Spent Nuclear Fuel Alternative Technology Risk Assessment

by

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Spent Nuclear Fuel Alternative Technology
Risk Assessment (U)
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<th>Acronym</th>
<th>Description</th>
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<tr>
<td>ANL</td>
<td>Argonne National Laboratory</td>
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<tr>
<td>CFR</td>
<td>Code of Federal Regulations</td>
</tr>
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<td>DE</td>
<td>Design Engineering</td>
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<td>DOE</td>
<td>Department of Energy</td>
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<tr>
<td>DOE-RW</td>
<td>Department of Energy, Office of Civilian Radioactive Waste Management</td>
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<tr>
<td>DWPF</td>
<td>Defense Waste Processing Facility</td>
</tr>
<tr>
<td>EBR</td>
<td>Experimental Breeder Reactor</td>
</tr>
<tr>
<td>HA</td>
<td>Handling Action</td>
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<tr>
<td>HEU</td>
<td>High Enriched Uranium</td>
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<tr>
<td>HLW</td>
<td>High Level Waste</td>
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<tr>
<td>LEU</td>
<td>Low Enriched Uranium</td>
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<tr>
<td>LLW</td>
<td>Low Level Waste</td>
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<td>MGDS</td>
<td>Mined Geologic Disposal System</td>
</tr>
<tr>
<td>MTR</td>
<td>Materials &amp; Test Reactor</td>
</tr>
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<td>NWPA</td>
<td>Nuclear Waste Policy Act</td>
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<td>Projects, Engineering &amp; Construction Division</td>
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<td>Research &amp; Development</td>
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<tr>
<td>RAPP</td>
<td>Risk Assessment Program Plan</td>
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<td>Record of Decision</td>
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<tr>
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</tr>
<tr>
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<tr>
<td>SRS</td>
<td>Savannah River Site</td>
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<tr>
<td>SRTC</td>
<td>Savannah River Technology Center</td>
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<tr>
<td>TBD</td>
<td>To Be Determined</td>
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<td>TSS</td>
<td>Transfer and Storage Services</td>
</tr>
<tr>
<td>U-Al</td>
<td>Uranium-Aluminum</td>
</tr>
<tr>
<td>WAC</td>
<td>(Mined Geologic Disposal System) Waste Acceptance Criteria</td>
</tr>
<tr>
<td>WBS</td>
<td>Work Breakdown Structure</td>
</tr>
<tr>
<td>WSRC</td>
<td>Westinghouse Savannah River Company</td>
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EXECUTIVE SUMMARY

A Research Reactor Spent Nuclear Fuel Task Team (RRTT) was chartered by the Department of Energy (DOE) Office of Spent Fuel Management with the responsibility to recommend a course of action leading to a final technology selection for the interim management and ultimate disposition of the foreign and domestic aluminum-based research reactor spent nuclear fuel (SNF) under DOE’s jurisdiction. The RRTT evaluated eleven potential SNF management technologies and recommended that two technologies, Direct Co-Disposal and an isotopic dilution alternative, either Press & Dilute or Melt & Dilute, be developed in parallel.

Based upon that recommendation, the Westinghouse Savannah River Company (WSRC), Spent Fuel Storage Division (SFSD), organized the SNF Alternative Technology Program to further develop the Direct Co-Disposal and Melt & Dilute technologies and ultimately provide a WSRC recommendation to DOE for a preferred SNF alternative management technology. A technology risk assessment was conducted as a first step in this recommendation process to determine if either, or both, of the technologies posed significant risks that would make them unsuitable for further development. This report provides the results of that technology risk assessment.

The risk assessment process involved the completion of the following three activities in accordance with the requirements of the Risk Assessment Program Plan, Transfer and Storage Services for Aluminum-Based Spent Nuclear Fuel:

1. Risk Identification - Identifying the risks for each SNF technology, for each Work Breakdown Structure (WBS) element;
2. Risk Analysis - Evaluating the identified risks (probability and consequences) and assessing them as High, Moderate, or Low; and,
3. Risk Handling Recommendation - Selecting a handling action for each risk (Mitigate, Avoid, Transfer, or Accept), and for a handling action of Mitigate, determining a mitigation strategy for each identified High and Moderate risk.

The SNF Alternative Technology Risk Assessment identified 24 active risks, of which only 5 were assessed as Moderate and 7 were assessed as High. All of the Moderate and two of the High risks were reduced to Low risks with success probabilities of 75% or greater, and 3 High risks were reduced to Moderate risks with success probabilities of 100% using mitigation strategies recommended by the assessment team. The remaining 2 High risks (one for each technology) address the possibility of existing repository-level performance requirements being redefined and imposed at the SNF disposal–form-level by the Department of Energy, Office of Civilian Radioactive Waste Management (DOE-RW). While these risks were judged by the assessment team to be Very Unlikely, the potential impact of changes in repository requirements will be mitigated by SFSD’s continuing dialog with DOE-RW and its Yucca Mountain repository managing and operating contractor.

Based upon the results of this assessment, it is the conclusion of the risk assessment team that the Melt & Dilute and Direct Co-Disposal alternative technologies are both acceptable for further development provided mitigation strategies recommended by the team for Moderate and High risks are followed and tracked through completion by a project team. SFSD has committed to proceed with the risk management process throughout implementation of the Treatment and Storage Facility Project.

* See Table 1 on Pages 13 & 14.
INTRODUCTION

BACKGROUND

The Record of Decision for the Environmental Impact Statement on the Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel directed the Department of Energy (DOE) to implement alternative treatment and packaging technologies that could be utilized in place of conventional processing to achieve safe and cost effective interim storage and ultimate disposal of aluminum-based spent nuclear fuel (SNF). As a result, the DOE Office of Spent Fuel Management chartered the Research Reactor Spent Nuclear Fuel Task Team (RRTT) with the responsibility to recommend a course of action leading to a final technology selection for the interim management and ultimate disposition of the foreign and domestic aluminum-based research reactor SNF under DOE's jurisdiction.

The RRTT evaluated eleven potential SNF management technologies, ranging from direct disposal and isotopic dilution to advanced treatments such as plasma arc treatment and glass material oxidation and dissolution. Using a modified Kepner-Tregoe evaluation process, the RRTT recommended that two technologies, Direct Co-Disposal and an Isotopic dilution alternative, either Press & Dilute or Melt & Dilute, be developed in parallel. The RRTT also recommended that an advanced technology, Electrometallurgy, although not directly developed for aluminum research SNF nor funded by the SNF program, be considered as a secondary and diverse backup.

Based on the recommendations of the RRTT report, WSRC organized the SNF Alternative Technology Program to further develop the Direct Co-Disposal and Melt & Dilute technologies and ultimately provide a WSRC recommendation to DOE for a preferred SNF alternative management technology. As a first step in this recommendation process, a technology risk assessment was conducted to determine if either, or both, of the technologies posed significant risks that would make them unsuitable for further development. This report provides the results of the technology risk assessment conducted in accordance with the requirements of the Risk Assessment Program Plan, Transfer and Storage Services for Aluminum-Based Spent Nuclear Fuel.

