COVER SHEET

RESPONSIBLE AGENCY: U.S. Department of Energy (DOE)

TITLE: Savannah River Site, Spent Nuclear Fuel Management Final Environmental Impact Statement (DOE/EIS-0279) EC

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ABSTRACT: The proposed DOE action considered in this environmental impact statement (EIS) is to implement appropriate processes for the safe and efficient management of spent nuclear fuel and targets at the Savannah River Site (SRS) in Aiken County, South Carolina, including placing these materials in forms suitable for ultimate disposition. EC Options to treat, package, and store this material are discussed. The material included in this EIS consists of approximately 68 metric tons heavy metal (MTHM) of spent nuclear fuel (20 MTHM of aluminum-based spent nuclear fuel at SRS, as much as 28 MTHM of aluminum-clad spent nuclear fuel from foreign and domestic research reactors to be shipped to SRS through 2035, and 20 MTHM of stainless-steel or zirconium-clad spent nuclear fuel and some Americium/Curium Targets TC stored at SRS.

Alternatives considered in this EIS encompass a range of new packaging, new processing, and conventional processing technologies, as well as the No Action Alternative. A preferred alternative is identified in which DOE would prepare about 97 percent by volume (about 60 percent by mass) of the aluminum-based fuel EC for disposition using a melt and dilute treatment process. The remaining 3 percent by volume (about 40 percent by mass) would be managed using chemical separation. EC Impacts are assessed primarily in the areas of water resources, air resources, public and worker health, waste management, socioeconomic, and cumulative impacts.

PUBLIC INVOLVEMENT: DOE issued the Draft Spent Nuclear Fuel Management EIS on December 24, 1998, and held a formal public comment period on the EIS through February 8, 1999. In preparing the Final EIS, DOE considered comments received via mail, fax, electronic mail, and transcribed comments EC made at public hearings held in Columbia, S.C. on January 28, 1999, and North Augusta, S.C. on February 2, 1999. Completion of the Final EIS has been delayed because DOE has performed additional analyses of the melt and dilute technology, discussed in Chapter 2 and Appendix G. Comments received and DOE's responses to those comments are found in Appendix G of the EIS.

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Change Bars

Changes from the Draft EIS are indicated in this Final EIS by vertical change bars in the margin. The bars are marked TC for technical changes, EC for editorial changes, or if the change was made in response to a public comment, the designated comment number is as listed in Appendix G of the EIS.

Abbreviations for Measurements

cfm	cubic feet per minute
cfs	cubic feet per second = 448.8 gallons per minute = 0.02832 cubic meter per second
cm	centimeter
gpm	gallons per minute
kg	kilogram
L	liter = 0.2642 gallon
lb	pound = 0.4536 kilogram
mg	milligram
µCi	microcurie
µg	microgram
pCi	picocurie
°C	degrees Celsius = 5/9 (degrees Fahrenheit – 32)
°F	degrees Fahrenheit = 32 + 9/5 (degrees Celsius)

Use of Scientific Notation

Very small and very large numbers are sometimes written using "scientific notation" or "E-notation" rather than as decimals or fractions. Both types of notation use exponents to indicate the power of 10 as a multiplier (i.e., 10^n, or the number 10 multiplied by itself "n" times; 10^{-n}, or the reciprocal of the number 10 multiplied by itself "n" times).

For example: $10^3 = 10 \times 10 \times 10 = 1{,}000$

$$10^{-3} = \frac{1}{10 \times 10 \times 10} = 0.001$$

In scientific notation, large numbers are written as a decimal between 1 and 10 multiplied by the appropriate power of 10:

4,900 is written $4.9 \times 10^3 = 4.9 \times 10 \times 10 \times 10 = 4.9 \times 1{,}000 = 4{,}900$
0.049 is written 4.9×10^{-2}
1,490,000 or 1.49 million is written 1.49×10^6

A positive exponent indicates a number larger than or equal to one; a negative exponent indicates a number less than one. | EC

In some cases, a slightly different notation ("E-notation") is used, where "× 10" is replaced by "E" and the exponent is not superscripted. Using the above examples

$4{,}900 = 4.9 \times 10^3$ = 4.9E+03
$0.049 = 4.9 \times 10^{-2}$ = 4.9E-02
$1{,}490{,}000 = 1.49 \times 10^6$ = 1.49E+06

Metric Conversion Chart

To convert into metric			To convert out of metric		
If you know	**Multiply by**	**To get**	**If you know**	**Multiply by**	**To get**
Length					
inches	2.54	centimeters	centimeters	0.3937	inches
feet	30.48	centimeters	centimeters	0.0328	feet
feet	0.3048	meters	meters	3.281	feet
yards	0.9144	meters	meters	1.0936	yards
miles	1.60934	kilometers	kilometers	0.6214	miles
Area					
sq. inches	6.4516	Sq. centimeters	sq. centimeters	0.155	sq. inches
sq. feet	0.092903	sq. meters	sq. meters	10.7639	sq. feet
sq. yards	0.8361	sq. meters	sq. meters	1.196	sq. yards
acres	0.0040469	sq. kilometers	sq. kilometers	247.1	acres
sq. miles	2.58999	sq. kilometers	sq. kilometers	0.3861	sq. miles
Volume					
fluid ounces	29.574	milliliters	milliliters	0.0338	fluid ounces
gallons	3.7854	liters	liters	0.26417	gallons
cubic feet	0.028317	cubic meters	cubic meters	35.315	cubic feet
cubic yards	0.76455	cubic meters	cubic meters	1.308	cubic yards
Weight					
ounces	28.3495	grams	grams	0.03527	ounces
pounds	0.4536	kilograms	kilograms	2.2046	pounds
short tons	0.90718	metric tons	metric tons	1.1023	short tons
Temperature					
Fahrenheit	Subtract 32 then multiply by 5/9ths	Celsius	Celsius	Multiply by 9/5ths, then add 32	Fahrenheit

Metric Prefixes

Prefix	Symbol	Multiplication Factor
exa-	E	1 000 000 000 000 000 000 = 10^{18}
peta-	P	1 000 000 000 000 000 = 10^{15}
tera-	T	1 000 000 000 000 = 10^{12}
giga-	G	1 000 000 000 = 10^{9}
mega-	M	1 000 000 = 10^{6}
kilo-	k	1 000 = 10^{3}
centi-	c	0.01 = 10^{-2}
milli	m	0.001 = 10^{-3}
micro-	μ	0.000 001 = 10^{-6}
nano-	n	0.000 000 001 = 10^{-9}
pico-	p	0.000 000 000 001 = 10^{-12}
femto-	f	0.000 000 000 000 001 = 10^{-15}
atto-	a	0.000 000 000 000 000 001=10^{-18}

SUMMARY

S.1 Introduction

The management of spent nuclear fuel (SNF) has been an integral part of the mission of the Savannah River Site (SRS) for more than 40 years. Until the early 1990s, SNF management consisted primarily of short-term onsite storage followed by processing in the SRS chemical separation facilities to produce strategic nuclear materials.

> ***What is Spent Nuclear Fuel?***
>
> Spent nuclear fuel is fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated. When it is removed from a reactor, spent nuclear fuel contains some unused enriched uranium and radioactive fission products. Because of its radioactivity (primarily from gamma rays), it must be properly shielded. The fuel elements exist in many configurations. Generally, a fuel element is covered by a metal called cladding and is shaped into long rods, flat plates, or cylinders.

With the end of the Cold War, the U.S. Department of Energy (DOE) decided in April 1992 to phase out processing of SNF for the production of nuclear weapons materials. Therefore, the management strategy for this fuel has shifted from short-term storage and processing for the recovery of highly-enriched uranium and transuranic isotopes to stabilization, when necessary, and interim storage pending final disposition. Interim storage includes preparing SNF for disposal in any potential geologic repository.

In addition to the fuel already onsite, the SRS will receive SNF from foreign research reactors until 2009 and potentially could receive SNF from domestic research reactors until 2035. As a result, the safe and efficient management of SNF will continue to be an important SRS mission.

A key element in the decisionmaking process for SNF management is a thorough understanding of the environmental impacts that may result from the implementation of the proposed action. The National Environmental Policy Act of 1969 (NEPA), as amended, provides Federal decisionmakers with a process to use when considering potential environmental impacts of proposed actions.

> ***National Environmental Policy Act of 1969:*** An act that requires Federal agencies to consider in their decisionmaking process the potential environmental effects of proposed actions, and to analyze alternative approaches to meeting the need for agency action.
>
> ***Environmental Impact Statement:*** A detailed environmental analysis of any proposed major Federal action that could significantly affect the quality of the human environment. It is a tool to assist the decisionmakers; it describes the positive and negative environmental effects of the proposed action and alternatives.
>
> ***Alternatives:*** The range of reasonable alternative actions, that could be taken to meet the need for agency action.
>
> ***Record of Decision:*** A concise public statement of the Federal agency's decision. It discusses the decision, identifies the alternatives considered, including the environmentally preferable alternative, and indicates whether all practicable means to avoid or minimize environmental harm were adopted (and if not, why not).

Following this process, DOE announced, on December 31, 1996 in the *Federal Register* its intent to prepare an EIS (61 FR 69085) and to establish a public comment period on the scope of the EIS that lasted until March 3, 1997. DOE accepted all comments received, even those received beyond the closing date. A public scoping meeting was held in North Augusta, South Carolina on January 30, 1997. Forty-one mem-bers of the public attended the meeting with 22 presenting comments or asking questions. In

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addition, during the scoping period DOE received letters, E-mails, and other written comments. Based upon these submittals and presentations, DOE identified 118 separate public comments which DOE divided into the following categories:

- Processing of Spent Nuclear Fuel
- Alternative Technologies
- EC Need for a Transfer and Storage Facility
- Reuse of Nuclear Material for the Generation of Electricity
- Waste Form/Road-Ready Condition/Repository/Yucca Mountain
- Socioeconomic Impacts
- Human (Occupational and Public) Health
- Chemistry of Spent Nuclear Fuel
- Privatization
- Waste Generation
- No-Action Alternative
- Out-of-Scope Comments

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Utilizing input from the public scoping meeting and the NEPA process, DOE prepared a draft Environmental Impact Statement (EIS) for public comment.

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A Notice of Availability of the Draft EIS appeared in the Federal Register on December 24, 1998. Public meetings to discuss and receive comments on the Draft EIS were held on Thursday, January 28, 1999 at the Holiday Inn Coliseum, Columbia, SC and on Tuesday, February 2, 1999 at the North Augusta Community Center, North Augusta, SC. The public comment period ended on February 8, 1999. In the public meetings 17 individuals commented on the draft EIS. During the 45-day comment period DOE also received 15 letters commenting on the Draft EIS. DOE also received seven letters commenting on the EIS after February 8, 1999, and the comments have been addressed in the final EIS.

For ease of discussing the comments in this Summary, DOE divided the comments into 12 major categories. The major points associated with the public comments and DOE's responses are summarized below.

Processing

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Comments were received related to processing of SNF. These ranged from support of processing as a proven method for disposition of SNF to admonitions that the processing facilities (canyons) should be shut down immediately. A number of comments asked for clarification regarding the criteria used for determining when processing would be necessary for SNF currently in storage. Commentors also criticized the method by which DOE outlined the missions of the canyons, and several requested definite closure dates for the canyons.

Response: The canyons at SRS cannot be shut down immediately because DOE is utilizing these facilities to stabilize nuclear materials. In this EIS, DOE proposes to use the canyons to process a relatively small amount (about 3 percent by volume or 40% by weight) of the SNF under consideration to eliminate the potential for certain health and safety problems. The basis for selecting the SNF proposed for processing is discussed in Section 2.4.3.2 of the Final EIS. DOE estimates the processing time would be less than 6 months in F Canyon and about 1 year in H Canyon. The proposed processing operations are within the current canyon schedule planning basis. In other words, the proposed SNF processing activities would not extend the planned canyon operations. However, establishing closure dates for the SRS canyons is beyond the scope of this EIS.

