex at SRS	Vitrify at Rocky Flats
Inorganic Ash Residues	Cement at Rocky Flats	Vitrify at Rocky Flats	Vitrify at Rocky Flats	Vitrify at Rocky Flats	Vitrify at Rocky Flats	Vitrify at Rocky Flats	Vitrify at Rocky Flats [b]	Vitrify at Rocky Flats
Molten Salt Extraction/ Electrorefining Salt Residues	Pyro-oxidize at Rocky Flats	Salt Distillation at Rocky Flats	Salt Scrub at Rocky Flats and Purex at SRS	Salt Scrub at Rocky Flats and Purex at SRS	Salt Distillation at Rocky Flats	Preprocess at Rocky Flats and Salt Distillation at LANL	Salt Distillation at Rocky Flats	Blend Down at Rocky Flats
Direct Oxide Reduction Salt Residues	Pyro-oxidize at Rocky Flats	Preprocess at Rocky Flats and Water Leach at LANL	Salt Scrub at Rocky Flats and Purex at SRS	Salt Scrub at Rocky Flats and Purex at SRS	Water Leach at Rocky Flats	Preprocess at Rocky Flats and Water Leach at LANL	Preprocess at Rocky Flats and Water Leach at LANL	Blend Down at Rocky Flats
Aqueous-Contaminated Combustible Residues	Neutralize/Dry at Rocky Flats	Neutralize/Dry at Rocky Flats	Blend Down at Rocky Flats	Blend Down at Rocky Flats	Neutralize/Dry at Rocky Flats	Neutralize/Dry at Rocky Flats	MEO at Rocky Flats	Neutralize/Dry at Rocky Flats
Organic-Contaminated Combustible Residues	Thermal Desorption/ Steam Passivation at Rocky Flats	Thermal Desorption/ Steam Passivation at Rocky Flats	Blend Down at Rocky Flats	Blend Down at Rocky Flats	Thermal Desorption/ Steam Passivation at Rocky Flats	Thermal Desorption/ Steam Passivation at Rocky Flats	MEO at Rocky Flats	Thermal Desorption/ Steam Passivation at Rocky Flats
Dry Combustible Residues	Repackage at Rocky Flats	Repackage at Rocky Flats	Blend Down at Rocky Flats	Blend Down at Rocky Flats	Repackage at Rocky Flats	Repackage at Rocky Flats	MEO at Rocky Flats	Repackage at Rocky Flats
Plutonium Fluoride Residues	Acid Dissolution/ Plutonium Oxidation at Rocky Flats	Preprocess at Rocky Flats and Purex at SRS	Preprocess at Rocky Flats and Purex at SRS	Preprocess at Rocky Flats and Purex at SRS	Acid Dissolution/ Plutonium Oxidation at Rocky Flats	Preprocess at Rocky Flats and Purex at SRS	Preprocess at Rocky Flats and Purex at SRS	Blend Down at Rocky Flats
HEPA Filter Media Residues	Neutralize/Dry at Rocky Flats	TBD	Blend Down at Rocky Flats	Blend Down at Rocky Flats	Vitrify at Rocky Flats	Vitrify at Rocky Flats	MEO at Rocky Flats	Vitrify at Rocky Flats
Ful Flo Filter Media Residues	Neutralize/Dry at Rocky Flats	TBD	Blend Down at Rocky Flats	Blend Down at Rocky Flats	Sonic Wash at Rocky Flats	Sonic Wash at Rocky Flats	MEO at Rocky Flats	Sonic Wash at Rocky Flats
Sludge Residues	Filter/Dry at Rocky Flats	TBD	Vitrify at Rocky Flats	Blend Down at Rocky Flats	Vitrify at Rocky Flats	Vitrify at Rocky Flats	Acid Dissolution/ Plutonium Oxidation at Rocky Flats	Vitrify at Rocky Flats

Continued on next page.

Table S-4 (continued). Strategic Management Approaches for Processing Rocky Flats Plutonium Residues and Scrub Alloy

Material Category	*No Action*	*Preferred*	*Minimize Total Process Duration at Rocky Flats* [a]	*Minimize Cost*	*Conduct All Processes at Rocky Flats*	*Conduct Fewest Actions at Rocky Flats*	*Process With Maximum Plutonium Separation*	*Process Without Plutonium Separation*
Glass Residues	Neutralize/Dry at Rocky Flats	Neutralize/Dry at Rocky Flats	Vitrify at Rocky Flats	Blend Down at Rocky Flats	Neutralize/Dry at Rocky Flats	Neutralize/Dry at Rocky Flats	MEO at Rocky Flats	Neutralize and Dry at Rocky Flats
Graphite Residues	Repackage at Rocky Flats	Repackage at Rocky Flats	Preprocess at Rocky Flats and MEO at SRS	Repackage at Rocky Flats	Repackage at Rocky Flats	Repackage at Rocky Flats	Preprocess at Rocky Flats and MEO at SRS	Repackage at Rocky Flats
Inorganic Residues	Repackage at Rocky Flats	Repackage at Rocky Flats	Preprocess at Rocky Flats and MEO at SRS	Repackage at Rocky Flats	Repackage at Rocky Flats	Repackage at Rocky Flats	Preprocess at Rocky Flats and MEO at SRS	Repackage at Rocky Flats
Scrub Alloy	Repackage at Rocky Flats	Preprocess at Rocky Flats and Purex at SRS	Preprocess at Rocky Flats and Purex at SRS	Preprocess at Rocky Flats and Purex at SRS	Calcine and Vitrify at Rocky Flats	Preprocess at Rocky Flats and Purex at SRS	Preprocess at Rocky Flats and Purex at SRS	Calcine and Vitrify at Rocky Flats

[a] *Minimum time to process residues and scrub alloy at Rocky Flats for shipment to Savannah River Site, Los Alamos National Laboratory, or WIPP. All residue and scrub alloy in Rocky Flats Building 707 is on the minimum process time critical path.*

[b] *No process with plutonium separation is available.*

HEPA = High-efficiency particulate air
SRS = Savannah River Site
MEO = Mediated electrochemical oxidation
TBD = To be determined; DOE has not yet selected preferred processing options for these residues

4.2.2.1 COMPARISON OF THE STRATEGIC MANAGEMENT APPROACHES

The primary impacts of the eight management approaches are presented in Table S-5. These impacts have been derived by summing the impacts for each material category.

Table S-5. Comparison of Certain Impacts of the Strategic Management Approaches

Impact	MANAGEMENT APPROACHES							
	No Action	*Preferred*[a]	*Minimize Total Process Duration at Rocky Flats*	*Minimize Cost*	*Conduct all Processes at Rocky Flats*	*Conduct Fewest Actions at Rocky Flats*	*Process with Maximum Plutonium Separation*	*Process without Plutonium Separation*
Products and Wastes								
Stabilized Residues (drums)	10,300	900	0	700	900	900	0	900
Transuranic Waste (drums)	3,500	11,200-13,600	5,800	11,200	15,400	6,900	9,900	31,000
High-Level Waste (canisters)	0	<6	37	4	0	34	43	0
Separated Plutonium (kg)[b]	0	1,538-1,673	2,467	1,348	1,204	2,512	2,786	0
Low-Level Waste (drums)	7,600	9,800-16,900	5,500	5,000	10,200	11,200	20,000	4,500
Public and Occupational Health and Safety								
Incident-Free Radiological Risk to the Public Maximally Exposed Individual (Probability of a Latent Cancer Fatality)	2.4×10^{-10}	5.5×10^{-6}	5.5×10^{-6}	5.5×10^{-6}	2.4×10^{-10}	5.5×10^{-6}	5.5×10^{-6}	2.4×10^{-10}
Incident-Free Radiological Risk to the Public Population (Latent Cancer Fatalities)	6.0×10^{-6}	0.0022	0.0089	0.0021	6.2×10^{-6}	0.0074	0.0078	3.9×10^{-6}
Incident-Free Radiological Risk to the Maximally Exposed Individual Worker (Probability of a Latent Cancer Fatality per Year)	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008	0.0008
Incident-Free Radiological Risk to the Worker Population (Latent Cancer Fatalities)	0.31	0.31-0.33	0.37	0.31	0.36	0.33	0.37	0.66
Accident Risk to the Public Maximally Exposed Individual (Probability of a Latent Cancer Fatality)	0.000023	0.000030-0.000031	0.000018	0.000017	0.000024	0.000050	0.000031	0.000027
Accident Risk to the Public Population (Latent Cancer or Traffic Fatalities)	0.41	0.47-0.48	0.34	0.31	0.43	0.53	0.50	0.47
Accident Risk to the Onsite Noninvolved Worker (Probability of a Latent Cancer Fatality)	0.00041	0.00054	0.00039	0.00035	0.00042	0.00090	0.00059	0.00046

Continued on next page.

Table S-5 (continued). Comparison of Certain Impacts of the Strategic Management Approaches

Impact	MANAGEMENT APPROACHES							
	No Action	*Preferred*[a]	*Minimize Total Process Duration at Rocky Flats*	*Minimize Cost*	*Conduct all Processes at Rocky Flats*	*Conduct Fewest Actions at Rocky Flats*	*Process with Maximum Plutonium Separation*	*Process without Plutonium Separation*
Other Impacts								
Intersite Round-Trip Transportation (1,000 km)[c]	0	223	847	204	0	786	815	0
Cost (millions $)[d]	633[e]	520[g]	670	483	628	645	816	718
Processing Duration at Rocky Flats (years)[g]	7.1	3.6	2.5	4.0	6.4	3.8	3.5	13.4
Proliferation Risk	See Note h	See Note i	See Note i	See Note i	See Note i	See Note i	See Note i	See Note i

SRS= Savannah River Site; LANL=Los Alamos National Laboratory; kg = kilograms; km = kilometers

[a] These impacts may be expressed as ranges because DOE has not yet selected processing options for some residues.

[b] To convert to pounds, multiply by 2.2.

[c] To convert thousands of kilometers to thousands of miles, multiply by 0.62.

[d] Undiscounted 1997 dollars. Fully allocated including all site overheads, common facility costs, and technology development costs.

[e] Of which $426 million is attributable to facilities costs and processing costs and $207 million is attributable to interim onsite storage at Rocky Flats from 2001 through 2015, plus offsite shipping. Assumes no safeguards termination limit variances.

[f] Assumes safeguards termination limits variances and no onsite interim storage for neutralize/dry for aqueous combustibles, thermal desorption/steam passivation for organic combustibles, repackaging for dry combustibles, neutralize/dry for glass, repackaging for graphite, and repackaging for inorganics. Assumes blend down for filter media and furnace vitrification for sludge.