TECHNOLOGY ALTERNATIVES

As noted above, only two technologies, Direct Co-Disposal and Melt & Dilute, were considered in this risk assessment. A brief description of each of these technologies is provided below. Pre-conceptual design has been completed on both technologies.

Direct Co-Disposal (see Figure 1 on page 3)

In this technology, the SNF will be packaged intact in a canister that has a diameter of approximately seventeen inches and a length of approximately 120 inches. The canister of fuel will be vacuum dried and back-filled with helium. The fuel will be separated in the canister with a basket containing neutron absorber materials. Three to four baskets will be stacked within each canister. After the canister is back-filled and sealed, it will be temporarily stored at the Savannah River Site (SRS) in horizontal concrete storage modules.

Press & Dilute was not considered further because it was as costly as Melt & Dilute and did not offer the isotopic dilution capabilities of Melt & Dilute.

Figure 8.5.2-1 from the Pre-conceptual Design Report reprinted here for information only.
Cask Handling Area:
- Cask receipt, staging, and washdown.
- Cask venting, sampling, and bolt removal.
- Cask decontamination stations (2).

Unloading Area/Lag Storage:
- Remove cask lid.
- Remove each assembly, can, or basket.
- Attach ID label to assembly or can, and place in Lag Storage Racks; 500 position capacity.
- Return cask to cask handling area for decon.

Decanning Station:
- Cut ends from cans or tubes, remove SNF.
- Cut scrap to 4' lengths.

Cropping Stations (2):
- Cut non fuel-bearing ends from SNF.
- Disassemble HFIR outer cores into quarters.

Primary Characterization:
- Visual, dimensions, weight.
- Thermal.
- Gamma, neutron.

Detailed Characterization:
- More rigorous measurements of selected SNF
- Gamma, neutron
- Thermal

Canning Station:
- Place failed SNF in can.
- Seat lid into can; no weld.

Basket Loading:
- Load SNF and/or cans into baskets.
- Nine basket loading positions available.

Verification/Test:
- Perform final characterization of loaded basket.
- Gamma, neutron, thermal, weight.

Canister Loading/Transfer:
- Place basket into canister/transfer cask and place shield plug into canister.
- Remove canister/transfer cask from hot cell and place in Canister Prep Station.

Canister Prep/Closure:
- Decon exposed surfaces of transfer cask
- Weld shield plug in canister; inspect weld.
- Vacuum dry, inert, and leak test canister.
- Weld outer lid. Bolt top lid on transfer cask.
- Two work stations provided.

Transfer to Road Ready Storage:
- Load transfer cask on specialized transport vehicle; transport to storage module.
- Align transfer cask with storage module.
- Activate hydraulic ram to slide canister into storage module; install shield door on storage module.
- Storage capacity for 1200 canisters.

Legend

Figure 1. Facility Process Flow Diagram, Direct Co-Disposition
Ultimately, the canisters will be shipped to a federal Mined Geologic Disposal System (MGDS) repository for final disposal. There each of the SNF canisters will be placed inside a larger waste package containing five Defense Waste Processing Facility (DWPF) high level waste (HLW) canisters before being emplaced in the repository.

The Direct Co-Disposal alternative will require a separate powder metallurgy process to accommodate the disposition of the foreign research reactor target oxide materials listed in Table 5.2-2 of the RRTT report. These materials could be combined at 30 wt% with aluminum powder (or higher if necessary to make a good compact), compressed to make 3" OD X 24" slugs, cold welded, loaded into the standard canister, filled with inert gas, welded, leak checked, and finally, interim-stored prior to shipment to the repository.

**Melt & Dilute (see Figure 2 on page 5)**

In this technology, the SNF will be melted in a furnace, and depleted uranium and aluminum (as needed to control the metallurgy and process temperature) will be added to the melt in order to reduce the 235U enrichment to below 20%, the level required to be treated as low enriched uranium (LEU). If required, neutron absorber materials will also be added to the melt to minimize the potential for long-term criticality in the repository. The melt will be solidified and placed in a steel canister similar to that for the Direct Co-Disposal alternative. Several ingots may be stacked in each canister. The canister will then be back-filled with helium, sealed, and temporarily stored at SRS in horizontal concrete storage modules. Even though additional mass will be added to the disposal form during the melting process (in the form of aluminum and depleted uranium), the total volume required for the disposal forms will only be approximately one quarter of that required for Direct Co-Disposal. Like the Direct Co-Disposal alternative, the canisters will ultimately be shipped to a federal MGDS repository for final disposal with DWPF canisters.

The melting process will cause volatilization of some fission products. Those gases will be collected and processed onsite as either HLW or low level waste (LLW), with the exception of noble gases such as krypton which will be released to the facility stack.

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4 Figure 8.6.2-1 from the Pre-conceptual Design Report reprinted here for information only.
Cask Handling Area:
- Cask receipt, staging, and washdown.
- Cask venting, sampling, and bolt removal.
- Cask transfer to hot cell.
- Cask decontamination stations (2).

Unloading Area/Leg Storage:
- Remove cask lid.
- Remove each assembly, can, or basket.
- Attach ID label to assembly or can, and place in Leg Storage Racks; 500 position capacity.
- Return cask to cask handling area for decon.

Decanning Station:
- Cut ends from cans or tubes; remove SNF.
- Cut scrap to 4' lengths.

Decommissioning Station:
- Cut non fuel-bearing ends from SNF (non aluminum SNF and some aluminum SNF with excessive aluminum for melt).

Characterization:
<table>
<thead>
<tr>
<th>Aluminum:</th>
<th>Non Aluminum:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thermal, gamma, neutron.</td>
<td></td>
</tr>
</tbody>
</table>

Detailed Characterization:
- More rigorous measurements of selected non aluminum SNF.
- Gamma, neutron, thermal.

Melt and Dilute:
- Select SNF for melter batch; determine "recipe".
- Preheat/dry SNF.
- Melt Al, DU, and SNF in Induction Melter.
- Sample molten alloy and analyze with mass spectrometer; make any necessary adjustments.
- Cast alloy into Primary Waste Form, approx 16” OD by 33” maximum length.

Canning Station:
- Place failed Non-Al SNF in can.
- Seat lid into can; no weld.

Baskets Loading:
- Load SNF, cans, or PWF into baskets.
- Three basket loading positions available.

Verification/Test:
- Perform final characterization of loaded basket.
- Gamma, neutron, thermal, weight.

Canister Loading/Transfer:
- Place basket into canister; transfer cask and place shield plug into canister.
- Remove canister/transfer cask from hot cell and place in Canister Prep Station.

Canister Prep/Closure:
- Decon exposed surfaces of transfer cask.
- Weld shield plug in canister; inspect weld.
- Evacuate, inert, and leak test canister.
- Weld outer lid; bolt top lid on transfer cask.
- One work station provided.