Alternatives

Comments were received regarding alternatives to conventional processing of SNF. The comments ranged from support for alternatives to conventional processing to questions regarding the details of alternatives and their impacts. Commentors also questioned DOE's ability to develop a new technology to treat SNF in a timely manner.

Response: DOE evaluated a variety of technologies for managing aluminum-based SNF at the SRS. DOE considers that the range of technologies included in the EIS to be an appropriate reflection of the technologies available. DOE also considers the range of alternatives evaluated in the EIS to represent a reasonable set of the technology combinations that could have been evaluated. Public comments did not reveal an SNF management technology that DOE has not considered. The DOE has completed considerable research and development work for the proposed SNF alternative treatment technology (i.e., Melt and Dilute). DOE is committed to developing and demonstrating that technology for aluminum-based SNF as quickly as possible.

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Waste Form

Comments were received relating to the acceptability in any geologic repository of the SNF waste form that would be produced using a new (alternative) SNF treatment technology. The principal concern was that waste acceptance criteria for a geologic repository have not been established. In this regard, the concern was that alternative technologies for the disposition of SNF may produce a product that will not meet the final repository criteria.

Response: Waste acceptance criteria describe the physical, chemical, and thermal characteristics to which SNF and associated canisters must conform for emplacement in a geologic repository. DOE has assessed the waste forms the primary new SNF treatment technologies (Melt and Dilute, and Direct Disposal/Direct Co-Disposal) would generate against potential repository preliminary waste acceptance criteria. DOE concluded that waste forms from both technologies would meet the preliminary criteria. Section 2.2.1 of the Final EIS has been revised to discuss the issue in greater detail.

Impacts

Comments were received related to the calculation of impacts from the proposed actions. These comments ranged from expressions that specific impacts were negligible to comments that the impacts from past Site activities had been underestimated.

Response: The impact estimates in the Final EIS are based on data from Site operations or operating experience and the judgement of expert analysts. DOE believes that the analyses presented in the EIS are adequate for comparing SNF management alternatives.

Openness/Independent Review

Comments were received regarding independent reviews of the SNF treatment technologies and how they would be used in the decisionmaking process. The comments called for increased public involvement. Some comments also called for DOE to share technology development data, particularly regarding the requirements and performance of the off-gas system. TC

Response: DOE believes that the EIS process provides adequate opportunities for public involvment. For example, DOE has invited public comment and input for this process during scoping meetings and during the public comment period for the Draft EIS. Information regarding technology development that is referenced in the Final EIS is available at the DOE Public Reading Room, University of South Carolina at Aiken, Gregg-Graniteville Library, University Parkway, Aiken, South Carolina and at the DOE Freedom of Information Reading Room (Room 1E-190), Forrestal Building, 1000 Independence Ave., Washington, D.C. Additionally, information regarding the development of the new SNF treatment technologies, including the off-gas system that would be used to collect fission products that could evolve during operation of the Melt and Dilute process, may be requested from Randall Ponik, U.S. Department of Energy, P.O. Box A, Aiken, South Carolina 29802, (803) 557-3263 or via E-mail at randall.ponik@SRS.gov. DOE has also solicited comments on the Melt and Dilute process from outside the Department. Contributing institutions include the University of South Carolina, the U.S. Nuclear Regulatory Commission (NRC), and the National Academy of Sciences. Their reports are publicly available, including in the DOE reading rooms, or upon request.

Cost

Comments were received regarding the potential costs of SNF treatment alternatives. These comments primarily questioned whether all costs and credits had been considered. This included the credits for the separation and sale of usable enriched uranium to the commercial nuclear power industry. Comments also were made regarding the adequacy of funding for the implementation of SNF treatment alternatives.

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Response: DOE prepared a report on costs associated with aluminum-based SNF treatment technologies. DOE considered all appropriate factors to prepare the report. A discussion of uranium credits (i.e., cost recovery based on the sale of low-enriched uranium to the private sector) was included in the cost analysis. The results of the cost report are discussed in Section 2.6.5 of the EIS. DOE obtained an independent review of the cost report; the recommendations from the independent review were factored into the report.

A timeline has been established for the development, design and implementation of the melt and dilute facility. This timeline will be controlled through DOE's line item budget and procurement process pending completion of this NEPA process. The design and construction of a full-scale facility would need to be developed in the context of constrained, out-year budget targets, and funding for such a facility would need to be balanced against other priorities at SRS. DOE has developed a schedule that can be used as a baseline for near-term planning and budgeting purposes. The FY 2000 budget has been established and includes funding for design completion of the L-Area Experimental Facility (LEF). The LEF is a pilot test facility which will demonstrate the feasibility of the melt and dilute technology. LEF is scheduled to be constructed and placed online by the end of FY 2002.

References

Comments were received related to the references used in the preparation of the EIS. The comments generally suggested alternate sources of information for the EIS and suggested that both foreign and domestic SNF handling experience be included in the discussion.

Response: DOE considered these suggestions. Based on the reports cited by the commentors, DOE believes accurate and current information was used to prepare the Final EIS. The information is based on actual Site operations (e.g., handling foreign and domestic SNF) and conditions or on estimates of operational activities and conditions that would exist for new facilities. As a result, DOE believes that data and references used in preparing the EIS provide an adequate basis for estimating impacts and for comparing technologies and alternatives. Current regulatory requirements and information have been cited as applicable. TC

Nonproliferation

Comments were received regarding nonproliferation issues as they relate to the treatment and disposition of SNF. A number of commentors felt that nonproliferation was being overemphasized in relation to its importance. However, one commentor doubted the independence of DOE in the preparation of the nonproliferation study, and another commentor stated that DOE should take a worldwide leadership role in nonproliferation by treating SNF without separating potential weapons materials.

Response: DOE believes nonproliferation to be one of the factors that must be considered during the decision-making process. DOE conducted a nonproliferation study for SNF treatment technologies in conjunction with the preparation of the Draft EIS. The study concluded that all technologies considered in the Draft EIS were compatible with the nonproliferation goals of the United States but that separations technologies, such as Conventional Processing, had distinct disadvantages because fissile material would be separated. The study was reviewed by experts independent of DOE: Matthew Bunn, Belfor Center for Science and International Affairs, Harvard University; Frank von Hipple, Woodrow Wilson School of Public and International Affairs, Princeton University; George Bunn, Center for International Security and Cooperation, Institute for International Studies, Stanford University; Harold Bengelsdorf, Bengelsdorf, McGoldrick and Associates, LLC; and David Albright, Institute for Science and International Security. No problems were identified with the conclusions presented in the report.

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Methodology

Comments were received related to the methodologies used in the preparation of the EIS. These included both positive and negative comments on health issues and environmental justice. One of the commenters asked what environmental impact would result from the release of cesium into the atmosphere in the event that the filtration system does not capture all the cesium. Another commenter stated that DOE had minimized impacts in the Cumulative Impacts Chapter and only used a limited amount of available information regarding actual operating experience. The Environmental Protection Agency (EPA) commended DOE on its method of segregating spent fuel by type and then applying the appropriate treatment methodology as the best way to proceed.

Response: Impacts in the EIS are estimated from the best available information, including operational data whenever possible. When operations data do not exist, SRS relies on experience and information from similar facilities and the best judgement of technical experts.

Purpose and Need

Comments were received related to the stated purpose and need for agency action. The comments generally focused on long-term solutions to the problems SNF poses and noted that other nuclear materials that could be processed in SRS facilities should also be addressed.

Response: DOE proposes to manage SNF in such a way as to prepare aluminum-based SNF to meet the requirements for disposal in a geologic repository, and will make the SNF ready for offsite shipment. DOE is separately evaluating potential geologic disposal of high-level waste and spent nuclear fuel in the EIS for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada as discussed in Section 1.6 of the SNF Management EIS. DOE has addressed other nuclear materials that could be managed at the SRS as part of the cumulative impacts discussion in Chapter 5 of this EIS. The inventory of material was based on recent studies completed by DOE (see Chapter 5). TC

Safety

Comments were received related to general safety issues of the proposed actions. Most comments were related to concerns on whether or not facilities would be constructed and operated using stringent safety standards.

Response: DOE is committed to the protection of workers, the public, and the environment. All operations and facilities at SRS meet or exceed all applicable health protection and safety requirements. SNF treatment facilities and operations will meet or exceed all applicable requirements.

Failure of Stored SNF Before Treatment

Comments were received regarding the possibility that stored SNF could fail before proposed treatment facilities are available. The comments requested impact estimates for these potential failures.

Response: The preferred alternative in the Final EIS includes a discussion of the action that would be taken (processing in SRS canyons) should SNF fail while in storage pending implementation of a new treatment technology. Section 1.5 of the Final EIS includes a qualitative discussion of the types of health and safety issues (e.g., uncontrolled release of fission products into storage basin water) that would be created by the failure of the SNF that DOE believes presents certain vulnerabilities for continued storage.

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In addition, a number of other comments were received that offered editorial suggestions, could not be easily categorized, or were deemed to be out of scope of this EIS. Comments received and DOE's responses to all comments are presented in Appendix G of the EIS.

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After consideration of public comments, DOE prepared a Final EIS. Decisions on the management of SNF at SRS will be presented in a Record of Decision issued at least 30 days after the Notice of Availability of the Final EIS is published in the *Federal Register*. The Record of decision will be published in the *Federal Register*.

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S.2 Background

S.2.1 HISTORIC MISSIONS

The U.S. Atomic Energy Commission, a DOE predecessor agency, established the SRS in the early 1950s for the production of special radioactive isotopes to support national programs. Historically, the primary Site mission was the production of strategic isotopes (plutonium-239 and tritium) for use in the development and production of nuclear weapons. The SRS produced other isotopes (e.g., californium-252, plutonium-238, americium-241) to support research in nuclear medicine, space exploration, and commercial applications. DOE produced these isotopes in the five SRS production reactors. After the material was produced at the SRS, it was shipped to other DOE sites for fabrication into desired forms.

S.2.2 FUEL CYCLE

The material in the SRS reactors consisted of nuclear fuel and targets. The nuclear fuel was enriched uranium that was alloyed with aluminum and then clad with aluminum. The targets were either oxides or metallic forms of various isotopes such as neptunium-237 or uranium-238 that were clad with aluminum. Fuel and targets were fabricated at the SRS and placed in the reactors, and then the reactors operated to create the neutrons necessary to transmute the target material. After irradiation, the fuel and targets (collectively referred to as spent nuclear fuel) were removed from the reactors and placed in water-filled basins for short-term storage, about 12 to 18 months, before they were reprocessed in the SRS separations facilities.

During processing, SNF was chemically dissolved in F or H Canyon to recover the uranium or transuranic isotopes for future use. The remaining residue from the fuel, high-level radioactive waste consisting primarily of fission products and cladding in liquid form, was transferred to large steel tanks for storage. The high-level waste is currently being vitrified in the Defense Waste Processing Facility at the SRS to prepare it for placement in any potential geologic repository. EC

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S.2.3 CHANGING MISSIONS

In 1992, the Secretary of Energy directed that processing operations to produce strategic nuclear materials be phased out throughout the DOE complex. However, SNF and targets from previous production reactor irradiation cycles remained in storage at SRS spent nuclear fuel storage facilities.

In addition to nuclear material production missions, another mission for the SRS was (and continues to be) the receipt of SNF from DOE, domestic, and foreign research reactors. Historically, SNF from these reactors was stored in the Receiving Basin for Offsite Fuel at SRS. In the past, much of the research reactor SNF was reprocessed in the same manner as spent fuel from SRS production reactors. However, with the end of the Site's strategic nuclear materials production mission, SNF from research reactors has been accumulating in the Receiving Basin for Offsite Fuel and in the L-Reactor Disassembly Basin.