[g] Assumes all processes at different buildings or modules at Rocky Flats are conducted concurrently. Canyon processing at the Savannah River Site depends on schedules for materials in programs outside the scope of this EIS. Processing duration at LANL is 0.75 years in the Preferred and Maximum Separation Management Approaches and zero in the others.

[h] The plutonium residues and scrub alloy would be left in a form that cannot be disposed of due to proliferation concerns (except for any material disposed of through use of safeguards termination limit variances).

[i] The plutonium residues and scrub alloy would be managed and placed in a form that can be disposed of in a manner that supports U.S. nuclear weapons nonproliferation policy.

4.2.2.1.1 PRODUCTS AND WASTES

The amounts of primary solid plutonium-bearing products and wastes that would be generated under the Strategic Management Approaches are compared in Figures S-17, S-18, and S-19. The bars for the Preferred Management Approach are often shown as ranges because DOE has not yet selected a preferred processing option for all the residues.

As shown in Figure S-17, the No Action Alternative would generate the most stabilized residues, by far. These stabilized residues would not be acceptable for disposal in WIPP unless variances were applied because their plutonium contents would exceed the safeguards termination limits. Under the Preferred Management Approach, DOE would generate about 900 drums of stabilized residues at Rocky Flats. DOE considers that these 900 drums of stabilized residues could be disposed of in WIPP because they either would have been processed to meet the safeguards termination limits or would have received variances from the safeguards termination limits.

As shown in Figure S-18, DOE would generate the most transuranic waste under the Process without Plutonium Separation Management Approach. DOE would generate substantially more transuranic waste under the Preferred Management Approach than under the No Action Alternative.

Figure S-19 shows the amounts of plutonium that could be separated from the plutonium residues and scrub alloy. Two of the management approaches do not involve any plutonium separation. Under the Preferred Management Approach, DOE would separate roughly half of the plutonium that could be separated under the Maximum Plutonium Separation Management Approach. If any plutonium is separated, it would be placed in safe, secure storage until DOE makes decisions on its disposal or other disposition. Under no circumstances, however, would DOE use this plutonium for nuclear explosive purposes.