Transfer to Road Ready Storage:
- Load transfer cask on specialized transport vehicle; transport to storage module.
- Align transfer cask with storage module.
- Activate hydraulic ram to slide canister into storage module; install shield door on storage module.
- Storage capacity for 400 canisters.

Legend
- Outside hot
- Inside hot cell

Figure 2. Facility Process Flow Diagram, Melt & Dilute
TEAM MEMBERS

As directed by the SNF Risk Assessment Program Plan (RAPP)², the following team comprised of individuals from Spent Fuel Storage Division (SFSD), Savannah River Technology Center (SRTC), Project, Engineering & Construction Division/Design Engineering (PE&CD/DE), and Project, Engineering & Construction Division/Systems Engineering (PE&CD/SE), was convened to conduct the risk assessment.

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<tr>
<th>Name</th>
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<tr>
<td>T. M. Adams</td>
<td>SRTC</td>
<td>Materials Application &amp; Corrosion Technology</td>
</tr>
<tr>
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<td>SFSD</td>
<td>Spent Fuel Storage Engineering</td>
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<td>J. M. Carter</td>
<td>PE&amp;CD</td>
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<td>E. W. Zimmerman</td>
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DISCUSSION

INITIATION OF TASK

In a series of five interactive meetings from 11/10/97 to 12/9/97, the team conducted a risk assessment for each of the two selected SNF technologies (Direct Co-Disposal and Melt & Dilute) using the process identified in Section 3.0 of the SNF RAPP. Since this assessment was to include all project risks, the following eight facets of risk as listed in the RAPP were addressed in this assessment to the extent possible:

- Safety
- Environmental
- Technical Performance
- Logistics Support
- Disposition
- Programmatic
- Cost
- Schedule

As noted in the RAPP, the assessment process followed the method of E7 Manual Procedure 2.16, Technical Risk Analysis⁵, with one exception. This exception involved the grading of risks as Low, Moderate, or High using a 3 X 3 probability versus consequence matrix, shown in Figure 3. The E7
Manual Procedure 2.16 prescribes the use of a risk factor equation that can result in many risks considered *Low* and *Moderate* by the risk assessment team falling into the *High* grade. The risk grading process used in this assessment emulates that of the technical community. The use of a matrix in grading risks is also one of the recommended methods in the *Project Risk Analysis Guide* which is referenced by E11 Manual Procedure 2.62, *Project Risk Analysis*.

![Risk Grades Diagram](image)

Figure 3. Risk Grades

The process used in this risk assessment involved the completion of the following three activities:

1. **Risk Identification** - Identifying the risks for each SNF technology, for each Work Breakdown Structure (WBS) element;
2. **Risk Analysis** - Evaluating the identified risks (probability and consequences) and assessing them as *High*, *Moderate*, or *Low*; and,
3. **Risk Handling Recommendation** - Selecting a handling action for each risk (*Mitigate*, *Avoid*, *Transfer*, or *Accept*), and for a handling action of *Mitigate*, determining a mitigation strategy for each identified *High* and *Moderate* risk.

*The 3 X 3 matrix is based upon a simplification of risk management categories shown in Figure 6.11 of *Systems Engineering* by Andrew P. Sage.*
RISK IDENTIFICATION

To facilitate the identification of risks, separate WBS trees were created for each of the subject areas: Manufacturing Facility (or process) and Disposal Form (or product). The WBS tree for each subject area was comprised of functional areas that supported the specific subject area. For the Manufacturing Facility WBS tree (Figure 4), the X.1 Common Facilities functional areas were derived from Section 4.2 of the Transfer and Storage Services Pre-conceptual Design report, and the X.2 Process Facilities functional areas were derived from Sections 4.3 and 4.4 of that same report. Functional areas Y.1.1 through Y.1.5 of the Disposal Form WBS tree (Figure 5) concentrated on canister design issues, while the remaining functional areas (Y.1.6 through Y.1.12) focused on disposal form issues deemed important by the team.

Figure 4. WBS Tree for Manufacturing Facility
The team used each of the WBS trees to assist in the identification and documentation of risks for each of the functional areas, as appropriate. Candidate risks for each of the subject areas were identified by the team based upon the following:

- Review of technology reports and documents to identify the known risks and inconsistencies;
- Review and analysis of assumptions made for the two SNF technologies during the down-select process;
- Review of assumption, uncertainties, and problems found in technology development and engineering development programs;
- Review of simulations, models, and other studies/analyses for the two SNF technologies; and,
- Review of DOE risk identifiers for applicability to the two SNF technologies.

Documents utilized in the assessment process are listed in the References beginning on Page 15.

![WBS Tree for Disposal Form](image)

**Figure 5. WBS Tree for Disposal Form**

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1 References 1, 4, 9, and 11 through 18.

DOES NOT CONTAIN UCNI
A SNF Risk Assessment database was created using guidelines provided in the RAPP to document each of the risks identified by the team. For each identified risk, the team provided the following initial information.

1. Statement of Risk – A brief, concise statement of the risk, indicating which WBS element or elements were vulnerable and the nature of the vulnerability.

2. Rational Basis for Risk – A brief rationale that makes clear what the impact will be if the risk materializes. This rationale was based upon either best engineering judgement or the results of technical analysis, if available.

**RISK ANALYSIS**

The team assigned a probability of occurrence and a severity of consequence grade for each of the identified risks documented in the database. These estimates of probability and consequence grades were also based upon either best engineering judgement or technical analysis results, if available, and utilized the following definitions.

1. Probability of Risk Materializing - The probability grade was designated to be Very Unlikely, Unlikely, or Likely as defined below.

   **Very Unlikely** - Not expected to occur anytime in the life cycle of the project or its operating facilities. Estimated recurrence interval exceeds 10,000 years.

   **Unlikely** - Not expected to occur in the life cycle of the project, and doubtful occurrence for its operating facilities. Estimated recurrence interval is 100 to 10,000 years.

   **Likely** - Expected to occur sometime during the life cycle of the project or its operating facilities. Estimated recurrence interval is less than 100 years.

2. Severity of Consequence - The consequence grade was designated to be Negligible, Marginal, or Critical as defined below.

   **Negligible** - Minor threat to cost, schedule, technical performance, environment or people. May require facility minor changes in operations or maintenance, with lost time extending to a few weeks but not months. May involve routine cleanup or first aid, but no redesign.

   **Marginal** - Nominal threat to cost, schedule, technical performance, environment or people. May require minor redesign or repair or environmental remediation with an impact of more than 5% but less than 10% of project schedule and/or life cycle cost. Has potential for minor occupational injury requiring medical intervention.

   **Critical** - Serious threat to cost, schedule, technical performance, environment or people. May prevent completing portions of the mission or cause failure to perform functions to meet requirements. May require major facility redesign or rebuilding, extensive environmental remediation or intensive medical care for life-threatening injury. Impacts will likely exceed 10% of project schedule and/or life cycle cost.