Some of the research reactor spent nuclear fuel sent to SRS was not aluminum based. Because DOE did not have the capability to reprocess that type of SNF at SRS, it was placed in wet storage at the Receiving Basin for Offsite Fuel, where it remains in storage.

By 1995 DOE was storing about 195 metric tons heavy metal (MTHM [metric tons heavy metal] – the mass of uranium in the fuel or targets, excluding cladding, alloy materials, and structural materials) – of aluminum-based SNF in the SRS reactor disassembly basins and the Receiving Basin for Offsite Fuel. DOE also was storing about 20 MTHM of non-aluminum-based SNF in the Receiving Basin for Offsite Fuel.

S.2.4 STABILIZATION

DOE has taken action to stabilize about 175 MTHM of the 195 MTHM of aluminum-based SNF that was in storage at SRS in 1995. DOE decided to stabilize this material following completion of the *Interim Management of Nuclear Materials Environmental Impact Statement* (DOE/EIS-0220). The primary purpose of the actions described in that EIS was to correct or eliminate potential health and safety vulnerabilities related to some of the methods used to store nuclear materials (including SNF) at SRS. In that EIS, DOE identified the remaining 20 MTHM (out of 195 MTHM) of aluminum-based SNF at SRS as "stable" (i.e., the SNF likely could be safely stored for about 10 more years, pending decisions on final disposition). That 20 MTHM of aluminum-based SNF is included in this EIS.

S.2.5 SPENT NUCLEAR FUEL CONSOLIDATION

In May 1995, DOE decided (60 FR 28680) under the *Department of Energy Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Final Environmental Impact Statement* to consolidate existing and newly generated SNF at three existing Departmental sites (including SRS) based on fuel type, pending future decisions on ultimate disposition. DOE designated the SRS as the site that would manage aluminum-based SNF. As a result, DOE will transfer 20 MTHM of non-aluminum-based SNF from the SRS to the Idaho National Engineering and Environmental Laboratory (INEEL) and DOE will transfer about 5 MTHM of aluminum-based SNF at the INEEL to the SRS. Additionally, the SRS could receive about 5 MTHM of aluminum-based SNF from domestic research reactors through 2035.

In May 1996, DOE announced a decision (61 FR 25092) under the *Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel* (Nonproliferation Policy and Spent Fuel EIS) to accept about 18 MTHM of aluminum-based SNF containing uranium of United States origin from foreign research reactors for management in the United States at the SRS. The receipt of foreign research reactor SNF at SRS is now underway and receipts are scheduled to be completed by 2009. The 18 MTHM of foreign research reactor SNF that could be received at SRS is included in the scope of this EIS. (Recent decisions by some foreign research reactor operators have reduced the quantity of SNF expected to be shipped to SRS from about 18 MTHM to about 14 MTHM; however, the 18 MTHM projection is used for analysis purposes in this EIS because foreign research reactor operators still have the option to ship to the United States.) Table S-1 summarizes the amount of SNF to be managed at SRS that is considered in this EIS.

S.3 Purpose and Need for Action

DOE anticipates disposing of most of its aluminum-based SNF inventory in a geologic repository after treatment or repackaging. However, DOE does not expect a geologic repository to be available until at least 2010 and shipments from DOE sites might not begin until about 2015. Until a repository is available, the Department needs to develop and implement a safe and efficient SNF management strategy that includes preparing aluminum-based SNF stored at SRS or expected to be shipped to SRS for disposition offsite. DOE is committed to avoiding indefinite storage at the SRS of this nuclear fuel in a form that is unsuitable for final disposition. Therefore, DOE needs to identify management technologies and facilities for storing and treating this SNF in preparation for final disposition.

Table S-1. Quantity of SNF discussed in this EIS.

• Aluminum-based SNF stored at SRS	20 MTHM
• Domestic and DOE aluminum-based research reactor SNF to be received at SRS	10 MTHM
• Foreign Research Reactor aluminum-based SNF to be received at SRS	18 MTHM
• Non-aluminum-based SNF at SRS (to be shipped to INEEL)	20 MTHM

S.4 Scope

In this EIS, DOE is evaluating the treatment and storage of about 48 MTHM of aluminum-based SNF including impacts from the construction and operation of facilities (either new or modified existing facilities) that would be used to receive, store, treat, and package SNF in preparation for ultimate disposition. Onsite transportation impacts are considered; however, no impacts associated with transporting SNF to SRS are included, because these impacts have been covered in other EISs. The potential impacts of transporting SNF to a geologic repository are discussed for completeness but no decisions related to transporting SNF offsite will be made under this EIS. Transportation of SNF to a federal repository will be addressed in the EIS for a Geologic Repository for the Disposal of Spent Nuclear Fuel and High-Level Radioactive Waste at Yucca Mountain, Nye County, Nevada (Notice of Availability of the Draft EIS published in 64 FR 44200, August 13 1999). The Yucca Mountain EIS is being prepared as part of the process to determine if the Yucca Mountain site is suitable as the site of the Nation's first geologic repository for SNF and high-level radioactive waste.

DOE also evaluates transferring 20 MTHM of non-aluminum-clad spent nuclear fuel currently stored in the Receiving Basin for Offsite Fuel at SRS to a new dry storage facility at SRS. This transfer would occur only if a dry storage facility were built as part of the implementation of a treatment technology to prepare aluminum-based spent nuclear fuel for disposition and if the dry storage facility became operational before the non-aluminum-clad fuel was transferred to the Idaho National Engineering and Environmental Laboratory. The transfer to dry storage would occur after the fuel had been relocated from the Receiving Basin for Offsite Fuel to the L-Reactor Disassembly Basin in support of activities necessary to phase out the use of the Receiving Basin for Offsite Fuel by fiscal year 2007.

This EIS does not evaluate the impacts of managing the non-aluminum-clad fuel at INEEL or of transporting the fuel to INEEL. These impacts were documented in the SNF management programmatic EIS (PEIS) and were evaluated as part of the process DOE used to decide to consolidate the storage of non aluminum-clad spent nuclear fuel at the INEEL.

SRS is storing Mark-51 and other targets in the Receiving Basin for Offsite Fuel (RBOF) in the Site's H-Area. This EIS evaluates the impacts of continuing to store the Mark-51 and other targets in RBOF, and evaluates an alternative of transferring them to dry storage to provide flexibility in material management operations.

DOE is evaluating potential uses for this material and the operations and facilities that would be necessary. The Mark-51 and other targets (described in Section 1.5 of this EIS) contain americium and curium isotopes that could be used to produce elements with higher atomic numbers such as californium-252. Californium-252 is used as a neutron source for radiography and in the treatment of certain types of cancer and for research in basic chemistry, nuclear physics, and solid-state chemistry. If DOE were to determine that a programmatic need for this material exists, the targets would continue to be stored at the SRS pending preparations to ship them to another DOE facility where isotope production capability currently exists or could be constructed. SRS does not have isotope production capability.

This EIS does not evaluate the impacts of utilizing target material for programmatic purposes such as production of californium. DOE would perform the appropriate National Environmental Policy Act review to evaluate the impacts of shipment of the targets to an isotope production facility and of construction (or modification) and operation of the production facility, should such such a programmatic purpose be identified.

TC

DOE is storing the Mark-18 targets in wet basins at the SRS. These targets are similar to the Mark-51 and other targets in that they contain americium and curium that could be used to produce elements with higher atomic numbers such as californium-252. They are different from the small (about two feet in length) Mark-51 and other targets because the Mark 18s are about 12 feet long and therefore have different requirements for storage, transportation and use. As is the case with the Mark-51 and other targets, DOE is not proposing any actions that would lead to programmatic use of the Mark-18 targets at this time. Because of their length, the Mark-18 targets would have to be reduced in size for use in production facilities at another DOE facility or transfer to dry storage at the SRS. This EIS considers only continued wet storage of Mark-18 targets. However, the Interim Management of Nuclear Materials EIS (which is incorporated herein by reference) considered the alternative of processing the Mark-18 targets in the SRS canyons, should they present potential health and safety vulnerabilities. See Section 1.5 of this EIS for more information.

S.5 Decisions to be Based on this EIS

DOE expects to make the following decisions on the management and preparation of SNF for storage and ultimate disposition.

- The appropriate treatment or packaging technologies to prepare aluminum-based SNF that is to be managed at SRS. EC
- Whether DOE should construct new facilities or use existing facilities to store and treat or package aluminum-based SNF that is expected to be managed at SRS. EC TC
- Whether DOE should repackage and dry-store stainless-steel and zirconium-clad SNF pending shipment to the Idaho National Engineering and Environmental Laboratory, EC
- Whether DOE should repackage and dry-store Mark-51s and other americium/curium targets in the event dry storage capability becomes available at SRS. TC

S.6 Proposed Action

DOE's proposed action is to safely manage SNF that is currently located or expected to be received at SRS, including treating or packaging aluminum-based fuel for possible offsite shipment and disposal in a geologic repository, and preparing non-aluminum-clad fuel and programmatic material (i.e., material that could be used in national programs) for dry storage or off-site shipment.

In the Record of Decision for the Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel (61 FR 25092, May 17, 1996), DOE stated the Department would embark on an accelerated program at SRS to identify, develop, and demonstrate one or more non-processing, cost-effective treatment or packaging technologies to prepare aluminum-based foreign research reactor spent nuclear fuel for ultimate disposition.

Based on that decision, DOE's strategy is to select a new non-chemical processing technology or a new packaging technology that would put aluminum-based foreign research reactor SNF into a form or container suitable for direct placement in a geologic repository. Treatment or conditioning of the fuel would ad-dress potential repository acceptance criteria or safety concerns. Implementing the new non-chemical processing treatment or packaging technology would allow DOE to manage the SNF in a road-ready condition at SRS in dry storage pending shipment to a geologic repository.

Because of the similarity of the material, DOE proposes to manage the other aluminum-alloy SNF that is the subject of this EIS (domestic research reactor and DOE reactor fuels) in the same manner as the foreign research reactor fuels.

In the Record of Decision for the Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel, DOE stated that, should it become apparent by the year 2000 that DOE will not be ready to implement a new SNF treatment technology, DOE would consider chemically processing foreign research reactor SNF in F Canyon. DOE committed that any decision to use conventional chemical processing would consider the results of a study (62 FR 20001, December, 1998) on the nonproliferation, cost, and timing issues associated with chemically processing the fuel. DOE stated that any highly enriched uranium separated during chemical processing would be blended down to low enriched uranium.

With the limited proposed processing, as discussed below, and the current nuclear material stabilization program at SRS, DOE expects the canyons will be utilized to their fullest extent over the next several years. DOE has greater confidence now in the feasibility and availability of new non-chemical processing technologies than at the time the Nonproliferation Policy and Spent Nuclear Fuel EIS's Record of Decision was issued. Therefore, except in the case of potential health and safety vulnerabilities as discussed below, the use of the canyons for processing research reactor fuel as a backup for new technology would not be as likely.

DOE has included chemical processing as a management alternative in this EIS. However, DOE's strategy and preference is to use non-chemical separations processes. DOE proposes to use chemical separation processes when a potential health or safety vulnerability exists for aluminum-based SNF that DOE considers should be alleviated before a non-chemical separations process is in operation.

The limited proposed canyon SNF processing is not expected to extend the operating schedules for these facilities beyond the current planning basis. Processing would eliminate potential health and safety problems that could occur prior to the availability of a new SNF treatment technology. In the event the new treatment process becomes available, the SNF with potential health and safety vulnerabilities could be processed using the new treatment technology.

DOE may decide, in the future, that the Higher Actinide Targets have no programmatic use. Therefore, DOE proposes to maintain the Mark-18's, Mark-51's, and other Higher Actinide Targets pending decisions on final disposition.