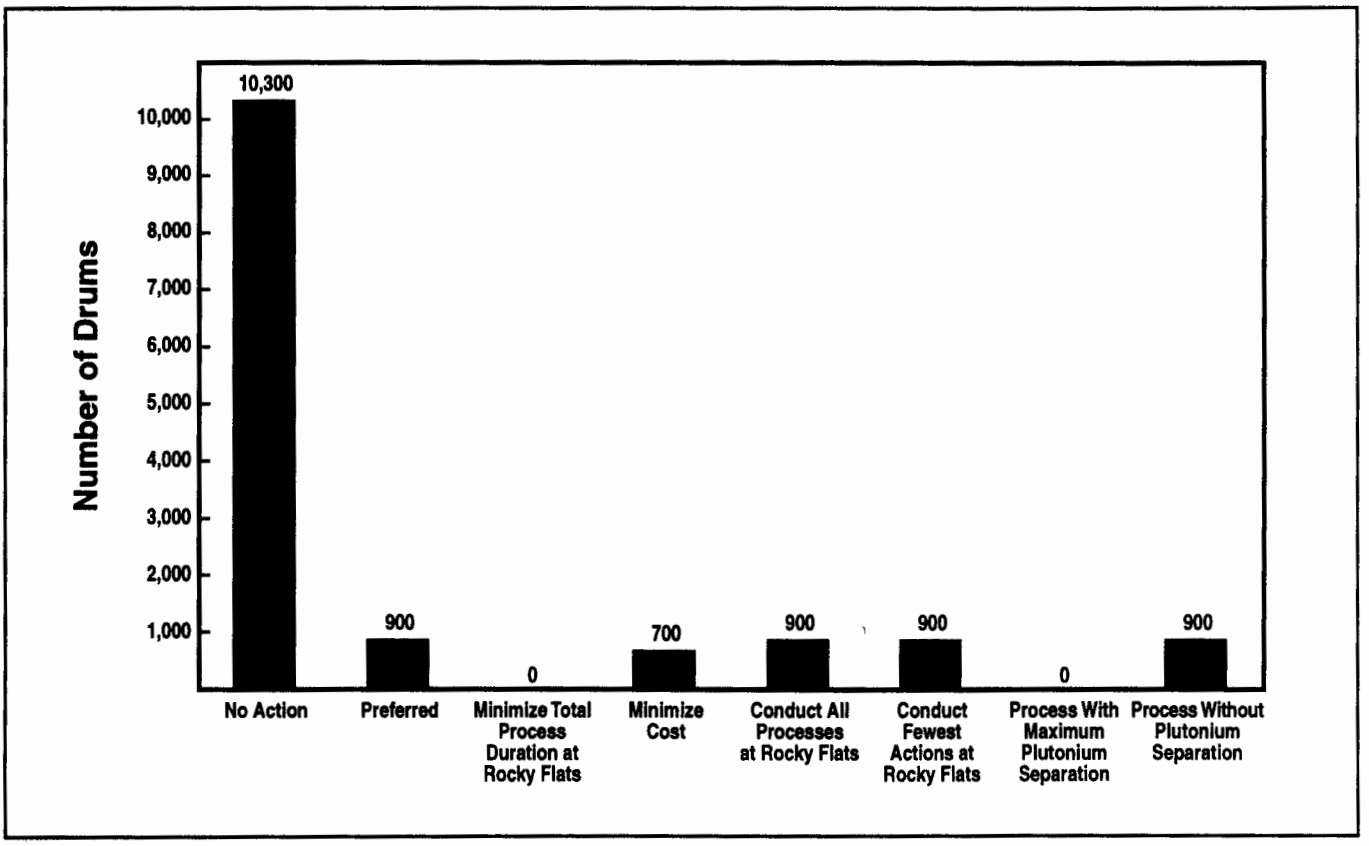


Figure S-17. Stabilized Residues Generated Under Each Management Approach

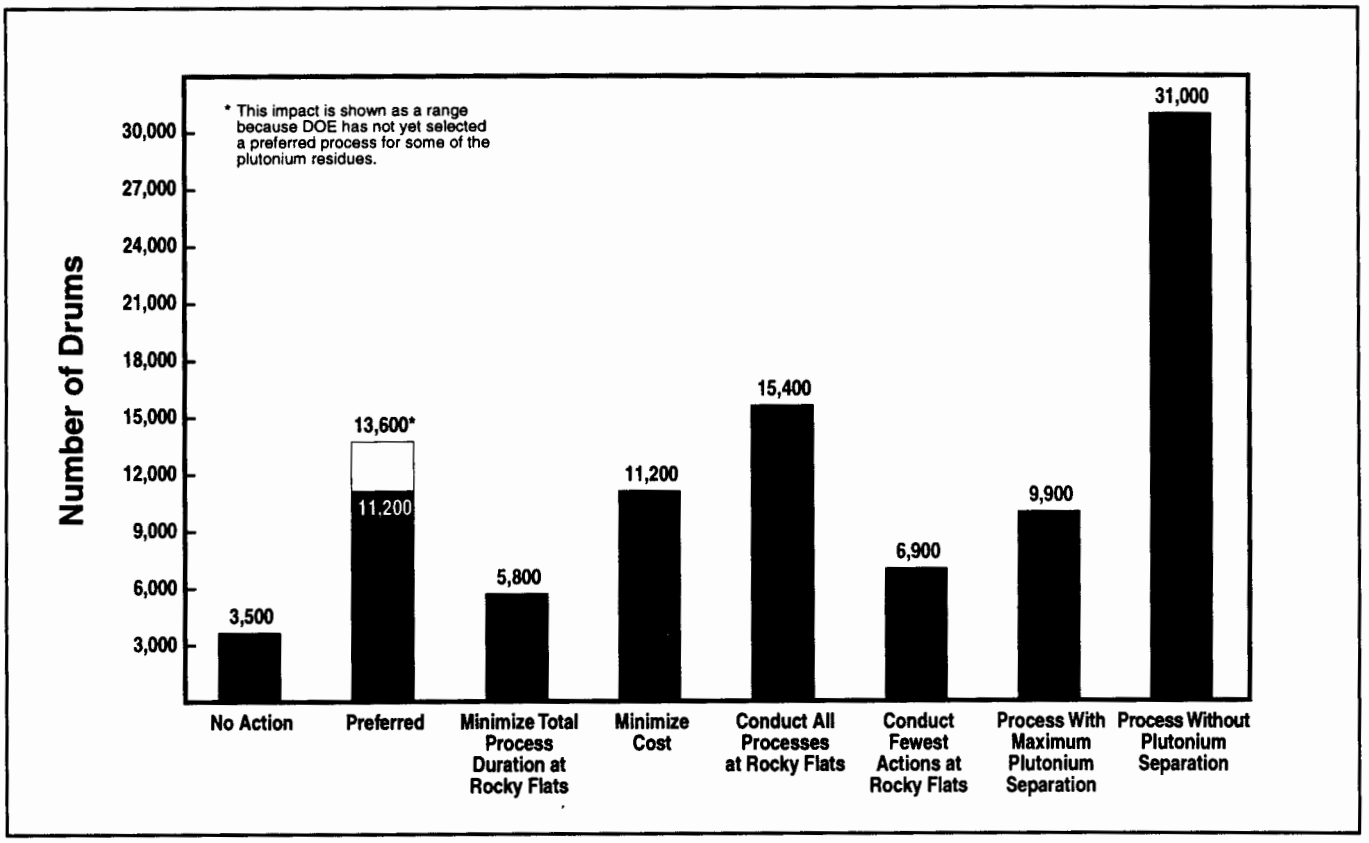


Figure S-18. Transuranic Waste Generated Under Each Management Approach

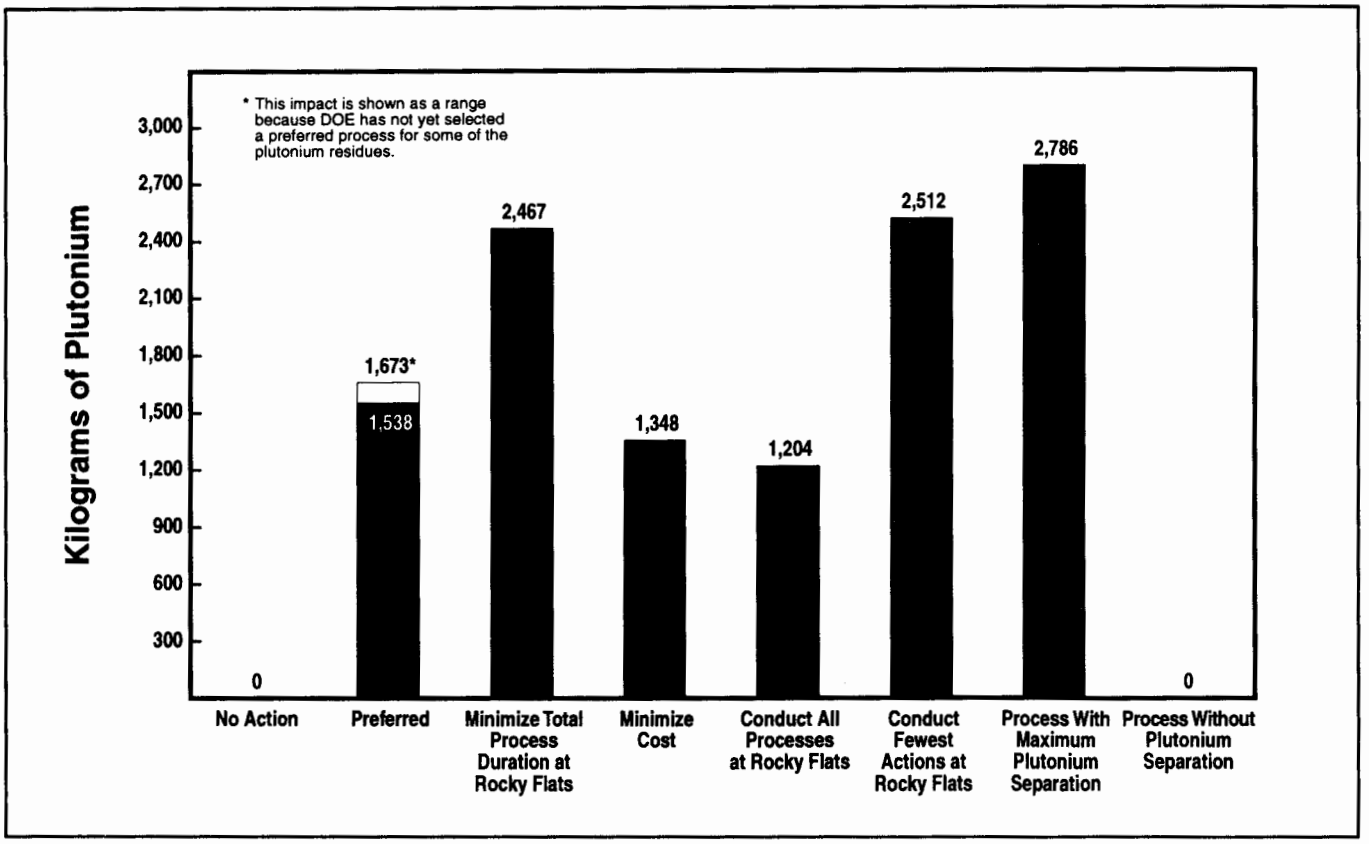


Figure S-19. Plutonium Separated Under Each Management Approach

4.2.2.1.2 PUBLIC AND OCCUPATIONAL HEALTH AND SAFETY IMPACTS

All of the management approaches present low risks to the public and to workers. DOE estimates less than one additional latent cancer fatality to occur in the general public as a result of radiation exposure, no matter which management approach is selected. Nevertheless, differences exist between the risks presented by the eight management approaches, and these could be of interest to Government officials and members of the public. Figures S-20 through S-25 display the risk comparisons for the public and workers under both incident-free and accident conditions.

As shown in Figure S-20, the management approaches with intersite transportation would involve greater risk to the public maximally exposed individual than the management approaches without intersite transportation. The greatest chance that this hypothetical individual would incur a latent cancer fatality would be about 5.5×10^{-6}, or less than one chance in 100,000. As shown in Figure S-21, three management approaches present risks between 0.007 and 0.009 additional cancer fatalities among the public population, while the Preferred Management Approach presents a risk of only 0.0022 additional latent cancer fatalities. In all cases the estimated risks are low; no member of the public would be likely to incur a latent cancer fatality due to incident-free operations.

All the management approaches are equal in terms of the risk to the maximally exposed individual worker (0.0008 cancer fatality per year). This is because DOE applied the same conservative assumption across the board for this part of the analysis. As shown in Figure S-22, most of the management approaches would cause between 0.3 and 0.4 additional latent cancer fatalities among the worker population. Only the Process without Plutonium Separation Management Approach would cause a noticeably greater risk to the work force.

As shown in Figures S-23, S-24, and S-25, the risks due to onsite and transportation accidents do not vary greatly among any of the management approaches. In general, the Minimize Total Process Duration at Rocky Flats and Minimize Cost Management Approaches present somewhat lower accident risks than the rest of the management approaches, but all the accident risks are very low.

4.2.2.1.3 OTHER IMPACTS

Five of the management approaches involve intersite transportation of plutonium residues and/or scrub alloy. Figure S-26 compares the amounts of intersite transportation that would be required under each management approach. Three of the management approaches would require about 800,000 km (500,000 mi) of intersite transportation, while the Preferred Management Approach would require about 223,000 km (138,000 mi).

The cost comparison is presented in Figure S-27. Cost estimates range from $483 million for the Minimize Cost Management Approach to $816 million for the Process with Maximum Plutonium Separation Management Approach. The Preferred Management Approach has the second lowest estimated cost ($520 million).

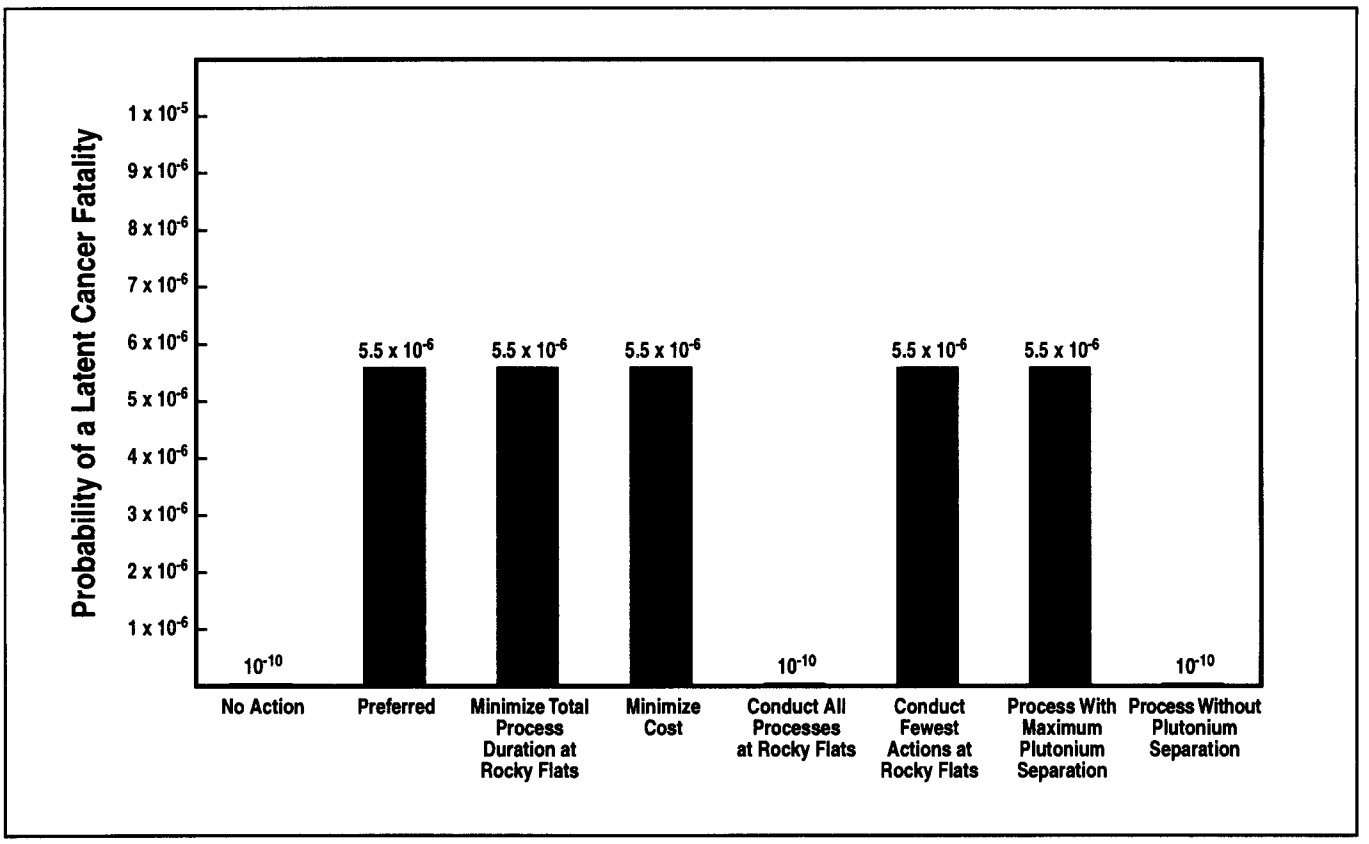


Figure S-20. Incident-Free Radiological Risk to the Public Maximally Exposed Individual Under Each Management Approach