With probability and consequence grades defined, the team used the 3 X 3 probability versus consequence matrix shown in Figure 3 to assign a risk grade to each of the identified risks.

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* See Appendix A.
RISK HANDLING RECOMMENDATION

According to the RAPP, each unacceptable risk must have a recommended handling action (HA) to make it acceptable. Consequently, the Moderate and High grade risks were evaluated against each of the following four possible strategies for risk handling before selecting the preferred strategy.

1. Mitigate the Risk - The project can use simulations (virtual prototypes), analytical models or research and development to test-validate assumptions or reduce uncertainties that underpin a risk.

2. Avoid the Risk - The project can simply avoid the risk by choosing another design or another technology or both, whichever is causing the risk.

3. Transfer the Risk - The project can transfer the risk to another of its WBS element or, in some unusual cases, transfer it to an insurance company. Insured risks were not a consideration for the SNF risk assessment.

4. Accept the Risk - The project can accept the risk and do nothing else except to monitor for early triggers or indicators that the risk will strike the project. Upon detecting a trigger, the project will take preplanned evasive action.

Risk handling strategies were selected by the team for each of the Moderate and High grade risks and documented in the database. Each of the handling action recommendations were to include:

- The basis for the recommendation;
- A rough estimate of the cost, schedule, facilities and manpower needed to accomplish the handling action;
- An estimate of the grade of the risk after the recommended handling action is complete (e.g., the reduction in risk resulting from the handling action);
- Closure criteria, making clear what results must be accomplished for success;
- The probability of success for the handling action.

ASSUMPTIONS

The team used the following general assumptions in conducting the risk assessment.

1. All aluminum-clad SNF types and materials listed in Table 5.2-1 of the Research Reactor SNF Task Team Report will be processed in the SRS canyons as recommended, and consequently, they were not considered in the technology risk assessment.

2. Target materials in powdered form to be received under FRR EIS (Canada, Belgium, Argentina, and Indonesia) listed in Table 5.2-2 of the Research Reactor SNF Task Team Report will be processed in the new Transfer and Storage Services (TSS) facility at SRS and were therefore included in the technology risk assessment.

3. Criterion 2.1.1 of the MGDS Waste Acceptance Criteria (WAC) requires compliance with the Nuclear Waste Policy Act (NWPA) "legal" definition of SNF - namely, "fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing." For the purposes of this risk assessment, it is assumed that the

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* Section 2.1 of the RAPP categorizes Moderate and High grade risks as unacceptable.
Melt & Dilute disposal form meets the intent of this definition (i.e. - treating the SNF to reduce enrichment and achieve the desired metallurgy is not considered to be reprocessing.)

FINDINGS

During the initial assessments, the team identified a total of 33 risks, 21 for Melt & Dilute and 12 for Direct Co-Disposal. Nine of those risks were later deemed by the team to be non-credible and were consequently eliminated from further consideration. Justifications for the elimination of these risks are found on the individual database records. An assessment summary for the remaining 24 active risks (14 Melt & Dilute, 10 Direct Co-Disposal) may be found in Table 1 on Pages 13 & 14.

Of the 24 active risks, there were 12 Low risks (9 Melt & Dilute / 3 Direct Co-Disposal), 5 Moderate risks (3 Melt & Dilute / 2 Direct Co-Disposal), and 7 High risks (2 Melt & Dilute / 5 Direct Co-Disposal). The handling action selected by the team for all of the Low risks was Accept, as recommended by the RAPP, and no additional action was required. All of the Moderate risks were assigned a handling action of Mitigate, and based upon strategies identified in the database, all of those risks were reduced to Low with success probabilities that ranged from 95% to 100%.

For the seven High risks, the team selected handling actions of Mitigate for five of the risks and Transfer for the other two. Of the five High risks with mitigating handling actions, two were reduced to Low with success probabilities of 75% and 85%, and the other three were reduced to Moderate with success probabilities of 100%. The remaining 2 High risks (one for each technology) address the possibility of existing repository-level performance requirements being redefined and imposed at the SNF disposal-form-level by DOE-RW. While these risks were judged by the assessment team to be Very Unlikely, the potential impact of changes in repository requirements will be mitigated by SFSD's continuing dialog with DOE-RW and its Yucca Mountain repository managing and operating contractor.

TECHNICAL RISK MITIGATION STRATEGIES

As noted above, the team recommended mitigation strategies for all Moderate and High risks except for the two High risks that had selected handling actions of Transfer. The strategies recommended by the team may be found on Page 2 of each of the appropriate database records. Estimates for handling actions were not provided in the database as a part of this task but were instead identified as “to be determined” (TBD). The team agreed that completion of these estimates should be deferred as an action item for a future project team with the appropriate resources. In addition, because there were so few High and Moderate risks, the team did not attempt to rank them or select a Top-10 list as allowed by the RAPP.

---

1 Refer to the SNF Risk Assessment Database located in Appendix A.
1 Risk ID numbers 06, 07, 08, 12, 15, 19, 26, 27, & 28.
2 Risk ID numbers 22 & 23.
3 Risk ID numbers 22 & 23.
4 Including Cost, Start Date, Completion Date, Resources Required, Closure Criteria, & Fallback Strategy.
5 Ref. 2, §3.6.
<table>
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<th>Title</th>
<th>Technology</th>
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CONCLUSIONS
The purpose of the SNF Alternative Technology Risk Assessment was to determine if either, or both, of the alternative technologies recommended by the RRTT posed significant risks that would make them unsuitable for further development. Based upon the results of this assessment, it is the conclusion of the risk assessment team that the Melt & Dilute and Direct Co-Disposal alternative technologies are both acceptable for further development provided mitigation strategies recommended by the team for Moderate and High risks are followed and tracked through completion by a project team. SFSD has committed to proceed with the risk management process throughout implementation of the Treatment and Storage Facility Project.

REFERENCES


**APPENDIXES**

Appendix A: SNF Risk Assessment Database
Appendix A

SNF Risk Assessment Database

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Risk Assessment Database - General ................................................................................. A-2
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Risk Assessment Database - General

The risk assessment database that comprises this appendix is a collection of data on all the identified project risks and reflects the current status of each risk. A two-page database record exists for each of the identified risks and contains all of the pertinent information collected during the assessment process for that specific risk. The database was created in compliance with the requirements of Section 4 of the RAPP. Custody of the database will be transferred to SFSD Engineering following the issuance of this report.

Risk Assessment Database - Description

The following paragraphs identify the database field names and provide a brief description of the field contents in the context of the risk assessment process. The location of the field on each of the records (Page 1 and/or Page 2) is also identified.

- **RISK ID (Pages 1 & 2)**
  A unique serial number which is assigned to the record when each new risk is entered into the database. The new ID number is the last previous risk ID number incremented by 1.

- **ORIGIN DATE (Pages 1 & 2)**
  The calendar date for initial entry of risk information into the database.

- **REV NO (Pages 1 & 2)**
  The current revision number for the risk. Starts with 0 and increments by 1 each time the risk undergoes a change in nature or handling strategy.