S.7 Categories of Spent Nuclear Fuel

DOE has categorized SNF at SRS into six groups (A through F), based on such characteristics as fuel size, physical or chemical properties, or radionuclide inventories. Table S-2 lists the amounts of each fuel type SRS expects to manage.

TC The aluminum-based fuels currently stored at SRS include some fuels that were not originally aluminum-clad (EBR-II and Sodium Breeder Experimental Reactor Fuel). Additionally, the aluminum-based category consists of one element not yet received but due to be shipped to SRS (the Advanced Reactivity Measurement Facility Core Filter Block). Most of the fuels that were not originally aluminum-clad (but are included under this EIS's major category of aluminum-based fuel) have been declad and placed in aluminum cans. In their present form they can be processed at the SRS through the existing technologies on site. Other fuels at SRS which are non-aluminum-clad fuels cannot be processed in their existing form using the existing technologies and are categorized in this EIS as non-aluminum-based fuel. The Core Filter Block is included under the category of aluminum-based fuel since the most practical way of dealing with it (based on its unique configuration) is to process it utilizing the existing technology at SRS. TC

Table S-2. Spent nuclear fuel groups.

	Fuel group	Volume (MTRE)[a]	Mass (MTHM)[b]	
				EC
A.	Uranium and Thorium Metal Fuels	610	19	
B.	Material Test Reactor-Like Fuels	30,800	20	
C.	HEU/LEU[c] Oxides and Silicides Requiring Resizing or Special Packaging	470[d]	8	TC
D.	Loose Uranium Oxide in Cans	NA	0.7	
E.	Higher Actinide Targets	NA	<0.1	
F.	Non-Aluminum-Clad Fuels[e]	1,900	20.4	TC
	Total	33,780	68.2	

a. MTRE = Materials test reactor equivalent. An MTRE is a qualitative estimate of SNF volume that provides information on the amount of space needed for storage. An MTRE of Materials Test Reactor-Like Fuels would usually be one fuel assembly measuring about 3 inches by 3 inches by 2 feet long. TC
b. MTHM = Metric tons of heavy metal.
c. HEU = highly enriched uranium; LEU = low enriched uranium.
d. Fuel group also includes about 2,800 pins, pin bundles, and pin assemblies.
e. This fuel group will be shipped to Idaho National Engineering and Environmental Laboratory. It will not be treated at SRS. TC

Categorization of SNF at the Savannah River Site

Group A: Uranium and Thorium Metal Fuels
Group B: Materials Test Reactor-Like Fuels
Group C: HEU/LEU Oxides and Silicides Requiring Resizing or Special Packaging
Group D: Loose Uranium Oxide in Cans
Group E: Higher Actinide Targets
Group F: Non-Aluminum-Clad Fuels

Uranium and Thorium Metal Fuels (Group A)

This group consists of fuels from the Experimental Breeder Reactor-II and the Sodium Reactor Experiment, as well as a core filter block from the Advanced Reactivity Measurement Facility at INEEL (that is scheduled to be transferred to SRS). This group also includes unirradiated Mark-42 targets that were manufactured from plutonium oxide-aluminum powder metal and formed into tubes that were clad with aluminum.

The Experimental Breeder Reactor-II fuel and Sodium Reactor Experiment fuel are uranium metal that has been declad and wet-stored in canisters in the Receiving Basin for Offsite Fuel at SRS. The declad fuel presents a potential health and safety vulnerability. These fuels have cores of reactive metals that were exposed when the fuel cladding was removed. Any contact of the reactive metal core with water would lead to relatively rapid oxidation of the core and disintegration of the fuel, resulting in the release of fission products and particulate fuel material to the water of the storage basin at SRS.

The unirradiated Mark-42 targets were manufactured from plutonium oxide-aluminum powder metal and formed into tubes that were clad with aluminum. The plutonium oxide and aluminum were pressed together in the manufacturing process. As a result, the unirradiated targets could be less durable than uranium-aluminum alloy SNF because of the particulate nature of the plutonium oxide, but more durable (i.e., less reactive) than uranium metal SNF since the plutonium is already in oxide form. The potential for dispersion of material into storage basin water in the event of cladding failure could present a health and safety vulnerability.

The core filter block at INEEL is made of depleted uranium and corrosion resistant metal (i.e., stainless steel), and was used as a neutron "filter" for reactivity experiments. As a result, the filter was subject to relatively short (or low-power level) exposure times in the test reactor and is only slightly irradiated.

Material in this fuel group in its current form may not be acceptable for disposal in a repository due to the reactive nature of uranium metal or the particulate nature of some of the material.

This group accounts for approximately 2 percent of the volume of aluminum-based fuel that DOE is likely to manage at SRS from now until 2035. Because the fuel in Group A is made of unalloyed metal (i.e., it contains little or no aluminum), it is more dense than most of the other spent fuel considered in this EIS. As a result, this small volume of fuel contains about 40 percent of the mass of heavy metal.

<u>Materials Test Reactor-Like Fuels (Group B)</u>

This group consists primarily of Materials Test Reactor fuels and other fuels of similar size and composition. Most research reactors – foreign and domestic – use Materials Test Reactor fuel. These fuels vary in uranium-235 content from just below 20 percent to about 93 percent. Approximately 70 percent of the Group B assemblies are highly enriched uranium (>20 percent uranium-235), and the remainder are low enriched uranium (<20 percent uranium-235). Group B accounts for approximately 97 percent of the volume of aluminum-based SNF that DOE will manage at SRS between now and 2035. DOE considers that there are no currently known health and safety vulnerabilities for this material that would preclude wet storage pending the operation of a new treatment technology.

Although some Group B fuels are stored at SRS in the Receiving Basin for Offsite Fuel or in L Reactor Disassembly Basin, at present most are at domestic universities, foreign research reactors, and DOE research facilities pending shipment to the Site.

<u>HEU/LEU Oxides and Silicides Requiring Resizing or Special Packaging (Group C)</u>

Fuels in this group are similar in composition to Group B fuels in that they are aluminum-based, highly enriched uranium and low enriched uranium oxides and silicides, but their size or shape might preclude packaging them in the disposal canisters proposed for use in a repository without resizing or special packaging considerations. Some fuel in this group is smaller in diameter and longer than Group B fuels or is larger than Group B fuels in both diameter and length; it often comes in odd shapes such as a 1.5-foot by 3-foot (0.46-meter by 0.9-meter) cylinder or a sphere with a diameter of 29 inches (74 centimeters). DOE would have to disassemble or use other volume-reduction activities to place such fuels in a nominal 17-inch direct co-disposal canister. At present, much of this fuel is at other DOE sites and in other countries but is scheduled to be received at SRS.

A small amount of this fuel (currently stored in 14 cans) presents a potential health and safety vulnerability. The fuel was cut apart for research purposes and could release fission products and particulate material to the water of the wet storage basin at SRS should the storage cans leak. Additionally, fuel in this condition may not be acceptable in a geologic repository because the fuel is no longer intact.

Together Group B and Group C fuels represent about 97 percent of the volume of all fuel to be treated at SRS.

<u>Loose Uranium Oxide in Cans (Group D):</u>

This group consists of loose uranium oxide with fission products distributed throughout the material. The only material in this fuel group currently stored at the SRS is 676 cans of Sterling Forest Oxide. The majority of the material (estimated at over 6,000 cans) has not yet been produced at foreign research reactors. Research reactors in Canada would be the greatest single source for future material and these reactor operators are among those that, as discussed in Section S.2.4, may not participate in the foreign research reactor SNF return program. DOE expects that the material in this fuel group would not be acceptable for placement in a geologic repository because it is not in a tightly bound metal or ceramic matrix (i.e., it is a powder). Additionally, the Sterling Forest Oxide fuel presents a potential health and safety vulnerability due to the dispersible nature of the material should a storage can fail.

<u>Higher Actinide Targets (Group E)</u>

This group contains irradiated and unirradiated target materials used to generate radionuclides with atomic numbers higher than that of uranium. The targets were aluminum-clad plutonium oxide that now contain significant quantities of americium and curium, which react under neutron irradiation to produce elements with still higher atomic numbers such as californium. All materials in this group are stored in the Receiving Basin for Offsite Fuel. Group E accounts for less than 1 percent of the volume of aluminum-based SNF DOE will manage at SRS.

The Higher Actinide Target fuel group consists of 60 Mark-51 targets, 114 other targets, and 65 Mark-18 targets. This material was evaluated in the *Final Environmental Impact Statement for Interim Management of Nuclear Materials* (DOE/EIS-0220). Under the Record of Decision for the Final Environmental Impact Statement for Interim Management of Nuclear Materials (FR 65300, 12/19/95), DOE decided that the targets should remain in wet storage.

In this EIS, DOE evaluates the continued wet storage of the Mark-51 and other targets pending shipment offsite, or alternatively repackaging the Mark-51 and other targets to place them in a new dry storage facility so that the material could be transferred to dry storage if necessary to provide flexibility in spent fuel storage operations.

The Mark-18 targets are different from the Mark-51 and other targets in several ways. The most important distinction is that each Mark-18 target is one continuous piece about 12 feet long. The Mark-51 and other targets are about 2 feet long and could be handled, transported, and stored (including in a dry storage facility) in their current configuration. The 12-long Mark-18 targets would require size reduction for transportion or storage in a dry storage facility. The standard method to reduce the size of the Mark-18 targets would be to cut them up under water in an SRS wet storage basin. However, the condition of the Mark-18 targets presents a health and safety vulnerability for under water cutting because of the suspected brittle condition of the targets and the uncertainty of the region of the target assemblies that contains the target product (i.e., americium and curium) and fission products. The brittle condition is due to a very long irradiation cycle in a reactor at SRS. Cutting the targets using the existing Site capability could result in the uncontrolled release of radioactive material to the water of the Receiving Basin for Offsite Fuel. For these reasons, a previous DOE assessment of this material (see Section 1.6.2 of this EIS) concluded that the Department should consider processing the Mark-18 targets in F Canyon. These alternatives are not included in this EIS because DOE performed that evaluation in the *Final Environmental Impact Statement for Interim Management of Nuclear Materials,* incorporated herein by reference. Those alternatives included dissolving the targets in F Canyon and then vitrifying the americium and curium in a new F-Canyon vitrification facility, dissolving the targets in F Canyon and recovering the americium and curium as an oxide, and dissolving the targets and transferring the americium and curium to the high-level waste tanks at the SRS.

Non-Aluminum-Clad Fuels (Group F):

This group consists of fuel that is clad in materials other than aluminum. It includes stainless-steel and zirconium-clad fuel at SRS that DOE plans to transport to the Idaho National Engineering and Environmental Laboratory in accordance with decisions based on the *Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement* (DOE/EIS-0203).

S.8 Affected Environment

The SRS is in west-central South Carolina and occupies an area of approximately 300 square miles (approximately 800 square kilometers) adjacent to the Savannah River, primarily in Aiken and Barnwell Counties. The Site is approximately 25 miles (40 kilometers) southeast of Augusta, Georgia, and 20 miles (32 kilometers) south of Aiken, South Carolina. All alternatives described in this EIS, including the possible construction of new facilities to implement some of the alternatives, would occur within existing industrial areas at SRS.

S.9 Technologies

S.9.1 NEW SNF MANAGEMENT TECHNOLOGIES

DOE has identified six reasonable new technologies to be analyzed in this EIS that could be used to prepare SNF at SRS for disposition. Most of the New Packaging Technology options and the New Processing Technology options are technologies that DOE has not previously applied to the management of aluminum-based SNF for the purpose of ultimate disposition. DOE assigned the highest confidence of success and greatest technical suitability to options that have relatively simple approaches.