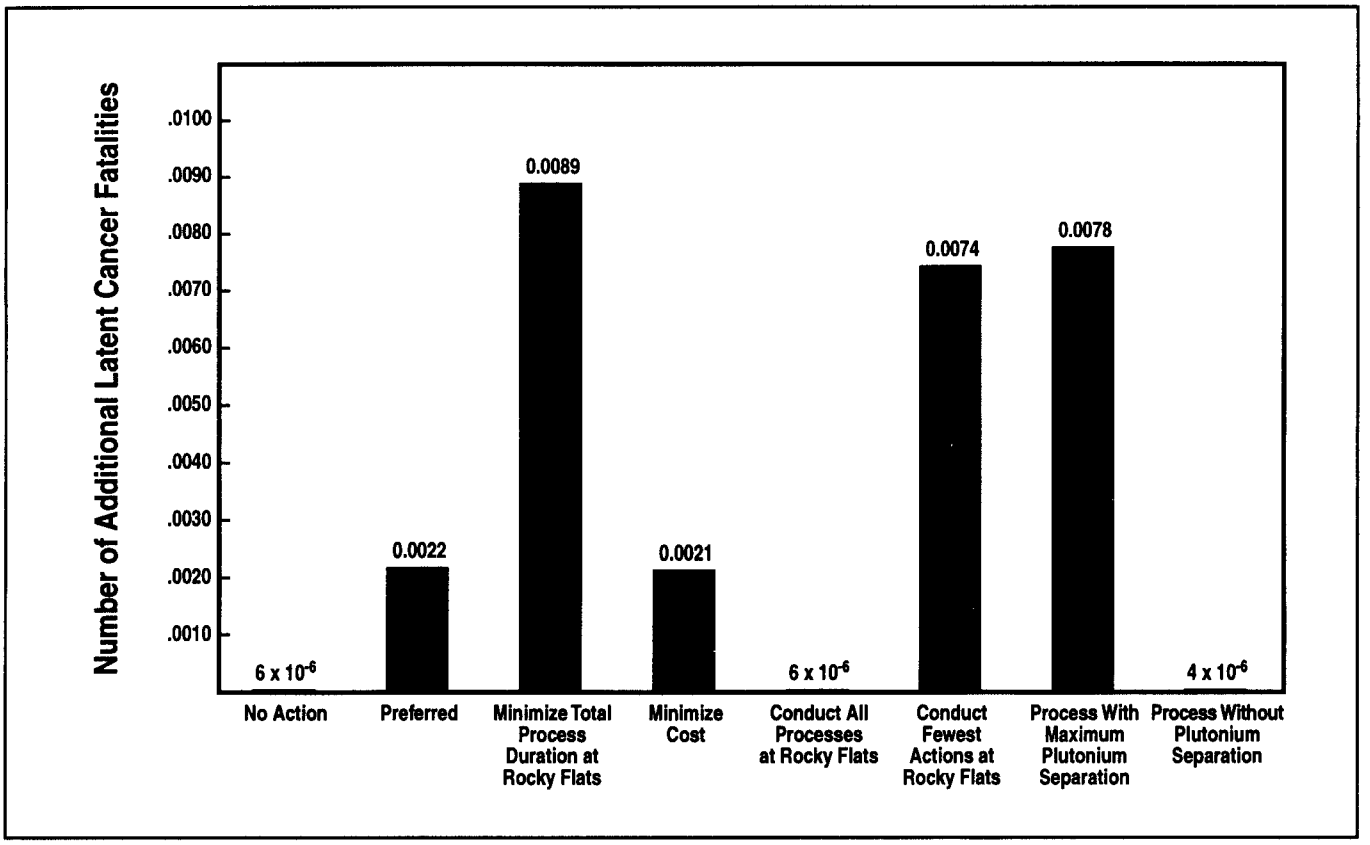


Figure S-21. Incident-Free Radiological Risk to the Public Population Under Each Management Approach

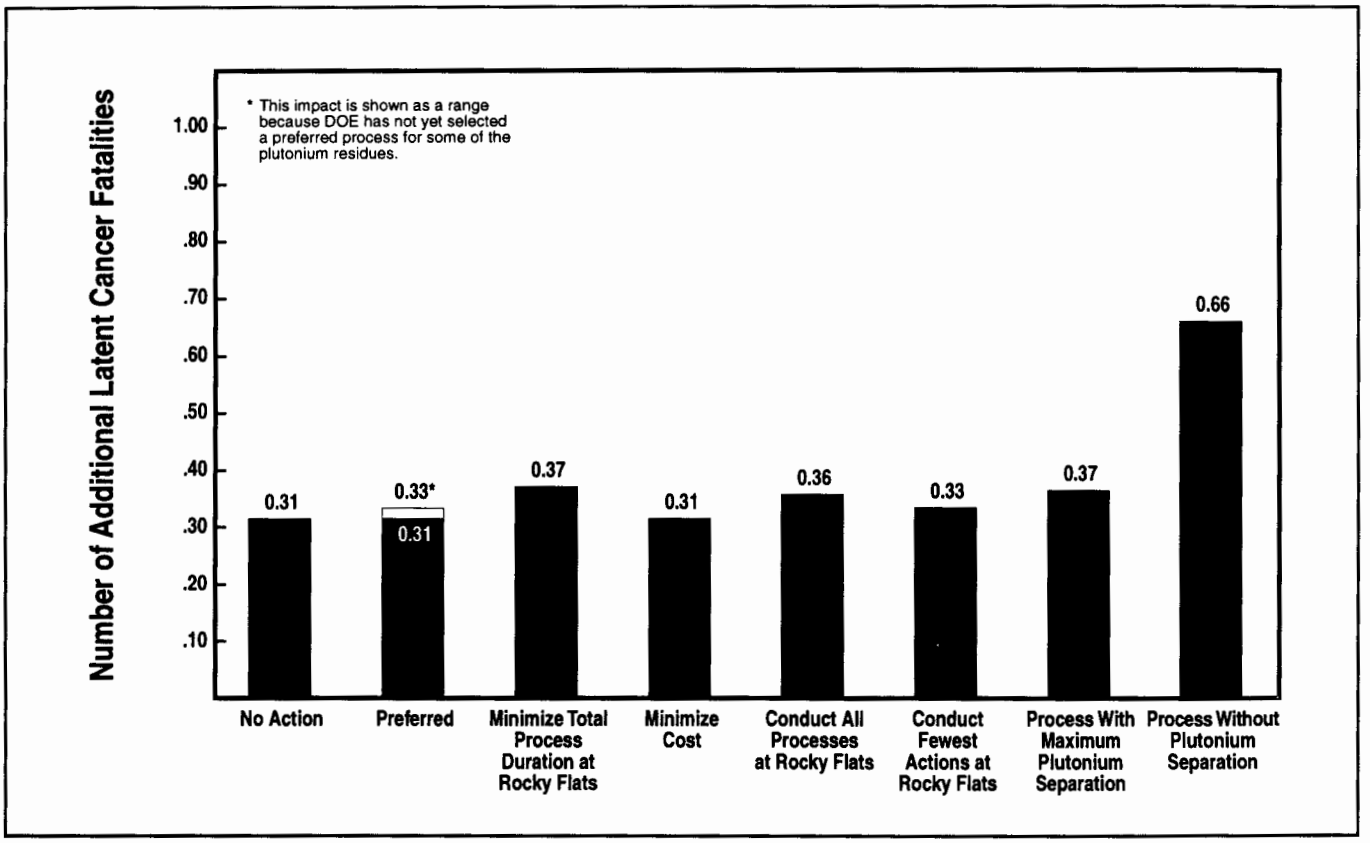


Figure S-22. Incident-Free Radiological Risk to the Worker Population Under Each Management Approach

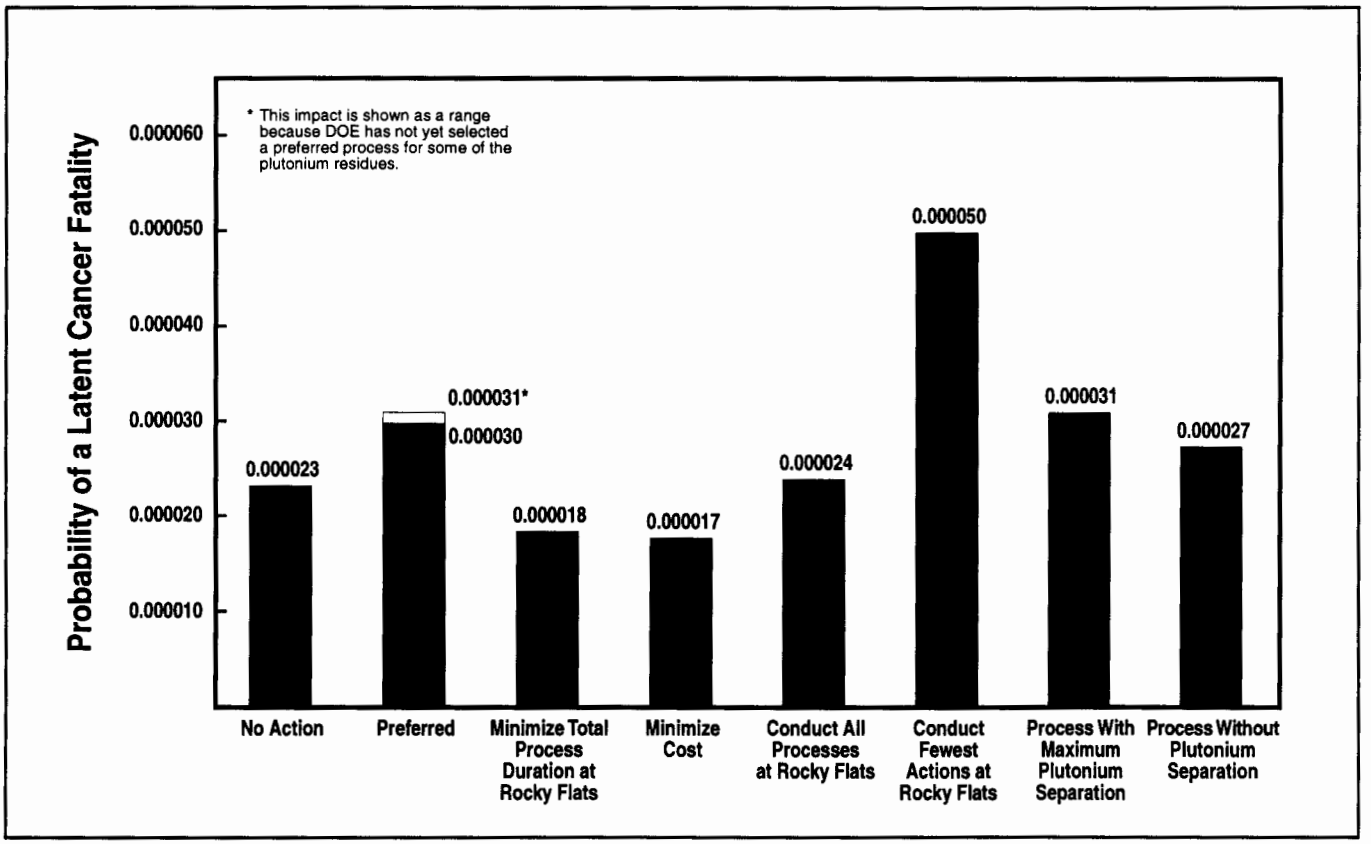


Figure S-23. Accident Risk to the Public Population Maximally Exposed Individual Under Each Management Approach