- **STATUS DATE (Pages 1 & 2)**
  The calendar date of the last formal review of risk status. Also, the calendar date of the last updating of the risk record data.

- **STATUS (Pages 1 & 2)**
  Current status of record. Status will be either *Active*, *Closed*, or *Deleted*.

- **WBS ELEMENT (Pages 1 & 2)**
  The particular WBS element(s) which the risk will most likely impact (Ref. Figures 4 & 5 in the body of the report).

- **SUBJECT AREA (Pages 1 & 2)**
  The subject area under which the WBS element impacted by the risk may be found (Ref. Figures 4 & 5 in the body of the report).

- **FUNCTIONAL AREA (Pages 1 & 2)**
  The functional area description for the WBS element impacted by the risk (Ref. Figures 4 & 5 in the body of the report).

- **TECHNOLOGY (Pages 1 & 2)**
  The specific technology impacted by the risk. For this assessment, technology will be either *Direct Co-Disposal* or *Melt & Dilute*.

*DOES NOT CONTAIN UCNI*
TITLE (Pages 1 & 2)
A brief descriptive title for the risk.

RISK CATEGORY (Pages 1 & 2)
The technical risk category from Attachment 8.2 of WSRC Manual E7 Procedure 2.16. T-1 indicates category 1 under Technology; I-1 indicates category 1 under Interfaces; etc..

RISK FACET (Pages 1 & 2)
The risk type or facet. Facets may be Technical Performance, Logistic Support, Disposition, Safety, Environmental, Programmatic, Cost, or Schedule.

RISK ASSESSMENT (Pages 1 & 2)
The initial assessment results for risk grading, either Low, Moderate, or High.

RANK (Pages 1 & 2)
The current rank order number for the Active risks. The Risk Assessment Team determines this number. A rank of 1 indicates the most significant Active risk.

DESCRIPTION (Page 1)
A brief description of the risk and the basis for the risk. The basis includes a brief discussion of impacts if the risk were to occur, e.g., damaged SNF, unacceptable or rejected SNF disposal form, environmental releases, a contamination event, etc.

PROBABILITY OF RISK (Page 1)
Initial assessment of risk probability. The possible values of the field are Very Unlikely, Unlikely, and Likely.

RISK PROBABILITY SOURCE (Probability of Risk) (Page 1)
Indicates the source of the estimate. The possible values of the field are Team Engineering Judgement or Technical Analysis.

BASIS (Probability of Risk) (Page 1)
A brief statement that provides the basis for the assessed risk probability.

CONSEQUENCE OF RISK (Page 1)
Initial assessment of risk consequence(s). The possible values of the field are Negligible, Marginal, and Critical.

RISK CONSEQUENCE SOURCE (Consequence of Risk) (Page 1)
Indicates the source of the estimate. The possible values of the field are Team Engineering Judgement or Technical Analysis.

BASIS (Consequence of Risk) (Page 1)
A brief statement that provides the basis for the assessed risk consequence(s).
HANDLING ACTION (Page 2)

Risk handling action recommended by Risk Team. The possible values of the field are Mitigate, Avoid, Transfer, or Accept.

BASIS (Handling Action) (Page 2)

A brief, high-level description of the risk handling action necessary to implement the strategy, with references to other documents for detail. Mitigation lists & summarizes recommended future development, study, modeling or other handling activities.

EFFECTIVENESS (Estimates for Handling Action) (Page 2)

The anticipated grade of the risk (High, Moderate, or Low) after a successful handling action is complete.

SUCCESS PROBABILITY (Estimates for Handling Action) (Page 2)

An estimate of the probability that handling action will be successful. Expressed in terms of percent.

COST (Estimates for Handling Action) (Page 2)

An estimate of the cost for performing the handling action.

START DATE (Estimates for Handling Action) (Page 2)

An estimate of the calendar date at which the handling action should begin.

COMPLETION DATE (Estimates for Handling Action) (Page 2)

An estimate of the calendar date at which the handling action could be complete.

RESOURCE REQUIRED (Estimates for Handling Action) (Page 2)

A brief description of the people, tools, facilities and other resources needed to execute the handling action.

CLOSURE CRITERIA (Page 2)

The closure criteria that confirm a successful completion of handling action. Criteria must be met to initiate risk closure.

FALLBACK STRATEGY (Page 2)

A brief summary of an alternative handling action should the recommended handling action fail to manage the risk.
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<tr>
<th>Risk ID</th>
<th>Title</th>
<th>Technology</th>
<th>WBS Element</th>
<th>Subject Area / Functional Area</th>
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## SNF Risk Assessment

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#### Description

R&D for the SNF disposal form and for the manufacturing facility are on or near the project's critical path. It is assumed that completion of R&D can occur within the normal project schedule. There is risk that normal R&D iterations can invalidate this assumption.

#### Risk Category

- **D-5:** Numerous or unclear assumptions or modification basis.

#### Risk Profile

- **High**
- **Likely**
- **Team Engineering Judgement**

#### Risk Source

- **Potential funding shortfalls could delay completion of R&D efforts.**

#### Consequence of Risk

- **Critical**
- **Team Engineering Judgement**

#### Risk Source

- **Normal R&D iterations can have severe negative impacts on project cost and schedule.**
### SNF Risk Assessment

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<td>2</td>
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<td>X.0</td>
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<td>Project Management</td>
<td>Melt &amp; Dilute</td>
<td>D-5: Numerous or unclear assumptions or modification basis.</td>
<td>Programmatic</td>
<td>High</td>
<td></td>
</tr>
</tbody>
</table>

#### Title
Performance of R&D on Project Critical Path

#### Mitigate

**Basis**
The project has been phased so that there is a design only project followed by a construction project. This will limit the financial liability that could be incurred if the R&D does not support the project assumptions. Additionally, the R&D efforts have been prioritized to focus early work on the most likely areas of concern.

#### Estimates for Handling Action

<table>
<thead>
<tr>
<th>Effectiveness</th>
<th>Success Probability</th>
<th>Cost</th>
<th>Start Date</th>
<th>Completion Date</th>
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</thead>
<tbody>
<tr>
<td>Moderate</td>
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<td>(TBD)</td>
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</tr>
</tbody>
</table>

#### Feedback Strategy
(TBD)

#### Resources Required
(TBD)
SNF Risk Assessment

Title: SNF Characterization Required at Receiving

Description:
SNF characterization is required upon receipt at SRS. It is assumed that only nominal characterization (visual, dimensional, serial number, etc.) is required at this time. This characterization will depend mostly on check offs, and will not require detailed characterization methods.

Should additional requirements for characterization at receipt inspection be imposed the project would be required to do more to address the new requirements.

Risk Category: D-1: Undefined, incomplete or unclear functional requirements.

Risk Probability: Very Unlikely
Risk Probability Source: Team Engineering Judgement

Risk Assessment: Low

Risk Facet: Technical Performance

The furnace Melt-Dilute process will provide the needed characterization data for the disposal form through sampling/analysis. Consequently, it is very unlikely that the characterization station will be required to provide anything more than simple check offs that confirm receipt of the correct material.