Technology Options for Management of SNF at the Savannah River Site

- New Packaging Technology
  1. Direct Disposal/Direct Co-Disposal
  2. Repackage and Prepare to Ship to Other DOE Sites
- New Processing Technology
  1 Melt and Dilute
  2. Mechanical Dilution
     -- Press and Dilute
     -- Chop and Dilute
  3. Vitrification
     -- Plasma Arc Treatment
     -- Glass Material Oxidation and Dissolution System
     -- Dissolve and Vitrify
  4. Electrometallurgical Treatment
- Conventional Processing Technology

S.9.1.1 New Packaging Technologies

Under the New Packaging Technology, two of the options, Direct Disposal and Direct Co-Disposal, are non-destructive methods to prepare and package aluminum-based SNF for placement in a geologic repository, while one technology option, Repackage and Prepare to Ship to Another DOE Site, is pertinent only to non-aluminum-clad SNF and higher actinide targets that are scheduled to be or could be shipped off-site.

EC

The Direct Disposal/Direct Co-Disposal process is relatively simple because the fuel would remain intact but be repackaged in a way that minimizes the possibility of criticality. Elaborate treatment processes and equipment would not be required. The dry storage method that would be used to store the fuel after repackaging is common for commercial SNF and is adaptable for aluminum-based SNF.

The Direct Disposal and Direct Co-Disposal technology options are discussed together in this EIS as Direct Disposal/Direct Co-Disposal. The only difference between the technologies is the diameter of the canister into which the SNF would be loaded. The Direct Disposal options would use a 24-inch diameter canister because this is the same size as the high-level waste canisters currently being produced at the SRS Defense Waste Processing Facility. The Direct Co-Disposal option would use a smaller diameter canister (17 inches) that could be placed in the void space at the center of high-level waste packages that will be assembled at the repository (i.e., a five-canister array of 24-inch diameter high-level waste canisters with one 17-inch diameter SNF canister placed in the center). In either case, the canisters would be stored at SRS and shipped from SRS in the same manner. In this EIS, Direct Disposal and Direct Co-Disposal are treated as the same technology and the final decision on canister diameter would be made during the engineering design phase of the project to implement the technology.

S.9.1.2 New Processing Technologies

DOE has identified four technology options that could treat aluminum-based SNF. These are: (1) Melt and Dilute, (2) Mechanical Dilution, (3) Vitrification, and (4) Electrometallurgical Treatment.

L10-2

The Melt and Dilute technology is more complicated than Direct Disposal since it would destroy the fuel elements, but it is one of the simplest of the destructive treatments. Under this technology, SNF would be melted along with other materials to ensure a low enriched uranium-aluminum product. Most fission products would remain trapped within the product matrix, although some would be volatilized. The melt product would be sealed in corrosion-resistant canisters. DOE has substantial experience melting SNF on a small scale for research purposes and has not identified any reasons why a full-scale operation to melt aluminum-based SNF and dilute the highly-enriched uranium would not be achievable.

L10-2

The Mechanical Dilution Technology would involve either the Press and Dilute or the Chop and Dilute options, which are similar. DOE has represented these two technologies for analysis as the Mechanical Dilution options.

In the Press and Dilute Technology, SNF would be crushed between layers of depleted uranium to produce a product with low overall enrichment. The product would be mixed with a neutron poison as necessary to prevent criticality. The final product would be sealed in special canisters.

In the Chop and Dilute Technology, SNF would be shredded and mixed with depleted uranium to produce a low enriched product. As in Press and Dilute, a neutron poison could be added as needed and the product sealed in special canisters.

Three SNF processing technologies, Plasma Arc Treatment, Glass Material Oxidation and Dissolution System, and Dissolve and Vitrify options all use processes that produce a product with properties similar to that produced at the Defense Waste Processing Facility at SRS. Therefore, DOE has represented these three as the Vitrification option.

L10-2

In the Plasma Arc Treatment Technology, SNF would be melted by a high-temperature plasma torch in a furnace. The melted SNF would be mixed with a ceramic material to produce a glass-ceramic product. Depleted uranium would be included as necessary to reduce the enrichment of the final product, which would be sealed in special canisters.

In the Glass Material Oxidation and Dissolution Technology, the SNF would be converted directly to borosilicate glass. Depleted uranium would be included as necessary to reduce the enrichment of the final product, which would be sealed in special canisters.

In the Dissolve and Vitrify Technology, SNF would be dissolved as in conventional processing, but the enriched uranium would not be extracted. Instead, the dissolved solution would be vitrified. Depleted uranium would be included as necessary to reduce the enrichment of the final product, which would be sealed in special canisters. DOE expects that the resulting waste form would be acceptable for disposal in a geologic repository.

DOE prepared the current waste acceptance criteria using information available to date. DOE considers the criteria to be conservative. As repository designs evolve and more information is available on waste form performance under relevant repository conditions, the acceptance criteria will change. DOE currently is characterizing conditions at the Yucca Mountain site in Nevada as a possible site for development of a geologic repository. If a decision were made to develop Yucca Mountain, DOE would submit a license application to the U. S. Nuclear Regulatory Commission (NRC). The acceptance criteria developed at that time would be the basis for waste acceptance specifications in the license application. These specifications likely would be available before the melt and dilute facility would be operational and before the canyons cease operating. Final waste specifications will not be available until after the NRC approves construction of a repository and authorizes a license for DOE to receive and store SNF and high-level radioactive waste, prior to the beginning of repository operations.

Electrometallurgical Treatment is an electrorefining process that would separate highly-enriched uranium from the aluminum and fission products in the SNF. In the Electrometallurgical Treatment Technology, the SNF would be melted into metal ingots. Processing of the ingots first would remove the aluminum from the material. Further processing would remove the uranium from the material. The remaining material would be oxidized and dissolved in glass and then sealed in special canisters. This is a process that DOE has been evaluating for the management of certain non-aluminum-based SNF at other DOE sites.

S.9.1.3 <u>Technical Considerations in Selecting a New Technology Option for SNF Processing</u>

Part of DOE's proposed action is to prepare SNF to meet the requirements that the Department anticipates will apply to material to be disposed of in a geologic repository. Any technology that DOE implements must be able to provide a product that is compatible with such criteria. DOE must rely on reasonable assumptions about what the acceptance criteria would include when making decisions on SNF treatment technologies. DOE anticipates that eventually it will place its aluminum-based SNF inventory in a geologic repository after treatment or repackaging.

One of the technical risks in implementing any of the new SNF technology options is the uncertainty surrounding the acceptability of DOE SNF for placement in a geologic repository. While DOE has documented preliminary acceptance criteria in the Waste Acceptance System Requirements Document (Rev. 3, 1999), the acceptance criteria will become more detailed. Final acceptance criteria will not be available until after DOE were to receive authorization from NRC to receive and possess SNF and high-level waste, based on criteria that meet NRC requirements. DOE-SR is working closely with NRC (the Federal agency that would license the operation of a geologic repository) to ensure that the final product from the selected SNF treatment technology would be acceptable at a repository.

Recognizing that repository disposal is the ultimate endpoint for the melt and dilute waste form, DOE-SR signed in August 1997 a Memorandum of Understanding with NRC for their review and feedback on the research effort that DOE-SR is conducting. DOE-SR has provided the NRC with several technical reports on the results obtained from the research effort. Based upon their initial review, NRC stated in a June 1998 letter that “both the direct co-disposal and melt-dilute options would be acceptable concepts for the disposal of aluminum-based research reactor SNF in the repository.” Additionally, as research efforts yield new findings, DOE is providing the information to the NRC for their feedback and review.

The EIS has been revised to discuss in greater detail the expected repository acceptance criteria and compare the treatment technology products to these criteria. This information is discussed in Section 2.2.1.

S.9.2 EXISTING SNF MANAGEMENT TECHNOLOGIES

The Conventional Processing technology is the only existing SNF treatment technology available at SRS.

With this technology, DOE would process SNF in F or H Canyon directly from wet storage. The process would chemically dissolve the fuel and separate fission products from the uranium by solvent extraction. Conventional Processing would apply to all SNF, except most of the targets in the Higher Actinide Targets fuel group (specifically the Mark-51 and “other” targets) and the non-aluminum-clad fuels. Non-aluminum-clad targets would be shipped to INEEL as a result of previous decisions by DOE.

The Record of Decision for the Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel described the possible use of F Canyon for SNF processing based on a preliminary concept to consolidate all processing operations in one canyon. Subsequent review has shown that consolidating highly enriched uranium spent fuel processing operations in F Canyon would not be practical due to criticality considerations and process capacity restrictions associated with the pluto-nium-uranium extraction system used in F Canyon. Thus, in this EIS, H Canyon is referenced in regard to chemically separating highly enriched uranium spent fuel.

S.10 Alternatives

Alternatives Considered

- Minimum Impact Alternative
- Direct Disposal Alternative
- Preferred Alternative
- Maximum Impact Alternative
- No-Action Alternative

Because of the differences in the characteristics of the SNF and the capabilities of the technologies, no single technology could be applied to all the SNF. Table S-3 lists the technologies appropriate for each of the six fuel groups.

Because of the many possible combinations of technologies and fuel groups (more than 700), DOE has chosen to evaluate a limited number of configurations (as alternatives). The alternatives illustrate the range of impacts that could occur from any configuration the decisionmakers might select. Table S-4 and the following paragraphs describe the five alternatives considered in this EIS. See Section S.11 for a detailed description of the preferred alternative.

- *Minimum Impact Alternative:* This alternative combines the technologies appropriate for each fuel group that DOE believes would result in the lowest overall impact.

- DOE recognizes that this alternative might not result in the lowest impact for each impact category (e.g., worker health and public health could be lowest, but radioactive waste generation could be higher) and that there are other reasonable technology

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Table S-3. Fuel groups and analyzed technology options.

Fuel group	New Packaging Technology: 1. Prepare for Direct Co-disposal	New Packaging Technology: 2. Repackage and Prepare to Ship[a]	New Processing Technology: 3. Melt and Dilute	New Processing Technology: 4. Mechanical Dilution	New Processing Technology: 5. Vitrification Technologies	New Processing Technology: 6. Electro-metallurgical Treatment	Conventional Processing Technology: 7. Conventional Processing in Canyons
A. Uranium and Thorium Metal Fuels	Yes[b]	No	Yes[c]	No	Yes	Yes	Yes
B. Materials Test Reactor-Like Fuels	Yes	No	Yes	Yes	Yes	Yes	Yes
C. HEU/LEU[d] Oxides and Silicides Requiring Resizing or Special Packaging	Yes	No	Yes	Yes	Yes	Yes	Yes
D. Loose Uranium Oxide in Cans	No	No	Yes	No	Yes	Yes	Yes
E. Higher Actinide Targets	No	Yes[e]	No	No	No	No	No[f]
F. Non-Aluminum-Clad Fuels[g]	No	Yes	No	No	No	No	No

a. This alternative describes repackaging for storage at SRS pending shipment offsite.
b. "Yes" indicates that the technology could be applied to the fuel group. "No" indicates that the technology should not be applied to the fuel group (see Sections S.9.1.3 and Tables 2-1 and 2-2 of the EIS).
c. Except for the core filter block that may be incompatible with the melt and dilute process.
d. HEU = highly enriched uranium; LEU = low enriched uranium.
e. The Mark-18 targets from Fuel Group E are not acceptable for repackaging as proposed in this EIS. See footnote f.
TC
f. This entry is with respect to the Proposed Action of this EIS. Conventional Processing with a follow-on treatment (e.g., vitrification, oxidation, or disposal) has been evaluated for the Mark-18 target material in the *Final Environmental Impact Statement for Interim Management of Nuclear Materials* (DOE/EIS-0220).
g. In light of a previous decision by DOE to transfer this material to INEEL, only packaging for dry storage needs to be considered further.

Table S-4. Alternatives analyzed in this EIS.