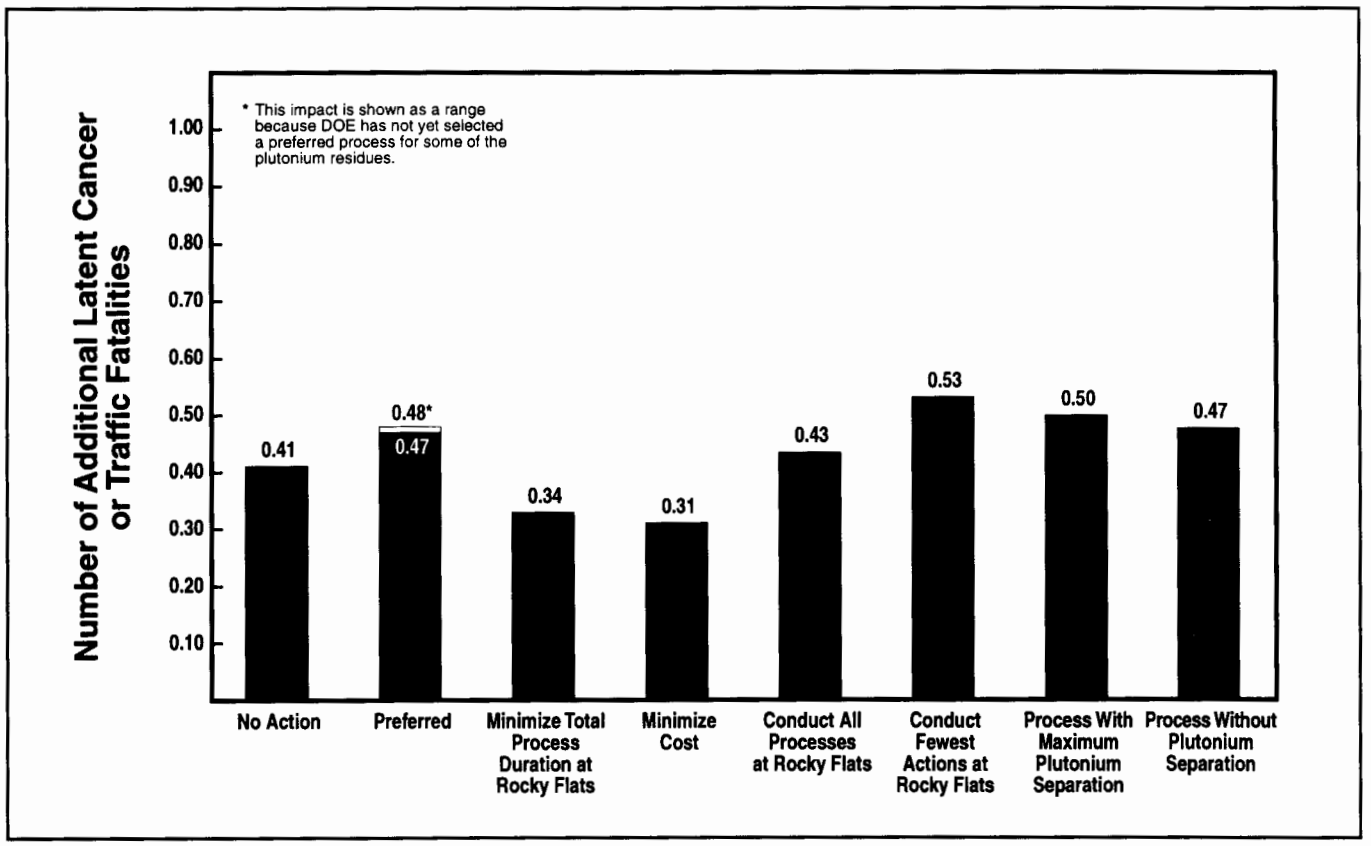


Figure S-24. Accident Risk to the Public Population Under Each Management Approach

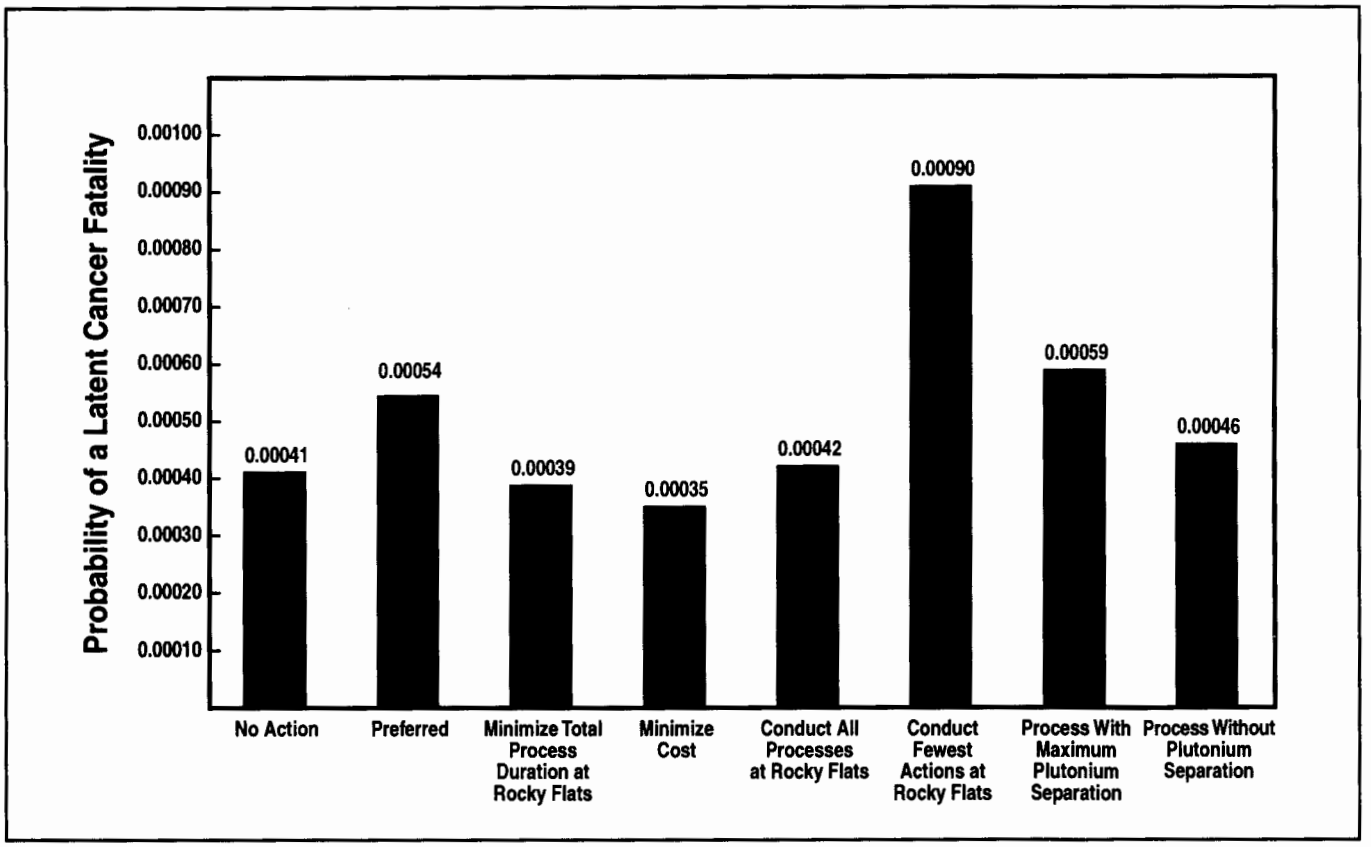


Figure S-25. Accident Risk to the Onsite Noninvolved Worker Under Each Management Approach

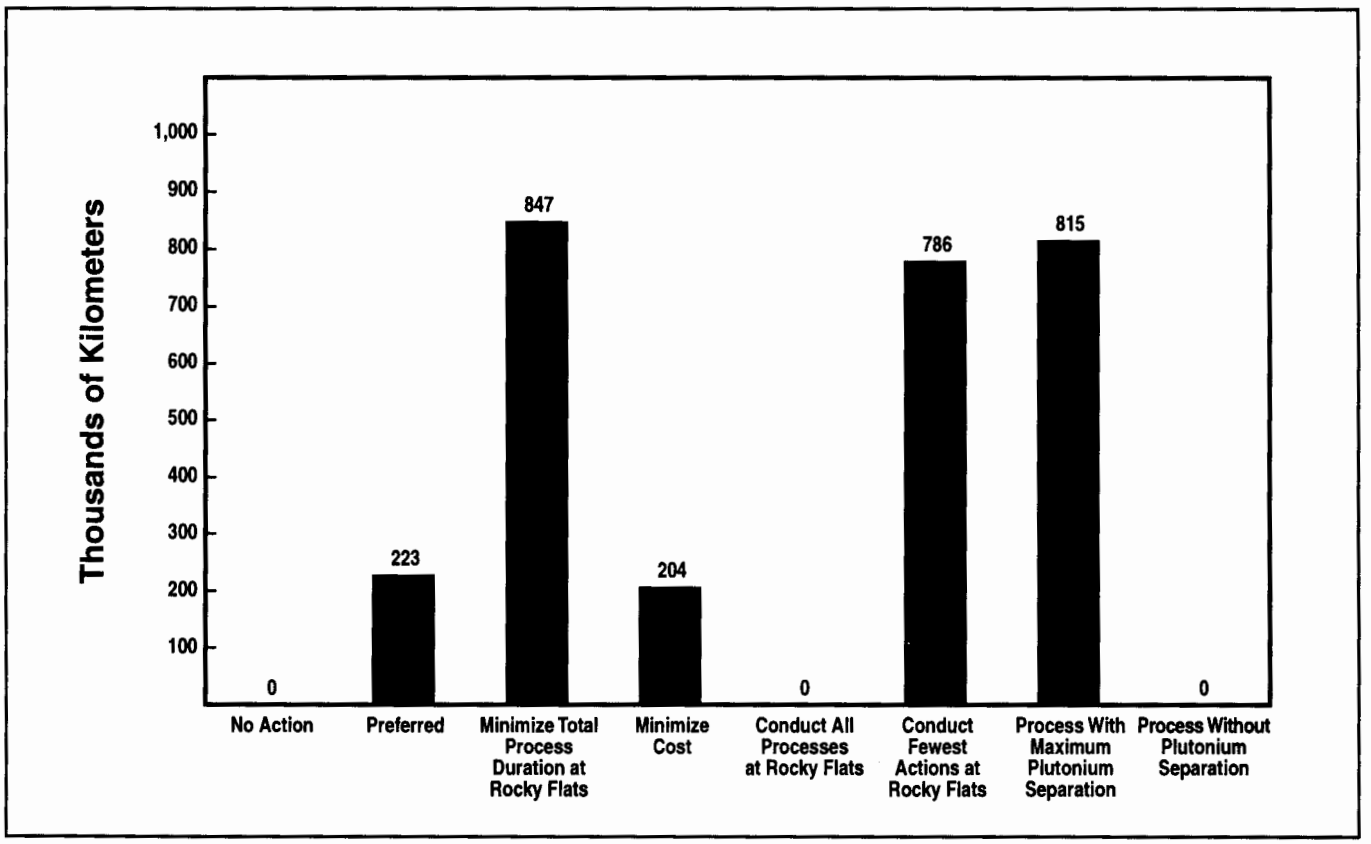


Figure S-26. Intersite Round-Trip Transportation Required Under Each Management Approach