Consequence of Risk: Negligible
Consequence Source: Team Engineering Judgement

The only characterization that the furnace does not obviate is the \(^{235}\text{U}\) content for nuclear criticality safety. In tag storage and the furnace itself, judicious design should make both of these processes criticality-safe for any maximum credible \(^{235}\text{U}\) loading without any impact on project cost or schedule.
## SNF Risk Assessment

### Handling Action

**Accept**

**Details:** At the present time the project will accept Appendix A characterization data as written and will not perform special tests to gain more detailed characterization.

### Risk Category

**D-1:** Undefined, incomplete or unclear functional requirements.

### Risk Facet

**Technical Performance**

<table>
<thead>
<tr>
<th>Risk Assessment</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
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</table>

### Closure Criteria

(N/A)

### Estimates for Handling Action

<table>
<thead>
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<tbody>
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<td>100%</td>
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</table>

### Fallback Strategy

(N/A)

### Resource Required

(N/A)
## SNF Risk Assessment

### SNF Characterization Required at Receiving

**Description**

SNF characterization is required upon receipt at SRS. The MGDS WAC (Ref. 9) identifies various information regarding the SNF that must be provided by SRS, however it is not yet determined what form or accuracy is required for the data (i.e., is it necessary to identify isotopic quantities, pyrophoric or hazardous contents, etc., in the fuel, or is it acceptable to simply verify that fuel constituents are below given limits?).

At the present time the project calls for assaying (sampling) SNF and assessing, through calculations, whether the remainder is within isotopic limits, and using historical data to evaluate hazardous, pyrophoric, etc. contents. The project has assumed that this is acceptable and is designing the facility accordingly, as this is consistent with the MGDS WAC.

There is a risk that the final MGDS WAC will impose additional characterization information requirements for the SNF disposal form.

### Risk Category

- **Risk Category**: D-1: Undefined, incomplete or unclear functional requirements.
- **Risk Focus**: Technical Performance

### Probability of Risk

- **Unlikely**
- **Risk Probability Source**: Team Engineering Judgement

### Risk Consequence

- **Critical**
- **Risk Consequence Source**: Team Engineering Judgement

### Notes

- Should additional requirements for characterization at receipt inspection be imposed, the project would be required to do more to address the new requirements.

Depending upon the required information, additional characterization of the SNF may be needed and data may need to be measured instead of calculated. This change could result in a need for additional equipment and a minor redesign, or it may result in a somewhat slower process. In either case, impact may exceed 10% of project schedule and/or life cycle cost of facility.
## SNF Risk Assessment

### Title
SNF Characterization Required at Receiving

<table>
<thead>
<tr>
<th>Risk Category</th>
<th>Risk Facet</th>
<th>Risk Assessment</th>
<th>Rank</th>
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</thead>
<tbody>
<tr>
<td>D-1: Undefined, incomplete or unclear functional requirements.</td>
<td>Technical Performance</td>
<td>High</td>
<td></td>
</tr>
</tbody>
</table>

### Handling Action
Mitigate

### Basis
The design calls for assaying SNF and assessing through calculations, whether it is within isotopic limits and using historical data to evaluate hazardous, pyrophoric, etc. contents. The design needs to be flexible (provide space, infrastructure, etc.) to accommodate additional characterization should it be required. A contingency should also be added to operating costs for the additional characterization.

### Estimates for Handling Action

<table>
<thead>
<tr>
<th>Effectiveness</th>
<th>Success Probability</th>
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<th>Completion Date</th>
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### Feedback Strategy
(TBD)

### Resources Required
(TBD)
### SNF Risk Assessment

<table>
<thead>
<tr>
<th>Title</th>
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<th>Risk Factor</th>
<th>Risk Assessment</th>
<th>Risk Probability Source</th>
<th>Probability of Risk</th>
<th>Risk Probability Source</th>
<th>Consequence of Risk</th>
<th>Risk Consequence Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accurate Reports of Material Received</td>
<td>1-1: Multiple system interfaces.</td>
<td>Disposition</td>
<td>Moderate</td>
<td>Team Engineering Judgement</td>
<td>Likely</td>
<td>Based upon experience to date, some records will not fully reflect materials received for processing.</td>
<td>Negligible</td>
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</tbody>
</table>

SRS will be processing SNF generated by other organizations, under control systems which differ from SRS's current programs. It is assumed that SRS will receive sufficiently accurate records of the legacy materials being received such that the material can be processed within the system as designed. There is a risk that material will be received that is not reflected in the records, and that it cannot be processed by SRS.

Inaccurate records could result in the receipt of materials which SRS is not prepared to handle. If all received material is fuel related, then bounding analyses will allow the system to accommodate and process the material. If material is not fuel related, a new strategy would be required, but this is not expected to impact this project's cost or schedule.
# SNF Risk Assessment

**Title:** Accurate Reports of Material Received  
**Risk Category:** I-1: Multiple system interfaces.

### Handling Action: Mitigate

**Basis:**

The project needs to:
1. Develop a position on handling material received which is outside the limits of the records received;
2. Develop administrative controls to process materials in an alternate manner; or,
3. Modify the facility to accept certain variant materials.

The material may simply require more characterization to make it acceptable.

<table>
<thead>
<tr>
<th>Estimates for Handling Action</th>
<th>Faliback Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effectiveness</td>
<td>Success Probability</td>
</tr>
<tr>
<td>LOW</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Resources Required:** (TBD)

---

The image contains the documentation for the SNF Risk Assessment, detailing the handling actions, estimates, and resources required for the mitigation of risks associated with accurate reports of material received.
### SNF Risk Assessment

**Title**: Accurate Reports of Material Received

**Description**: SRS will be processing SNF generated by other organizations, under control systems which differ from SRS's current programs. It is assumed that SRS will receive sufficiently accurate records of the legacy materials being received such that the material can be processed within the system as designed. There is a risk that material will be received that is not reflected in the records, and that it cannot be processed by SRS.

<table>
<thead>
<tr>
<th>Risk Category</th>
<th>Risk Facet</th>
<th>Probability of Risk</th>
<th>Risk Probability Source</th>
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<tbody>
<tr>
<td>I-1: Multiple system interfaces.</td>
<td>Disposition</td>
<td>Likely</td>
<td>Team Engineering Judgement</td>
</tr>
<tr>
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<td></td>
<td>Based</td>
<td>Team Engineering Judgement</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Based upon experience to date, some records will not fully reflect materials received for processing.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Consequence of Risk</th>
<th>Risk Consequence Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negligible</td>
<td>Team Engineering Judgement</td>
</tr>
</tbody>
</table>

Inaccurate records could result in the receipt of materials which SRS is not prepared to handle. If all received material is fuel related, then bounding analyses will allow the system to accommodate and process the material. If material is not fuel related, a new strategy would be required, but this is not expected to impact this project's cost or schedule.
### Record Page 2 of 2

#### SNF Risk Assessment

<table>
<thead>
<tr>
<th>Risk ID</th>
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</table>

#### Title
Accurate Reports of Material Received

#### Risk Category
I-1: Multiple system interfaces.

#### Risk Facet
Disposition

#### Risk Assessment
Moderate

#### Closeout Criteria
(TBD)

### Handling Action

#### Mitigate

**Goals**
- The project needs to:
  1. Develop a position on handling material received which is outside the limits of the records received;
  2. Develop administrative controls to process materials in an alternate manner; or,
  3. Modify the facility to accept certain variant materials.