Fuel Group	No-Action Alternative	Minimum Impact Alternative	Direct Disposal Alternative	Preferred Alternative	Maximum Impact Alternative
A. Uranium and Thorium Metal Fuels	Continued Wet Storage	Prepare for Direct Co-Disposal	Conventional Processing	Conventional Processing	Conventional Processing
B. Materials Test Reactor-like Fuels	Continued Wet Storage	Prepare for Direct Co-Disposal	Prepare for Direct Co-Disposal	Melt and Dilute	Conventional Processing
C. HEU/LEU Oxide and Silicides Requiring Resizing or Special Packaging	Continued Wet Storage	Prepare for Direct Co-Disposal	Prepare for Direct[a] Co-Disposal	Melt and Dilute[a]	Conventional Processing
D. Loose Uranium Oxide in Cans	Continued Wet Storage	Melt and Dilute	Melt and Dilute[b]	Melt and Dilute[b]	Conventional Processing
E. Higher Actinide Targets	Continued Wet Storage	Repackage and Prepare to Ship to Another DOE Site	Repackage and Prepare to Ship to Another DOE Site[c]	Continued Wet Storage	Repackage and Prepare to Ship to Another DOE Site[c]
F. Non-Aluminum-Clad Fuels	Continued Wet Storage	Repackage and Prepare to Ship to Another DOE Site	Repackage and Prepare to Ship to Another DOE Site	Repackage and Prepare to Ship to Another DOE Site	Repackage and Prepare to Ship to Another DOE Site

a. Conventional processing would be the preferred technology for the failed or sectioned Oak Ridge Reactor fuel, High Flux Isotope Reactor fuel, Tower Shielding Reactor fuel, Heavy Water Components Test Reactor fuel, and a Mark-14 target (i.e., <1 percent of the material in this fuel group).
b. Conventional processing is the preferred technology for the Sterling Forest Oxide fuel (i.e., about 10 percent of the material in this fuel group).
c. Mark-18 target assemblies (approximately 1 kilogram heavy metal) would undergo conventional processing.

configurations that would result in similar minimal impacts. DOE expects that the impacts of this combination would be representative of the lower bound of impacts from the Proposed Action. This scenario would utilize the New Packaging and New Processing Technologies.

TC

The Uranium and Thorium Metal Fuels would be treated using the Direct Disposal/Direct Co-Disposal technology with more complicated treatment (i.e., hot-vacuum drying). DOE recognizes that there is technical uncertainty regarding the acceptability of this material (treated this way) in a repository because of the potential reactivity of the material; however, Direct Disposal/Direct Co-Disposal was postulated to represent minimum impacts based on the assumption that the waste form would be acceptable for disposal in a geologic repository. Materials Test Reactor-like Fuels and HEU/LEU Oxides and Silicides Requiring Resizing or Special Packaging would receive minimum treatment (i.e., cold-vacuum drying and canning or resizing) using the Direct Disposal/Direct Co-Disposal technology before being placed in dry storage. The loose uranium oxide in cans would be treated using the Melt and Dilute Technology.

TC

DOE would continue to wet-store the Mark-51 and other Higher Actinide Targets at the SRS. DOE would continue to wet-store the non-aluminum-clad spent nuclear fuel at SRS until the material is shipped to the Idaho National Engineering and Environmental Laboratory. In the event the non-aluminum-clad fuel has not been transferred offsite by the time a dry storage facility is in operation at the SRS (to support the Melt and Dilute Technology), DOE could repackage the fuel and transfer the material to dry storage. To maintain operational flexibilty DOE could transfer the Mark-51 and other targets to dry storage. DOE would maintain the Mark-18 targets in wet storage pending disposition decisions due to potential health and safety concerns associated with the actions that would be required to repackage the Mark-18 target assemblies.

- *Direct Disposal Alternative*: This alternative combines the New Packaging and New Processing Technologies with Conventional Processing Technology. Materials Test Reactor-like Fuels and HEU/LEU Oxides and Silicides Requiring Resizing or Special Packaging (except for the failed or sectioned fuel) would receive minimum treatment (i.e., cold-vacuum drying and canning) using the Direct Disposal/Direct Co-Disposal technology before being placed in dry storage.

  All material in the Uranium and Thorium Metals Fuel group, the Sterling Forest Oxide fuel from the Loose Uranium Oxide in Cans group, and the failed or sectioned fuel from the HEU/LEU Oxides and Silicides Requiring Resizing or Special Packaging group would be treated with Conventional Processing because this material presents potential health and safety concerns and probably would not be suitable for placement in a geologic repository. Melt and Dilute would be applied to the majority of the material in the Loose Uranium Oxide in Cans fuel group because that material could be received after a melt and dilute facility was available.

  EC

  TC

  DOE would manage the Higher Actinide Targets and the non-aluminum-clad SNF as described in the Maximum Impact Alternative.

  TC

> ***DOE's Preferred Alternative:*** The alternative which DOE believes would best fulfill its statutory mission and responsibilities, giving consideration to economic, environmental, technical, and other factors.

Preferred Alternative: This alternative combines a New Packaging Technology option, a New Processing Technology option, and the Conventional Processing Technology option. Materials Test Reactor-like Fuels, most HEU/LEU Oxides and Silicides Requiring Resizing or Special Repackaging, and most Loose Uranium Oxide in Cans would be stored and then treated using the Melt and Dilute technology option when that option became available. The Conventional Processing Technology option would be used for the Uranium and Thorium Metal Fuels, about 10 percent of the HEU/LEU Oxides and Silicides Requiring Resizing or Special Repackaging; and about 10 percent of the Loose Uranium Oxide in Cans because of the potential health and safety vulnerability of continuing wet storage of those fuels while awaiting the availability of Melt and Dilute technology.

TC

DOE is not proposing any actions that would lead to the programmatic use of the Higher Actinide Targets. Therefore, DOE will maintain the Mark-18, Mark-51 and other targets in wet storage until decisions are made on final disposition.

TC

EC

- *Maximum Impact Alternative:* This alternative would provide Conventional Processing for all SNF except the Mark-51 and other" targets and the non-aluminum-clad fuels already selected for offsite shipment. This alternative provides the upper bound on range of impacts from potential configurations because the analyses presented are conservative in that they assume that the entire SNF inventory would be processed in the separations facilities, which would produce the greatest impacts of all the treatment options.

  TC

  DOE would manage the Mark-51 and other Higher Actinide Targets and the non-aluminum-clad SNF as described in the Minimum Impact Alternative. DOE would process the Mark-18 Higher Actinide Targets in F Canyon followed by vitrification of the americium and curium in the new F-Canyon Vitrification Facility as analyzed in the *Final Environmental Impact Statement for Interim Management of Nuclear Materials*.

- *No-Action Alternative*: The implementing regulations of NEPA require the inclusion of a No-Action Alternative. Under this alternative, DOE would continue to store the SNF in the wet basins at SRS even though this would not meet the purpose and need for action. To maintain safe conditions, DOE would take necessary actions to ensure safe storage in the basins, such as consolidation of fuel and upgrades of systems to ensure good water quality. As determined by the Record of Decision for the *Programmatic Spent Nuclear Fuel Management and Idaho National Engineering Laboratory Environmental Restoration and Waste Management Programs Environmental Impact Statement* (DOE/EIS-0203), DOE would transport the Non-aluminum Clad Fuels to the Idaho National Engineering and Environmental Laboratory.

S.11 Preferred Alternative

DOE proposes to implement several technologies to manage spent nuclear fuel at SRS. These technologies are Melt and Dilute, Conventional Processing, and Repackage and Prepare to Ship. Each of these technologies would treat specific groups of spent nuclear fuel, as described below. The technology and fuel group combinations form DOE's Preferred Alternative in this EIS. Figure S-1 provides a flowchart for the preferred alternative.

<u>Melt And Dilute</u>

> Melt and Dilute is the preferred treatment for 97 percent by volume (60 percent by mass) of the aluminum-based SNF at the Savannah River Site.

DOE has identified the Melt and Dilute process as the preferred method of treating most (about 97 percent by volume or about 32,000 MTRE) of the aluminum-based SNF considered in this EIS. DOE will continue to pursue a research and development program leading to a demonstration of the technology in FY 2001 using full-size irradiated research reactor spent nuclear TC

fuel assemblies. With a successful demonstration of the technology, DOE expects to have ready a treatment facility to perform production melt and dilute operations in FY 2008. DOE will ensure the continued availability of SRS conventional processing facilities until it has successfully demonstrated implementation of the Melt and Dilute treatment technology.

The fuel proposed for the preferred Melt and Dilute technology includes the Material Test Reactor-like fuel, most of the Loose Uranium Oxide in Cans fuel, and most of the HEU/LEU Oxide and Silicide fuel. Exceptions are the uranium and thorium fuel, failed and sectioned oxide and silicide fuel, some loose uranium oxide in cans fuel, the Higher Actinide Targets, and non-aluminum-clad fuel.

The Melt and Dilute Technology would satisfy DOE's objective and preference, as stated in the Record of Decision for the Final Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel (60 FR 25091), to select a non-chemical separations-based technology to prepare aluminum-based SNF for placement in a geologic repository. Additionally, this new technology would provide significant waste reduction (of high-level, low-level, transuranic, etc.) in comparison to conventional chemical processing and is fully compatible with and supportive of the non-proliferation objectives of the United States. In the Melt and Dilute process, aluminum-based SNF would be melted and highly-enriched uranium would be diluted with depleted uranium to produce low-enriched uranium. No separation of fissile materials from fission products would occur.

The potential impacts (e.g., worker and public health, waste generation, socioeconomics, etc.) among the new non-separations based technologies were all very similar; however, the Melt and Dilute option was the most efficient in volume reduction and produced the fewest number of SNF canisters. In fact, Melt and Dilute would volume reduce the fuel by more than 3 to 1 over Direct Disposal/Direct Co-Disposal. The volume reduction is achieved because the melt and dilute process eliminates voids in the fuel elements and in the canisters and fuel baskets used in the Direct Disposal/Direct Co-Disposal technology. DOE considered Melt and Dilute to be among the most "proven" of the new non-separations-based technologies because DOE has extensive experience with fuel melting operations for research purposes.

The Melt and Dilute technology offers DOE the flexibility to engineer the final waste form to provide a high degree of confidence that the material would be acceptable for placement in a geologic repository. Major technical concerns such as fuel characterization, criticality control, and repository performance can be reduced or eliminated by tailoring the chemical and physical form of the final product to meet specific criteria. DOE expects the Melt and Dilute option would be relatively simple to implement and would be less expensive than other similar technology options, although the ongoing technology development initiative will determine the viability of this alternative. The major technical issue for implementing this technology would be the design of an off-gas ventilation system to capture volatilized fission products. Preliminary engineering studies indicate that the system could be designed using proven approaches for managing off-gases.

To implement the preferred alternative (Melt and Dilute technology), DOE would construct a melt and dilute facility in the existing 105-L building at SRS and build a dry-storage facility in L Area, near the 105-L building. DOE is proposing to use this facility to house the Melt and Dilute process for the following reasons: the existing structure can accommodate the process equipment and systems; the applicable portions of the structure will meet DOE requirements for resistance to natural hazards (e.g., earthquakes); the integral disassembly basin has sufficient capacity for all expected SNF receipts and the current Site inventory; using 105-L avoids creating a new radiologically controlled facility that would eventually require decontamination and decommissioning; and DOE has estimated the cost

EC savings versus a new facility to be about $70 million.

Using the Melt and Dilute technology, DOE would melt aluminum-based SNF and blend down any highly enriched uranium to low enriched uranium using depleted uranium that is currently stored at SRS. The material would be cast as ingots that would be loaded into stainless-steel canisters approximately 10 feet tall and 2 feet (or less) in diameter. The canisters would be TC placed in dry storage pending shipment to a geologic repository.