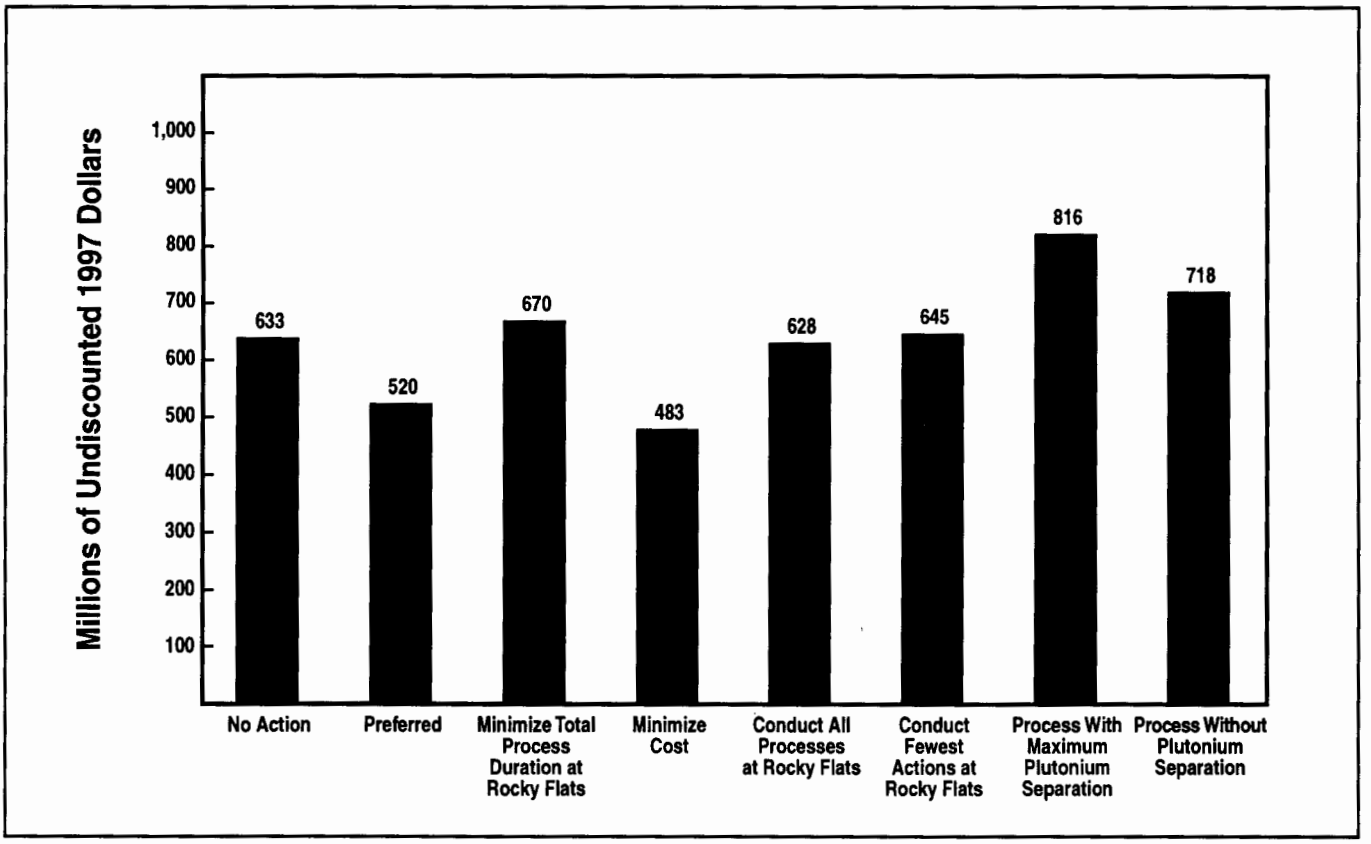


Figure S-27. Cost of Each Management Approach

4.2.3 RANGE OF RADIOLOGICAL AND CHEMICAL IMPACTS AT EACH SITE

All the residues could be processed at Rocky Flats, and portions of the residues could be processed at the Savannah River Site or the Los Alamos National Laboratory. This section presents the range of radiological and chemical impacts which could result from the processing options at Rocky Flats, the Savannah River Site, and Los Alamos National Laboratory.

4.2.3.1 ROCKY FLATS

- ***Incident-Free Radiological Impacts*** — The range of radiological impacts to the public and the workers associated with incident-free implementation of various processing options at Rocky Flats is presented in Table S-6.

Table S-6. Range of Radiological Impacts Due to Incident-Free Operations at Rocky Flats

Offsite Public Maximally Exposed Individual		Offsite Public Population	
Dose (mrem)	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*
0.00014 to 0.0011	7.0×10^{-11} to 5.5×10^{-10}	0.0054 to 0.025	2.7×10^{-6} to 0.000012
Maximally Exposed Individual Worker		**Worker Population**	
Dose (mrem per year)	*Probability of a Latent Cancer Fatality Per Year*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*
2,000	0.0008	477 to 2,060	0.19 to 0.82

The public maximally exposed individual at Rocky Flats would be a hypothetical individual who lives downwind at the site boundary. The estimated total dose for this maximally exposed individual could range from 0.00014 mrem to 0.0011 mrem. This individual's chance of incurring a latent cancer fatality due to process operations would be less than one in one billion (7.0×10^{-11} to 5.5×10^{-10}).

The total public population radiation dose would range from 0.0054 person-rem to 0.025 person-rem. These doses are so small that they would cause far less than one additional latent cancer fatality among the people living near the Rocky Flats site (2.7×10^{-6} to 0.000012). During incident-free storage, there would be no release of radioactive material, so the impact on the public would be equal to zero.

The maximally exposed individual worker dose assumes that an individual worker receives a dose below the DOE Administrative Limit of 2,000 mrem per year to reflect DOE's commitment to maintain doses as low as reasonably achievable.

The total worker population radiation dose would be from 477 person-rem to 2,060 person-rem, which would cause 0.19 to 0.82 additional latent cancer fatalities among the workers directly involved in the operations. Onsite workers who are not involved with the actual processing of the residues are designated as noninvolved workers. The impacts to these workers would be much smaller than the impacts to the involved workers. During the post-processing storage period, inspections of the storage facility would expose the worker population to very small incremental additions.

- ***Incident-Free Hazardous Chemical Impacts*** — The range of impacts of hazardous chemical releases (e.g., carbon tetrachloride and hydrochloric acid) associated with incident-free implementation of the various processing options at Rocky Flats is presented in Table S-7. The probability of excess latent cancer incidence for the offsite population maximally exposed individual resulting from releases of hazardous chemicals ranges from 0 to $3x10^{-10}$. From zero to less than one latent cancer incidence is expected to occur in the offsite population of 2.4 million individuals living within a 50-mile radius of Rocky Flats.

Table S-7. Range of Chemical Impacts Due to Incident-Free Operations at Rocky Flats

Offsite Public Maximally Exposed Individual		Offsite Public Population
Probability of a Cancer Incidence	*Hazard Index*	*Number of Cancer Incidences*
0 to $3x10^{-10}$	0 to 0.006	0 to <1
Maximally Exposed Individual Worker		**Worker Population**
Probability of a Cancer Incidence	*Hazard Index*	*Number of Cancer Incidences*
0 to $1x10^{-8}$	0 to 0.2	0 to <1

The maximally exposed individual worker probability of excess latent cancer incidence ranges from 0 to $1x10^{-8}$. If all site workers were exposed to the maximally exposed individual concentration of carbon tetrachloride, which is an extremely conservative and unrealistic assumption, less than 1 excess latent cancer would be expected to occur in the workforce population. The Hazard Index value of 0.2 suggests that noncancer adverse health effects are not expected in the worker population.

- ***Radiological Impacts Due to Accidents*** — The range of radiological impacts to the public and the workers due to accidents during the implementation of the various processing options for plutonium residues and scrub alloy at Rocky Flats is presented in Table S-8.

Table S-8. Range of Radiological Impacts[a] Due to Accidents at Rocky Flats

Offsite Public Maximally Exposed Individual Risk	Offsite Public Population Risk	Noninvolved Onsite Worker Maximally Exposed Individual Risk
Probability of a Latent Cancer Fatality	*Number of Latent Cancer Fatalities*	*Probability of a Latent Cancer Fatality*
0.0000029 to 0.000028	0.035 to 0.50	0.000030 to 0.00050[b]

[a] *The impacts are given as risks which are additive, rather than consequences, which are not additive for accidents.*

[b] *If an earthquake strong enough to collapse Building 707 and damage Building 371 occurs, 200 involved workers would be at risk of death or injury.*

The public maximally exposed individual at Rocky Flats would be a hypothetical individual who lives downwind at the site boundary. The public population is defined as the residential population within a radius of 80 km (50 mi). An onsite worker is defined as an individual worker who is located 100 m (328 ft) or more downwind from the release point when an accidental release of radioactive material occurs. (This is the same for all three sites evaluated.)

The estimated risk of a latent cancer fatality for the maximally exposed individual at Rocky Flats could range from 0.0000029 to 0.000028. This individual's chance of incurring a latent cancer fatality due to an accident during process operations would be increased by less than 1 in 10,000. The estimated risk of latent cancer fatalities for the general population would be in the range of 0.035 to 0.50. The fatal cancer risk to the onsite worker is in the range of 0.000030 to 0.00050. This onsite worker's chance of incurring a latent cancer fatality due to an accident during process operations would be increased by less than 1 in 1,000.