The material may simply require more characterization to make it acceptable.

#### Estimates for Handling Action

<table>
<thead>
<tr>
<th>Effectiveness</th>
<th>Success Probability</th>
<th>Cost</th>
<th>Start Date</th>
<th>Completion Date</th>
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<tr>
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<td>100%</td>
<td>(TBD)</td>
<td>(TBD)</td>
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</table>

#### Fallout Strategy
(TBD)
SNF Risk Assessment

Risk Category: D-1: Undefined, Incomplete or unclear functional requirements.

Risk Factor: Technical Performance

Risk Assessment: Low

Description:

The MGDS WAC requires processed SNF to be packaged such that materials are not combustible, pyrophoric, organic or chemically reactive over a temperature range of 25 to 400°C and a pressure range of 1 to 5 atmospheres. The packaging limits have not yet been defined in the MGDS WAC which will ensure acceptance at the repository. Additionally, canister internal pressure cannot exceed 150 kPa over the entire range of all projected canister temperatures.

The project assumes that a disposal form will be generated which will comply with the limits when they are established. There is a risk that packaging limits will be so stringent that the project will have difficulty meeting them.

Probability of Risk: Very Unlikely

Risk Probability Source: Team Engineering Judgement

Basis:
The proposed waste form is expected to be inherently stable under the normal storage condition. Non of the materials packaged in the waste form are expected to contain combustible, pyrophoric, organic or chemically reactive constituents. Consequently, it is very unlikely that the disposal form will have difficulty meeting the packaging limits.

Likewise, all free fission gases and high vapor pressure elements will be released during the Melt-Dilute process, making it very unlikely that significant outgassing will occur from the disposal form and overpressurize the canister. However, research into this issue should continue to confirm these expectations.

Consequence of Risk: Negligible

Risk Consequence Source: Team Engineering Judgement

Basis:
Should the packaging limits for combustibles, etc., be very stringent, rework of the disposal form will be necessary. The life cycle cost and schedule impacts of this rework should not exceed 5% provided DOE-RW establishes these limits in 1998 as currently scheduled.
<table>
<thead>
<tr>
<th>Record ID</th>
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<th>Facility</th>
<th>Packaging</th>
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<th>Risk Assessment</th>
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<th>Financial Required</th>
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<td>(NA)</td>
<td>(NA)</td>
<td>(NA)</td>
</tr>
</tbody>
</table>

At the present time the project will accept this risk.
SNF Risk Assessment

Title: Quality of Final Product

Description:
The MGDS WAC requires processed SNF to be packaged such that materials are not combustible, pyrophoric, organic or chemically reactive over a temperature range of 25 to 400°C and a pressure range of 1 to 5 atmospheres. The packaging limits have not yet been defined in the MGDS WAC which will ensure acceptance at the repository. Additionally, canister internal pressure cannot exceed 150 kPa over the entire range of all projected canister temperatures.

The project assumes that a disposal form will be generated which will comply with the limits when they are established. There is a risk that packaging limits will be so stringent that the project will have difficulty meeting them.

Risk Category: D-1: Undefined, incomplete or unclear functional requirements.

Risk Probability Source: Very Unlikely

Risk Source: Team Engineering Judgement

Probability of Risk: Very Unlikely

Risk Assessment: Low

Risk Description:
The SNF form is inherently stable under the normal storage conditions. The use of a vacuum dryer will reduce the amount of free water in the sealed canister to reduce the radiolytic generation of hydrogen gas. The relatively low temperature of the repository disposal environment makes it very unlikely that intact SNF assemblies will outgas significantly to overpressurize the canister. Even though SNF is not expected to contain combustible, pyrophoric, organic or chemically reactive constituents, it is also very unlikely that the characterization station, as currently conceptualized, will fail to detect these constituents so that compliance with the packaging limits are assured. However, research into this issue should continue to confirm these expectations.

Consequence of Risk: Negligible

Risk Consequence Source: Team Engineering Judgement

Baseline:
Should the packaging limits for combustibles, etc., be very stringent, rework of the disposal form will be necessary. The life cycle cost and schedule impacts of this rework should not exceed 5% provided DOE-RW establishes these limits in 1998 as currently scheduled.
# SNF Risk Assessment

<table>
<thead>
<tr>
<th>Risk ID</th>
<th>Orig Date</th>
<th>Rev No.</th>
<th>Status Date</th>
<th>Status</th>
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<th>Risk Facet</th>
<th>Risk Assessment</th>
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<tr>
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<td>Active</td>
<td>X.2.4</td>
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<td>D-1: Undefined, incomplete or unclear functional requirements.</td>
<td>Technical Performance</td>
<td>Low</td>
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</table>

## Handling Action

**Accept**

**Basis**

At the present time the project will accept this risk.

## Estimates for Handling Action

<table>
<thead>
<tr>
<th>Effectiveness</th>
<th>Success Probability</th>
<th>Cost</th>
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<td>100%</td>
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<td>(N/A)</td>
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</tbody>
</table>

**Resources Required**

(N/A)
### SNF Risk Assessment

**Title:** Non-Fuel Products Received in SNF

**Description:**
There may be some unknown non-fuel related materials received in the SNF or some process upsets (e.g., foaming or slag productions) which could result in a U-Al ingot which is unacceptable to the repository. The current TSS design will detect a range of anticipated non-fuel materials and process upsets and disposition of these unacceptable U-Al ingots. Because this design has some first-of-a-kind features, there is a risk that the current design cannot detect a flawed U-Al ingot, and consequently, the process would not be pre-certified by DOE-RW. There is an additional risk that even if the design can detect the flaw, the current process cannot recycle the unacceptable ingot.

**Risk Category:** T-3: New application of existing technology.

**Risk Factor:**
- Risk Probability: Unlikely
- Risk Probability Source: Team Engineering Judgement

**Risk Assessment:**
- Risk Category: T-3
- Risk Face: Technical Performance
- Risk Probability: Unlikely
- Risk Probability Source: Team Engineering Judgement

**Consequence of Risk:**
- Consequence: Negligible
- Consequence Source: Team Engineering Judgement

**Basis:**
The facility may produce one or two unacceptable U-Al ingot during the operating lifetime. These ingots would be handled and disposed of on an ad hoc basis with minimal impact on the facility life cycle cost and schedule.
**SNF Risk Assessment**

<table>
<thead>
<tr>
<th>Risk ID</th>
<th>Origin Date</th>
<th>Rev No.</th>
<th>Status Date</th>
<th>Status</th>
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**SNF Alternative Technology Risk Assessment**

<table>
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<td>Non-Fuel Products Received in SNF</td>
<td>T-3: New application of existing technology.</td>
<td>Technical Performance</td>
<td>Low</td>
<td></td>
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</tbody>
</table>

**Handling Action**

- **Accept**

  **Basis**

  At the present time the project will accept this risk.