TC During the development of the Melt and Dilute technology, DOE may determine that, for technical, regulatory, or cost reasons, the Melt and EC Dilute option is not viable. As a back-up to Melt and Dilute, DOE would continue to pursue the Direct Co-Disposal option of the New Packaging Technology and would implement this option if Melt and Dilute were no longer feasible or preferred. Direct Co-Disposal has the potential to be the least complicated of the new technologies and DOE believes this option could be implemented in the same timeframe as the Melt and EC Dilute option. However, DOE believes there is greater risk in attempting to demonstrate that aluminum-based SNF, packaged according to the TC Direct Co-Disposal option, would be acceptable in a geologic repository. A comparison of the preferred (Melt and Dilute) and back-up (Direct Co-Disposal) technologies DOE proposes to use to manage most of the aluminum-based SNF at SRS is presented in Table S-5.

If DOE identifies any imminent health and safety concerns involving any aluminum-based SNF, TC DOE could use F and H canyons to stabilize the material of concern prior to the melt and dilute facility becoming operational.

Conventional Processing

> Conventional Processing is the preferred treatment for 3 percent by volume (40 percent by mass) of aluminum-based SNF at the Savannah River Site.

DOE proposes to use conventional processing to stabilize some materials before a new treatment facility is in place. The rationale for this processing is to avoid the possibility of urgent future actions, including expensive recovery actions that would entail unnecessary radiation exposure to workers, and in one case, to manage a unique waste form (i.e., core filter block).

The total amount proposed for conventional processing is a relatively small volume of aluminum-based SNF at the SRS (about 3 % by volume and 40 % by mass). This material includes the Experimental Breeder Reactor-II fuel, the Sodium Reactor Experiment fuel, the Mark-42 targets and the core filter block from the Uranium and Thorium Metal fuel group; the failed or sectioned Tower Shielding Reactor, High Flux Isotope Reactor, Oak Ridge Reactor, and Heavy Water Components Test Reactor fuels and a Mark-14 target from the HEU/LEU Oxides and TC Silicides fuel group; and the Sterling Forest Oxide (and any other powdered/oxide fuel that may be received at SRS while H Canyon is still in operation) from the Loose Uranium Oxide in Cans fuel group. Although it is possible that a new treatment technology, such as melt and dilute, could be applied to most of these materials, DOE considers timely alleviation of the potential health and safety vulnerabilities to be the most prudent course of action because it would stabilize materials whose forms or types pose a heightened vulnerability to releasing fission products in the basin. Nonetheless, if these materials have not been stabilized before a new treatment technology becomes available, that new technology (melt and dilute) may be used rather than conventional processing.

The Experimental Breeder Reactor-II fuel and Sodium Reactor Experiment fuel are uranium metal that has been declad and stored in canisters in the Receiving Basin for Offsite Fuel. The declad fuels present a potential health and safety vulnerability. Should their existing storage containers leak, the metal fuel would corrode and release fission products to the water of the storage basin. Once the metal of the fuel is wetted, simply repackaging the fuel in a water-

Table S-5. Comparison of preferred and backup technologies for aluminum-SNF disposal.

Technology	Advantages	Disadvantages
Preferred technology: Melt-Dilute Process	• U-235 enrichment readily adjusted by dilution with depleted uranium to meet non-proliferation policy and nuclear criticality constraints. • Melting reduces the volume of the fuel (see Section A.2.1). DOE estimates about 400 canisters would be generated in comparison to about 1,400 canisters for Direct Co-Disposal. • Homogenous melt product provides basis for predictable behavior in a geologic repository. TC	• Implementation requires high temperature operation of melter and offgas control equipment in shielded cells.
Backup technology: Direct Co-Disposal Process	• Process technically straightforward to implement. Shielded-cell handling procedures well developed. • Meets non-proliferation policy criteria better than other technologies.	• Different SNF configurations, materials, and U-235 enrichments present packaging complexities. • No adjustment of U-235 enrichment possible to meet criticality constraints in a geologic repository. May require the use of exotic nuclear poisons. TC • No reduction in the volume of the fuel. • Non-uniform SNF structures and compositions complicates documentation of fuel characteristics to meet repository waste acceptance criteria and to predict behavior in a repository. TC

TC

tight container would not arrest the corrosion and, in fact, could exacerbate storage concerns since potentially explosive hydrogen gas would continue to be generated inside the storage canister as the fuel continued to corrode. An instance of water intrusion and subsequent fuel corrosion has already occurred with one Experimental Breeder Reactor-II canister stored in the Receiving Basin for Offsite Fuel. Additionally, several problems have occurred with other uranium metal fuel in similar storage conditions at SRS (e.g., the Taiwan Research Reactor fuel with failed or missing cladding that was overpacked in canisters and stored in SRS wet basins). DOE addressed these situations by processing the failed or declad fuel in F Canyon to eliminate the health and safety vulnerability.

The failed or sectioned Tower Shielding Reactor, High Flux Isotope Reactor, Oak Ridge Reactor, and Heavy Water Components Test Reactor fuel, and a sectioned Mark-14 target from the HEU/LEU Oxides and Silicides fuel group also present potential health and safety vulnerabilities. The integrity of these fuels was destroyed for research purposes. Then the material was canned and placed in wet storage at SRS. A breach of or leak in the cans would expose the interior surfaces of the sectioned fuel to water, contaminating the water in the storage basin with

TC

radioactivity, and accelerating the corrosion of the fuel.

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the Sterling Forest Oxide fuel from the Loose Uranium Oxide in Cans fuel group. Should a breach occur in the cladding on the Mark-42 targets or in the canisters of Sterling Forest Oxide fuel, the particulate nature of the nuclear material in the targets and the Sterling Forest Oxide fuel could lead to dispersion of radioactive material in the water of the Receiving Basin for Offsite Fuel. Therefore, DOE is proposing to take action now to avoid the possibility of urgent future actions, including expensive recovery actions that also would entail unnecessary radiation exposure to workers.

DOE proposes to process the Experimental Breeder Reactor-II fuel and the Mark-42 targets in F Canyon. That fuel contains plutonium, approximately 114 kg of which would be recovered as part of the normal F Canyon chemical separations process and then transferred to FB-Line for conversion to metal. The plutonium metal would TC be considered surplus to the nation's nuclear weapons program and would be placed in storage at the SRS pending disposition pursuant to the January 2000 Record of Decision (ROD) for the Surplus Plutonium Disposition Environmental Impact Statement (DOE 1999). The surplus plutonium would be immobilized using the can-in-canister process or fabricated into mixed-oxide (MOX) commercial power reactor fuel at the SRS. DOE has scheduled processing of the Experimental Breeder Reactor-II fuel and the Mark-42 targets in FY00.

DOE proposes to process the Sodium Reactor Experiment fuel, the failed or sectioned fuel from the HEU/LEU Oxides and Silicides fuel group, and the Sterling Forest Oxide fuel in H-Canyon where the highly enriched uranium would be blended down to low enriched uranium and stored pending potential sale as feed-stock for commercial nuclear fuel. DOE would begin processing operations in H Canyon in 2000 and could complete them in about 18 months.

A potential health and safety vulnerability also DOE/EIS- exists for the unirradiated Mark-42 targets from the Uranium and Thorium Metal fuel group and DOE also proposes to process the core filter block from the Uranium and Thorium Metals fuel group. The core filter block is made of depleted uranium but it contains corrosion-resistant metal (e.g., stainless-steel) that would be incompatible with the Melt and Dilute Technology for aluminum-based SNF. The core filter block could be processed in either F Canyon or H Canyon. In either case, the material would become feedstock to blend down highly enriched uranium from either conventional processing or melt and dilute operations.

The processing operations described above in both F and H Canyons would occur when the canyons were being operated to stabilize other nuclear material. It is the preference of the Department of Energy not to utilize conventional reprocessing for reasons other than safety and health. However, the core filter block is not compatible with the melt and dilute process for aluminum-based SNF. The benefit to develop a new process to accommodate this form(?) would be disproportionately small when compared to the cost (DOE 1998a). Consequently, the Department proposes an exception in this case.

Repackaging

> Repackaging and dry storage is the preferred alternative for non-aluminum-clad SNF (about 6 percent by volume and 30 percent by mass of all the fuel considered in this EIS). Mark-51 targets, and other targets would be managed using onsite storage pending disposition decisions. TC

DOE would continue to wet-store the non-aluminum clad spent nuclear fuel at SRS until the material is shipped to the Idaho National Engineering and Environmental Laboratory. EC TC DOE could transfer the non-aluminum clad fuel to dry storage after the material had been relocated from TC the Receiving Basin for Offsite Fuel to the L-Reactor Disassembly Basin in support of activities to phase out operations in the Receiving Basin for Offsite Fuel by fiscal year 2007.

Continued Wet Storage

DOE is not proposing any actions that would lead to programmatic use of the Higher Actinide Targets. Therefore, the Mark-18, Mark-51 and other Higher Actinide Targets will be maintained in wet storage until decisions are made on their final disposition. TC

S.12 Comparisons of Environmental Impacts Among the Alternatives

Operational Impacts

Impacts from operations under all of the alternatives would have no effect on ecological resources, water resources, or cultural resources. The impacts from onsite transportation of SNF would be small under all alternatives. EC

TC Processing the Mark-18 targets (about 1 kilogram of heavy metal) was previously analyzed in the *Final Environmental Impact Statement on Interim Management of Nuclear Materials* and, therefore, was not analyzed in this EIS. The impacts of processing this small amount of material are minor and would not significantly add to the impacts currently analyzed for the Maximum Impact Alternative in this EIS. For example, total radiological dose from the Preferred Alternative to the maximally exposed individual for the entire period of analysis would be 0.67 millirem. Processing the Mark-18 targets would result in a dose of 0.0035 millirem. These extremely small doses are unlikely to result in any health effects.

Tables S-6 and S-7 list impacts for the five alternatives. The EIS identifies the following operational impacts with potential to be discriminators among the alternatives:

Worker and public health impacts – Estimated impacts are reported as latent cancer fatalities for the involved worker population, noninvolved worker, the maximally exposed member of the public, and offsite population (Table S-6). These impacts are summed over the period of analysis based on annual emissions and radiation doses. EC

Involved worker doses are estimated under the assumption that no worker would receive more than the SRS administrative annual limit of 500 millirem from normal operations. The estimated latent cancer fatalities for the involved worker population for the entire period of analysis would be 0.28 for the Minimum Impact Alternative and 0.84 for the Maximum Impact Alternative. TC EC

EIS Operational Impact Potential Discriminators

- Worker and Public Health Impacts
- Nonradiological Air Impacts
- Waste Generation
- Utilities and Energy Consumption
- Accidents

The noninvolved worker highest estimated probability of a latent cancer fatality over the entire period of analysis would be 2.0×10^{-9} for the Minimum Impact Alternative and 6.3×10^{-7} for the Maximum Impact Alternative.

Table S-6 provides the incremental impact for health effects to the noninvolved worker, maximally exposed individual, and the offsite population above the current baseline for the operations of the wet storage basins at the SRS (the No-Action Alternative) over the entire period of analysis. Summing these baseline and incremental values is conservative because there would not be two SNF wet basins operating over the entire 38-year period of analysis.

The estimated latent cancer fatality probability to the maximally exposed individual over the entire period of analysis would be 3.0×10^{-10} for the Minimum Impact Alternative and 3.4×10^{-7} for the Maximum Impact Alternative. The

Table S-6. Impact summary by combination strategy.