In any accident scenario, the individuals most likely to be injured are the involved workers. The risk to these workers would be due to both radiological and nonradiological effects. In a fire, the involved workers could be exposed to airborne radioactive material, in addition to the smoke and heat of the fire. In an explosion, there could be flying debris and containment barriers could be broken, exposing workers to airborne radioactive material. Most spills would not have a major effect on involved workers because they would clean up the spill wearing protective clothing and respirators as necessary. An accidental criticality could expose involved workers to large doses of prompt penetrating radiation, which could cause death in a short period of time. The earthquake and aircraft crash accident scenarios present very severe nonradiological effects to the involved workers. In these scenarios, the workers are likely to be hurt or killed from the collapse of the building or the impact of the aircraft crash before they could be evacuated.

The maximum number of involved workers at risk is estimated to be equal to the number of workers who would be working on plutonium residues or scrub alloy at any one time in each of the processing buildings at each of the three sites. Buildings 707 and 371 at Rocky Flats would each have about 100 involved workers inside, which is more involved workers than any facility at either of the other two sites. Thus, if an earthquake strong enough to collapse Building 707 and damage Building 371 hits Rocky Flats, approximately 200 involved workers would be at risk of death or injury due to activities associated with plutonium residues and scrub alloy.

4.2.3.2 SAVANNAH RIVER SITE

- ***Incident-Free Radiological Impacts*** — The range of radiological impacts to the public and the workers associated with incident-free implementation of various processing options at the Savannah River Site is presented in Table S-9.

Table S-9. Range of Radiological Impacts Due to Incident-Free Operations at the Savannah River Site

Offsite Public Maximally Exposed Individual		Offsite Public Population	
Dose (mrem)	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*
0 to 0.0034	0 to 1.7×10^{-9}	0 to 0.38	0 to 0.00019
Maximally Exposed Individual Worker		**Worker Population**	
Dose (mrem per year)	*Probability of a Latent Cancer Fatality Per Year*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*
0 to 2,000	0 to 0.0008	0 to 469	0 to 0.19

Note: The lower value of each range is zero because it is possible that no processing would take place at the Savannah River Site

The public maximally exposed individual at the Savannah River Site would be a hypothetical individual who lives downwind at the site boundary. The estimated total dose for this maximally exposed individual would range from 0 mrem to 0.0034 mrem. This individual's chance of incurring a latent cancer fatality due to process operations would be less than one in one-hundred million (0 to 1.7×10^{-9}).

The total public population radiation dose would range from 0 person-rem to 0.38 person-rem. The dose is estimated to result in far less than one additional latent cancer fatality among the people living near the Savannah River Site (0 to 0.00019). During incident-free storage, there would be no release of radioactive material, so the impact on the public would be equal to zero.

The maximally exposed individual worker dose range assumes that an individual worker receives a dose below the DOE Administrative Limit of 2,000 mrem per year to reflect DOE's commitment to maintain doses as low as reasonably achievable.

The total worker population radiation dose would range from 0 person-rem to 469 person-rem, which would cause 0 to 0.19 additional latent cancer fatalities among the workers directly involved in the operations. Onsite workers who are not involved with the actual processing of the residues are designated as noninvolved workers. The impacts to these workers would be much smaller than the impacts to the involved workers. During the post-processing storage period, inspections of the storage facility would expose the worker population to very small incremental additions.

- ***Incident-Free Hazardous Chemical Impacts*** — The range of impacts of hazardous chemical releases associated with incident-free implementation of the various processing options at the Savannah River Site is presented in Table S-10. No carcinogenic chemicals are expected to be released from the processing of plutonium residues and scrub alloy at the Savannah River Site; therefore, maximally exposed individual cancer probability and population cancer incidences were not evaluated for the offsite population or workers. The Hazard Index range of 0 to 0.2 suggests that noncancer adverse health effects are not expected for the offsite maximally exposed individual as a result of releases of phosphoric acid, ammonium nitrate, or fluorides. The Hazard Index of 2.7 for the maximally exposed worker indicates that there is a potential for adverse noncancer health effects following long-term exposure to the estimated concentrations of contaminants.

Table S-10. Range of Chemical Impacts Due to Incident-Free Operations at the Savannah River Site

Offsite Public Maximally Exposed Individual		Offsite Public Population
Probability of a Cancer Incidence	*Hazard Index*	*Number of Cancer Incidences*
N/A	0 to 0.2	N/A
Maximally Exposed Individual Worker		**Worker Population**
Probability of a Cancer Incidence	*Hazard Index*	*Number of Cancer Incidences*
N/A	0 to 2.7	N/A

N/A = not applicable

- ***Radiological Impacts Due to Accidents*** — The range of radiological impacts to the public and the workers due to accidents during the implementation of the various processing options for the processing of plutonium residues and scrub alloy at the Savannah River Site is presented in Table S-11.

Table S-11. Range of Radiological Impacts[a] Due to Accidents at the Savannah River Site

Offsite Public Maximally Exposed Individual Risk	Offsite Public Population Risk	Noninvolved Onsite Worker Maximally Exposed Individual Risk
Probability of a Latent Cancer Fatality	*Number of Latent Cancer Fatalities*	*Probability of a Latent Cancer Fatality*
0 to 2.4×10^{-7}	0 to 0.011	0 to 0.000078[b]

[a] *The impacts are given as risks which are additive, rather than consequences, which are not additive for accidents.*

[b] *If an earthquake strong enough to damage H-Canyon and H-B Line occurs, 54 involved workers could be at risk of death or injury.*

Note: The lower value of each range is zero since it is possible that no processing will take place at the Savannah River Site.

The estimated risk of a latent cancer fatality for the maximally exposed individual could range from 0 to 2.4×10^{-7}. This individual's chance of incurring a latent cancer fatality due to an accident during processing operations would be increased by less than one in one million. The estimated risk of latent cancer fatalities for the general population could be in the range of 0 to 0.011. The onsite worker risk is in the range of 0 to 0.000078. This onsite worker's chance of incurring a latent cancer fatality due to an accident during processing operations would be increased by less than 1 in 10,000 (0 to 0.000078).

4.2.3.3 LOS ALAMOS NATIONAL LABORATORY

- ***Incident-Free Radiological Impacts*** — The range of radiological impacts to the public and the workers associated with incident-free implementation of processing options at Los Alamos National Laboratory is presented in Table S-12.

Table S-12. Range of Radiological Impacts Due to Incident-Free Operations at Los Alamos National Laboratory

Offsite Public Maximally Exposed Individual		Offsite Public Population	
Dose (mrem)	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*
0 to 0.00032	0 to 1.6×10^{-10}	0 to 0.00095	0 to 4.8×10^{-7}
Maximally Exposed Individual Worker		**Worker Population**	
Dose (mrem per year)	*Probability of a Latent Cancer Fatality Per Year*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*
0 to 2,000	0 to 0.0008	0 to 29	0 to 0.012

Note: The lower value of each range is zero because it is possible that no processing would take place at Los Alamos National Laboratory.

The public maximally exposed individual at Los Alamos National Laboratory would be a hypothetical individual who lives downwind of anticipated releases. As shown in Table S-12, the estimated total dose for this maximally exposed individual would range from 0 mrem to 0.00032 mrem. This individual's chance of incurring a latent cancer fatality due to processing operations would be less than one in one billion (0 to 1.6×10^{-10}).

The total public population radiation dose would range from 0 person-rem to 0.00095 person-rem. The dose is small and would cause far less than one additional fatal latent cancer among the people living near Los Alamos National Laboratory (0 to 4.8×10^{-7}). During incident-free storage, there would be no release of radioactive material, so the impact on the public would be equal to zero.

The maximally exposed individual worker dose range assumes that an individual worker receives a dose below the DOE Administrative Limit of 2,000 mrem per year to reflect DOE's commitment to maintain doses as low as reasonably achievable.

The total worker population radiation dose would range from 0 person-rem to approximately 29 person-rem, which would cause 0 to 0.012 additional latent cancer fatalities among the workers directly involved in the operations. Onsite workers who are not involved with the actual processing of the residues are designated as noninvolved workers. The impacts to these workers would be much smaller than the impacts to the involved workers. During the post-processing storage period, inspections of the storage facility would expose the worker population to very small incremental additions.

Incident-Free Hazardous Chemical Impacts — No hazardous chemicals are expected to be released from the proposed processing of plutonium residues at Los Alamos National Laboratory under the various processing options evaluated in this EIS because no hazardous chemicals are reported to be used in these operations.

- ***Radiological Impacts Due to Accidents*** — The range of radiological impacts to the public and the workers due to accidents during the implementation of the various processing options for plutonium residues at Los Alamos National Laboratory is presented in Table S-13.

Table S-13. Range of Radiological Impacts[a] Due to Accidents at Los Alamos National Laboratory

Offsite Public Maximally Exposed Individual Risk	Offsite Public Population Risk	Noninvolved Onsite Worker Maximally Exposed Individual Risk
Probability of a Latent Cancer Fatality	*Number of Latent Cancer Fatalities*	*Probability of a Latent Cancer Fatality*
0 to 0.000023	0 to 0.030	0 to 0.00039[b]

[a] *The impacts are given as risks which are additive, rather than consequences, which are not additive for accidents.*

[b] *If an earthquake occurs at TA-55 strong enough to damage Building PF-4, 30 involved workers would be at risk of death or injury.*

Note: The lower value of each range is zero since it is possible that no processing will take place at Los Alamos National Laboratory.

The estimated risk of a latent cancer fatality for the maximally exposed individual at Los Alamos National Laboratory would range from 0 to 0.000023. This individual's chance of incurring a latent cancer fatality due to an accident during processing operations would be increased by less than 1 in 10,000. The estimated risk of latent cancer fatalities for the general population would be in the range of 0 to 0.030. The fatal cancer risk to the onsite worker is in the range of 0 to 0.00039. This onsite worker's chance of incurring a latent cancer fatality due to an accident during processing operations would be increased by less than 1 in 1,000.

4.2.4 RANGE OF INTERSITE TRANSPORTATION IMPACTS

Some of the processing options would require transporting plutonium residues or scrub alloy from Rocky Flats to either the Savannah River Site or Los Alamos National Laboratory. Considering all the options, the number of truck shipments from Rocky Flats to the Savannah River Site could range from zero to 208. Similarly, the number of truck shipments from Rocky Flats to Los Alamos National Laboratory could range from zero to 62. This section describes the estimated radiation dose rate near the transport containers and the range of radiological and chemical impacts which could result from intersite transportation. The detailed analysis of the intersite transportation impacts are presented in Appendix E of the EIS.

The regulatory external radiation dose limit for ground transport is 10 mrem per hour at 2 m (6.6 ft) from the vehicle (49 CFR 173.441). Historical data from actual plutonium residue and scrub alloy handling experience have shown dose rates below this regulatory limit. Dose rates at 2 m (6.6 ft) from the Type 9975 and Type 6M containers have often been between 0.15 and 0.6 mrem per hour, depending on the age and type of residue. Because Safe Secure Trailers carry up to 30 Type 9975 and 38 Type 6M containers, dose rates around the vehicle would be higher than around a single container, but would be lower than the regulatory limit.

To be conservative, the analyses in this chapter use the regulatory limit of 10 mrem per hour at 2 m (6.6 ft) from the side of the transport vehicle. This conservative value was used in the calculation of incident-free doses to members of the public and ground transport workers. For radiation workers handling containers at the DOE sites, the dose rate close to the shipping containers was estimated by the conservative methodology presented in Appendix D of the EIS.

The range of radiological impacts due to incident-free transportation is presented in Table S–14. For every impact, the low end of the range is always zero because there are options that involve no transportation. The high end of each range is always low, which indicates that DOE would expect no latent cancer fatalities (0. to 0.026) from any

Table S-14. Range of Radiological Impacts Due to Incident-Free Transportation

Destination	Public MEI		Public Population	
	Dose (mrem)	*Probability of a Latent Cancer Fatality*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*
Savannah River Site	0 to 11	0 to 5.5×10^{-6}	0 to 21	0 to 0.011
Los Alamos National Laboratory	0 to 11	0 to 5.5×10^{-6}	0 to 1.7	0 to 0.00085
Destination	MEI Transport Worker		Transport Worker Population	
	Dose (mrem per yr)	*Probability of a Latent Cancer Fatality Per Year*	*Dose (person-rem)*	*Number of Latent Cancer Fatalities*
Savannah River Site	0 to 100	0 to 0.000040	0 to 32	0 to 0.013
Los Alamos National Laboratory	0 to 100	0 to 0.000040	0 to 2.6	0 to 0.0010

MEI = maximally exposed individual

combination of transportation options.

The only chemical impact would be latent cancer fatalities due to vehicle exhaust. The vehicle exhaust gases from the maximum number of truck shipments (round trip) to the Savannah River Site and Los Alamos National Laboratory could cause 0.0027 and 0.00028 latent cancer fatalities, respectively.

The potential impacts due to transportation accidents are presented in Table S-15. For every impact, the low end of the range is always zero because there are options that involve no transportation. The table shows that the risk of prompt death due to the trauma of a traffic accident is much greater than the risk due to radiological exposure following an accident. The highest risk is 0.021, which means that there would be about a 2 percent chance of one traffic fatality if DOE decides to make all 208 possible truck shipments to the Savannah River Site.

Table S-15. Range of Impacts[a] Due to Transportation Accidents

Destination	Public Population Radiological Risk	Public Population and Worker Trauma Risk
	Number of Latent Cancer Fatalities	*Probability of One Traffic Fatality*
Savannah River Site	0 to 8.4×10^{-6}	0 to 0.021
Los Alamos National Laboratory	0 to 3.7×10^{-7}	0 to 0.00046

[a] *The impacts are given as risks which are additive, rather than consequences, which are not additive for accidents.*

4.2.5 PLUTONIUM AND AMERICIUM TOXICITY

The adverse health effects experienced following exposure to plutonium result predominantly from its radiological toxicity rather than its chemical toxicity. Plutonium is not readily absorbed from the gastrointestinal tract following ingestion or through the intact skin following dermal exposure; inhalation is the most common route of human exposure. Once inhaled, the rate of clearance from the lungs is influenced by particle size, specific isotope, and chemical form. Following inhalation exposure, different amounts of plutonium travel to the liver and bone. The radiotoxicity of plutonium results from its emission of ionizing radiation, primarily in the form of alpha particles, although low-energy gamma radiation and low-energy neutrons are also released. In studies with laboratory animals, exposure to high radiation doses of plutonium isotopes has resulted in decreases in lifespans, diseases of the respiratory tract, and cancer.

Plutonium residues and scrub alloy contain a number of different plutonium isotopes, including plutonium-241, which emits low-energy beta particles and decays to form americium-241 as a daughter product. Americium-241 is radiotoxic because it produces high gamma radiation doses and also emits alpha particles and neutrons. Like plutonium, the radiotoxicity of americium is of much greater concern than its chemical toxicity.

4.2.6 ENVIRONMENTAL JUSTICE

Executive Order 12898 directs Federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of agency actions on minority populations and low-income populations. As discussed previously (in Section 4.2.3), the proposed action and alternatives will have no significant adverse or beneficial environmental effects on the general population. Nor will the proposed action and alternatives have any significant effects on any particular group within the general population, including minority populations or low-income populations.

A detailed discussion of Environmental Justice is given in Appendix F of the EIS.

4.2.7 CUMULATIVE IMPACTS

The radiological and chemical releases associated with normal operations of any of the processing alternatives evaluated in this EIS result in less than one cancer fatality to the offsite populations around each of the three sites. The contribution to existing and projected impacts associated with all other site activities is very small. Section 4.25 of the EIS provides a detailed presentation of the cumulative impacts around each site.

5.0 APPLICABLE LAWS, REGULATIONS, AND OTHER REQUIREMENTS

Numerous laws, regulations, and other requirements apply to the proposed action and alternatives. These include Federal regulations; Executive Orders; DOE Orders, Notices, and Standards; agreements between the States and DOE; and those Federal statutes, Executive Orders, and Federal regulations applicable to emergency management and response. A detailed description of these requirements is contained in Chapter 5 of the EIS.

6.0 PUBLIC READING ROOMS

A complete copy of the Draft EIS may be reviewed at any of the Public Reading Rooms and Libraries listed below.

Simi Valley Public Library
2629 Tapo Canyon Road
Simi Valley, CA 93063

Lawrence Livermore National Laboratory
East Gate Visitors Center
Greenville Road
Livermore, CA 94550

CSU Northridge/Oviatt Library
18111 Nordhoff Street
Northridge, CA 91330

U.S. Department of Energy
Oakland Operations Office
1301 Clay Street
Room EIC, 8th Floor
Oakland, CA 94612

Platt Brand Public Library
23600 Victory Boulevard
Woodland Hills, CA 91367

U.S. Department of Energy
Golden Field Office
Public Reading Room
14869 Denver West Parkway
Golden, CO 80401

U.S. EPA
Superfund Records Center
999 18th Street, Floor 5
Denver, CO 80202

Rocky Flats Citizens Advisory Board
Public Reading Room
9035 Wadsworth Avenue, Ste. 2250
Westminster, CO 80021

Standley Lake Public Reading Room
8485 Kipling Street
Arvada, CO 80005

Rocky Flats Public Reading Room
Front Range Community College Library
3645 W. 112th Avenue
Westminster, CO 80030

University of Colorado Libraries
Government Publications
Campus Box 184
Boulder, CO 80309

Colorado Department of Public Health
4300 Cherry Creek Drive South
Denver, CO 80222

Colorado State University
Document Department
The Libraries
Fort Collins, CO 80523

Colorado School of Mines
Arthur Lakes Library
1400 Illinois Street
P.O. Box 4029
Golden, CO 80401

Colorado State University
Library Documents Department
Ft. Collins, CO 80523

U.S. Department of Energy
1000 Independence Avenue SW
FOI Room, 1E-190, Forrestal Bldg.
Washington, DC 20585

Pullen Public Library
100 Decatur Street SE
Atlanta, GA 30303

Chatham Effingham Library
2002 Bull Street
Savannah, GA 31499

Reese Library
Augusta College
2500 Walton Way
Augusta, GA 30904

Georgia Institute of Technology
Bobby Dodd Way
Atlanta, GA 30332

Argonne National Laboratory
Technical Library
P.O. Box 2528
Idaho Falls, ID 83403

University of Illinois at Chicago
U.S. DOE Public Documents Room
801 S. Morgan Street, 3rd Floor
Chicago, IL 60607

East St. Louis Public Library
Dr. Ram Chauhan
405 North 9th Street
East St. Louis, IL 62201

Lincoln Library
Reference Department
326 South 7th Street
Springfield, IL 62701

Salina Public Library
Marc Boucher, Reference Librarian
301 West Elm
Salinas, KS 67401

Washburn Law Library
1700 College
Topeka, KS 66621

Paducah Public Library
555 Washington Street
Paducah, KY 42001

U.S. DOE
Environmental Information Center
175 Freedom Boulevard
Kevil, KY 42053

Mid Continent Public Library
Blue Ridge Branch
9253 Blue Ridge Boulevard
Kansas City, MO 64138

St. Louis Public Library
1301 Olive Street
St. Louis, MO 63103

Scenic Regional Library
308 Hawthorn Drive
Union, MO 63084

Los Alamos Community Reading Room
1350 Central Avenue, Suite 101
Los Alamos, NM 87544

U.S. DOE Albuquerque Operations Office
National Atomic Museum
20358 Wyoming Boulevard SE
Kirtland Air Force Base
P.O. Box 5400
Albuquerque, NM 87185

U.S. Department of Energy
FOIA Reading Room
4700 Morris NE
Albuquerque, NM 87111

U.S. Department of Energy
Technical Vocational Institute
Main Campus Library
525 Buena Vista SE
Albuquerque, NM 87106

Los Alamos Community Reading Room
1350 Central Avenue, Suite 101
MS-C314
Los Alamos, NM 87544

New Mexico State Library
325 Don Gasper
Santa Fe, NM 87503

U.S. Department of Energy
Gregg Graniteville Library
171 University Parkway
Aiken, SC 29801

County Library
404 King Street
Charleston, SC 29403

South Carolina State Library
1500 Senate Street
P.O. Box 11469
Columbia, SC 29211

Orangeburg County Free Library
510 Louis Street NE
P.O. Box 1367
Orangeburg, SC 29116

Lawson McGhee Public Library
500 West Church Avenue
Knoxville, TN 37902

Nashville Public Library
225 Polk Avenue
Nashville, TN 37203

DOE Public Reading Room
Oak Ridge Operations Office
55 Jefferson Circle, Room 1123
Oak Ridge, TN 37831