	Parameter	No Action Alternative (baseline)	Minimum Impact Alternative	Direct Disposal Alternative	Preferred Alternative	Maximum Impact Alternative
	Health Effects for Entire Period of Analysis (1998-2035)					
TC	Integrated latent cancer fatality probability for the noninvolved worker	1.7×10^{-6}[(a)]	2.0×10^{-9}	9.6×10^{-9}	6.1×10^{-7}	6.3×10^{-7}
TC	Integrated latent cancer fatality probability for the maximally exposed member of the public	3.1×10^{-7}[(a)]	3.0×10^{-10}	3.6×10^{-9}	9.5×10^{-8}	3.4×10^{-7}
	Integrated latent cancer fatalities for the worker population	0.30	0.28	0.34	0.33	0.84
	Integrated latent cancer fatalities for the general public	1.1×10^{-2}[(a)]	1.1×10^{-5}	3.8×10^{-5}	3.4×10^{-3}	4.4×10^{-3}
	Waste Generation for the Entire Period of Analysis (1998-2035)					
TC	Liquid (cubic meters)	2,300	660	1,200	1,050	10,500
	High-level waste generated (equivalent DWPF[b] canisters)	38	11	20	17	160
	Transuranic waste generated (cubic meters)	0	15	360	563	3,700
	Hazardous and mixed low-level waste generated (cubic meters)	76	25	46	103	267
	Low-level waste generated (cubic meters)	57,000	20,000	31,000	35,260	140,000
	Utilities and Energy for the entire period of analysis (1998-2035)					
	Water consumption (millions of liters)	1,100	660	1,400	1,186	8,000
	Electricity consumption (megawatt-hours)	46,000	27,000	81,000	116,000	600,000
	Steam consumption (millions of kilograms)	340	190	520	650	3,600
	Diesel fuel consumption (thousands of liters)	230	180	2,300	2,760	22,000
EC	**SNF Disposal Canisters (1998-2035)**	0	~1,400	~1,300	400	0[c]

a. Reflects current reactor-area emissions (including two SNF wet basins) for the entire period of analysis.
b. DWPF = Defense Waste Processing Facility.

c. The technology used in the Maximum Impact Alternative (i.e., Conventional Processing) would not produce any canisters of SNF.

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Table S-7. Estimated maximum incremental concentrations of nonradiological air pollutants at SRS boundary for each alternative (percent of regulatory standard).

No Action Alternative	Minimum Impact Alternative	Direct Disposal Alternative	Preferred Alternative	Maximum Impact Alternative
0.03 (nitrogen oxides)	0.07 (ozone [as VOC])	1.2 (nitrogen oxides)	1.1 (nitrogen oxides)	3.6 (nitrogen oxides)

VOC = volatile organic compound.

estimated offsite latent cancer fatalities would be 1.1×10^{-5} for the Minimum Impact Alternative and 4.4×10^{-3} for the Maximum Impact Alternative. The estimated latent cancer fatalities in the offsite population affected by SRS over the entire period of analysis would be much less than 1 for any alternative.

- *Nonradiological Air Quality* – Table S-7 presents the estimated maximum incremental concentration of the nonradiological air pollutant that would contribute the most to the deterioration of air quality at the SRS boundary for each alternative. As noted from Table S-7, the concentration of the nonradiological constituent contributing the highest fraction of the offsite air qualitystandard would range from 0.03 percent of the standard for the No-Action Alternative to 3.6 percent of the standard for the Maximum Impact Alternative. Under all alternatives, nonradiological air concentrations at the SRS boundary would be well below applicable standards.

- W*aste generation* – Wastes volumes were estimated over the period of analysis. The Maximum Impact Alternative would generate the greatest volume of waste, while the Minimum Impact Alternative would generate the least volume of waste (Table S-6). For wastes generated under all alternatives, DOE would use the surplus capacity in existing SRS waste management facilities to treat, store, dispose, or recycle the waste in accordance with applicable regulations.

- U*tilities and energy consumption* – The quantities of water, electricity, steam, and diesel fuel that would be required over the entire period of analysis were estimated (Table S-6).

  The Maximum Impact Alternative would require the most water, electricity, steam, and diesel fuel, while the Minimum Impact Alternative would require the least. For all alternatives, water and steam would be obtained from existing onsite sources and electricity and diesel fuel would be purchased from commercial sources. These commodities are readily available and the amounts required would not have an appreciable impact on available supplies or capacities.

- *Accidents* – DOE evaluated the impacts of potential accidents related to each of the alternatives. For each potential accident, the impacts were evaluated as radiation dose to the noninvolved worker, radiation dose to the offsite maximally exposed individual, collective radiation dose to the offsite population, and latent cancer fatalities to the offsite population. Table S-8 presents the results of this analysis. Table S-8 also indicates the estimated frequency of occurrence for each accident.

  The highest consequence accident postulated under the continued wet storage, direct co-disposal, and repackage and prepare to ship technologies is a seismic/high wind-induced criticality, which is estimated to result in 6.2 latent cancer fatalities in the offsite population. The highest consequence accident under conventional processing technology is a TC coil and tube failure with an estimated offsite population impact of 39 latent cancer fatalities. The frequencies of these accidents are once in 2,000 to once in 26,000 years.

TC For the other new SNF technologies evaluated, the maximum consequence accident (earthquake induced spill with loss of ventilation) is associated with the melt and dilute process. This accident is estimated tooccur once in 200,000 years and to result in 10 latent cancer fatalities in the offsite population.

Construction Impacts

> Impacts of construction would be minor and short-lived.

Construction activities could affect four resources: surface water, air, ecological resources, and socioeconomics. However, because workers would build the facilities needed to carry out the proposed action in an area of the Site that is already industrialized, DOE expects little impact to these resources from construction activities.

In summary, none of the alternatives analyzed would result in undue adverse environmental effects. The preferred alternative is the alternative that DOE considers provides the greatest assurance of preparing the SNF for ultimate placement in a geologic repository by using a relatively simple new processing technology and a proven technology.

S.13 Cumulative Impacts

L3-8 DOE evaluated the cumulative impacts of SNF management activities coupled with other past, present, and reasonably foreseeable future actions that could impact the SRS and its environs.

This cumulative impacts analysis included the impacts from SNF management, other related DOE NEPA actions, current SRS operations, and potential processing in the SRS canyons of other nuclear materials located at other DOE sites. DOE analyzed cumulative impacts for the following areas: (1) air resources, (2) water resources, (3) public and worker health, (4) waste generation, and (5) utilities and energy consumption. Table S-9 presents the results of the nonradiological air resources cumulative impact analysis. Table S-10 presents the results of the cumulative analysis for the other technical discipline areas. L3-8

S.14 Other Factors

DOE evaluated other factors such as technical availability, nonproliferation and safeguards, labor availability and core competency, custodial care, and cost. These factors are discussed in Section 2.6 of the Final EIS.

Life-cycle costs (1998 billion of dollars) for each of the alternatives were estimated as follows:

- Minimum Impact Alternative 1.9
- Direct Disposal Alternative 1.9 EC
- Preferred Alternative 2.0
- Maximum Impact Alternative 2.0
- No Action Alternative 1.7

Life-cycle cost comparisons indicate that the No Action Alternative would be the least expensive. EC However, the cost of continued wet storage does not include costs of actions necessary to prepare SNF for ultimate disposition. The Direct Disposal Alternative and the Preferred Alternative (both using a renovated reactor building) have approximately the same life-cycle cost. Installation in a renovated reactor facility presents cost advantages of about $70 million compared to a new treatment facility. TC

Table S-8. Estimated maximum consequence accident for each technology.

Option	Accident Frequency	Consequences: Noninvolved Worker (rem)	Consequences: MEI (rem)	Consequences: Offsite Population (person-rem)	Consequences: Latent Cancer Fatalities
Continued Wet Storage (No Action)[a]					
RBOF (high wind-induced criticality)	Once in 26,000 years	13	0.22	12,000	6.2
L-Reactor basin (basin-water draindown)	Once in 500 years	0.014	0.016	(b)	(b)
Direct Co-Disposal					
Dry Storage phase (earthquake-induced criticality)	Once in 2,000 years	13	0.22	12,000	6.2
Repackage and Prepare to Ship					
Dry Storage phase (earthquake-induced criticality)	Once in 2,000 years	13	0.22	12,000	6.2
Conventional Processing					
Processing phase in F/H Canyons (coil and tube failure)	Once in 14,000 years	13	1.3	78,000	39
Melt and Dilute					
Dry Storage phase (earthquake-induced criticality)	Once in 2,000 years	13	0.22	12,000	6.2
Melt and dilute phase (earthquake-induced spill)	Once in 200,000 years	30	0.5	21,000	10
TC **Mechanical Dilution**					
Dry Storage phase (earthquake-induced criticality)	Once in 2,000 years	13	0.22	12,000	6.2
Mechanical dilution phase (criticality with loss of ventilation)	Once in 33,000 years	0.71	0.074	3,000	1.5
Vitrification Technologies					
Dry Storage phase (earthquake-induced criticality)	Once in 2,000 years	13	0.22	12,000	6.2
Vitrification phase (earthquake-induced release with loss of ventilation)	Once in 200,000 years	0.10	0.0017	71	0.035
Electrometallurgical Treatment					
Dry Storage phase (earthquake-induced criticality)	Once in 2,000 years	13	0.22	12,000	6.2
Electrometallurgical phase (earthquake induced spill with loss of ventilation)	Once in 200,000 years	30	0.5	21,000	10

MEI = Maximally Exposed Individual.
RBOF = Receiving Basin for Offsite Fuels.
a. All alternatives would use RBOF and the L-Reactor Disassembly Basin; therefore, accidents in these facilities are possible for each technology.
b. Not available.

Table S-9. Estimated maximum cumulative ground-level concentrations of nonradiological pollutants (micrograms per cubic meter) at SRS boundary.

Pollutant	Averaging time	SCDHEC ambient standard (μg/m^3)	Cumulative concentration (μg/m^3)	Percent of standard
Carbon monoxide	1 hour	40,000	10,093	25
	8 hours	10,000	6,921	69
Oxides of Nitrogen	Annual	100	33.1	33
Sulfur dioxide	3 hours	1,300	1,206	93
	24 hours	365	351.7	96
	Annual	80	34.1	43
Ozone	1 hour	235	1.8	1
Lead	Max. quarter	1.5	0.03	2
Particulate matter (≤10 microns aerodynamic diameter)	24 hours	150	130.4	87
	Annual	50	25.1	50
Total suspended particulates (μg/m^3)	Annual	75	67.1	89

Table S-10. Cumulative impacts.

Parameter	Cumulative total
Radiological Air Impacts	
Annual MEI[a] Dose (rem)	1.0×10^{-4}
MEI LCF[b] Probability (unitless)	5.1×10^{-8}
Annual Population dose (person-rem)	5.6
Population LCFs (unitless)	$2.8\text{x}10^{-3}$
Radiological Water Impacts	
Annual MEI Dose (rem)	2.4×10^{-4}
MEI LCF Probability (unitless)	$1.2\text{x}10^{-7}$
Population dose (person-rem)	2.6
Population LCFs (unitless)	1.3×10^{-3}
Worker and Public Health (Air and Water)	
Annual Total MEI dose (rem)	3.4×10^{-4}
Total MEI LCF probability (unitless)	1.7×10^{-7}
Annual Total population dose (person-rem)	8.2
Total population LCFs (unitless)	0.004
Annual Collective worker dose (rem)	859
Collective worker LCFs (unitless)	0.34
Waste Generation (Life-Cycle Waste)	
High-level waste generation (cubic meters)	94,681
Low-level waste generation (cubic meters)	430,401
Hazardous/mixed waste generation (cubic meters)	14,745
Transuranic waste generation (cubic meters)	18,532
Utilities and Energy	
Annual electricity consumption (megawatt-hours)	$5.77\text{x}10^{5}$
Water usage (liters)	1.79×10^{10}

a. MEI = Maximally Exposed Individual.
b. LCF = Latent Cancer Fatality.

EC
TC