**Estimates for Handling Action**

<table>
<thead>
<tr>
<th>Effectiveness</th>
<th>Success Probability</th>
<th>Cost</th>
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<td>100%</td>
<td>(N/A)</td>
<td>(N/A)</td>
<td>(N/A)</td>
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</tbody>
</table>

**Defect Strategy**

(N/A)
SNF Risk Assessment

Title: Behavior of Fuels During Melt-Dilute

Description:
Spent nuclear fuels will change state during processing. It is uncertain how the spent fuels will behave metallurgically since a large scale integrated Melt-Dilute process has not been demonstrated.

The project design assumes that unirradiated U-Al metallurgy adequately reflects the metallurgy of SNF. There is a risk that SNF metallurgy could invalidate that assumption.

Risk Category: T-2: Unknown or unclear technology.
Risk Facet: Technical Performance
Risk Assessment: Moderate

Probability of Risk: Unlikely
Risk Probability Source: Team Engineering Judgement

ANL-West is now melting EBR fuels with no reported problems of low melting eutectics from fission products. Tests at SRS and other laboratories for reactor safety studies have been completed using irradiated U-Al alloy and oxide fuels. In addition, the project plans to meld irradiated fuel to demonstrate the concept. Calculations have been completed for the expected fission products in highly irradiated MTR fuels; results show only trace amounts of these elements. Consequently, it is unlikely that SNF metallurgy will present significant problems during the Melt-Dilute process.

Consequence of Risk: Marginal
Risk Consequence Source: Team Engineering Judgement

If the SNF metallurgy differs from the design basis metallurgy, a minor redesign of the furnace process may be necessary to deal with the fission and activation products.
## SNF Risk Assessment

<table>
<thead>
<tr>
<th>Risk ID</th>
<th>Origin Date</th>
<th>Rev No.</th>
<th>Status Date</th>
<th>Status</th>
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<td>Furnace Melt and Dilute</td>
<td>Melt &amp; Dilute</td>
</tr>
</tbody>
</table>

### Risk Category
- **T-2**: Unknown or unclear technology.
- **Risk Factor**: Technical Performance
- **Risk Assessment**: Moderate

### Handling Action
- **Mitigate**

**Details**
- Use data from existing processes to predict outputs.
- Demonstrate the system prior to final design.
- Retrieve data from Argonne-West for actual melt-dilute of spent fuels.

### Estimates for Handling Action

<table>
<thead>
<tr>
<th>Effectiveness</th>
<th>Success Probability</th>
<th>Cost</th>
<th>Start Date</th>
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### Resources Required
- (TBD)
## SNF Risk Assessment

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<td>Manufacturing Facility</td>
<td>Furnace Melt and Dilute</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Title: Furnace Melt and Dilute System Performance

**Description:**
The integrated system planned for the furnace Melt-Dilute system is a first-of-a-kind, although the individual subsystems and components are not. Based on the technology available, site personnel are assuming that system operation can be predicted. There is a risk that the integrated system will encounter interface or other first-of-a-kind problems which will prevent it from performing as predicted.

**Risk Category:**
I-1: Multiple system interfaces.

**Risk Factor:**
Technical Performance

**Risk Probability:**
Unlikely

**Risk Probability Source:**
Team Engineering Judgement

**Risk Assessment:**
Low

**Risk Consequence:**
Negligible

**Risk Consequence Source:**
Team Engineering Judgement

**Risk Basis:**

Should system integration problems occur, minor redesign will be necessary to insure correct interfaces. Costs of redesign necessary to resolve any interface problems are expected to be below 5% of the life cycle cost and schedule.
## SNF Risk Assessment

### Risk ID 14

<table>
<thead>
<tr>
<th>Risk ID</th>
<th>Origin Date</th>
<th>Rev No</th>
<th>Status Date</th>
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<tbody>
<tr>
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<td>X.2.12</td>
<td>Manufacturing Facility</td>
<td>Furnace Melt and Dilute</td>
<td>Melt &amp; Dilute</td>
</tr>
</tbody>
</table>

### This Risk
Furnace Melt and Dilute System Performance

#### Handling Action
- **Accept**

#### Basis
At the present time the project will accept this risk.

### Estimates for Handling Action

<table>
<thead>
<tr>
<th>Effectiveness</th>
<th>Success Probability</th>
<th>Cost</th>
<th>Start Date</th>
<th>Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>100%</td>
<td>(N/A)</td>
<td>(N/A)</td>
<td>(N/A)</td>
</tr>
</tbody>
</table>

**Resources Required** (N/A)

### Risk Category
I-1: Multiple system interfaces.

### Risk Facet
Technical Performance

### Risk Assessment
- **Rank**: Low

### Closure Criteria
(N/A)
<table>
<thead>
<tr>
<th>SNF Risk Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Description</strong></td>
</tr>
<tr>
<td>The process to clean the off gas systems and the process to treat the removed</td>
</tr>
<tr>
<td>fraction and activation products will generate contaminated liquid and solid waste.</td>
</tr>
<tr>
<td>However, the volume of the waste generated from the cleaning and treatment system</td>
</tr>
<tr>
<td>can be handled by existing SRS processes. There is a risk that the HLW stream will</td>
</tr>
<tr>
<td>require additional processing before ultimate disposal.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Probability of Risk</th>
<th>Risk Probability Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very unlikely</td>
<td>Team Engineering Judgement</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Risk Category</th>
<th>Risk Disposition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td></td>
</tr>
</tbody>
</table>

**Note:**

- The existing SRS processes have a proven record for handling a wide array of waste streams. Any required redesign to accommodate furnace off gas waste streams would be minor.
## Disposition of Off Gas System Waste

### Handling Action
- **Accept**

### Basis
At the present time the project will accept this risk.

### Estimates for Handling Action

<table>
<thead>
<tr>
<th>Effectiveness</th>
<th>Success Probability</th>
<th>Cost</th>
<th>Start Date</th>
<th>Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>100%</td>
<td>(N/A)</td>
<td>(N/A)</td>
<td>(N/A)</td>
</tr>
</tbody>
</table>

### FAILURE CRITERIA
- **(N/A)**

### TECHNOLOGY
- **Melt & Dilute**

### TECHNOLOGY RISK

- **R/V-3:** Undefined disposal methods.

### Risk Assessment
- **Low**
### SNF Risk Assessment

<table>
<thead>
<tr>
<th>Risk ID</th>
<th>Origin Date</th>
<th>Rev No.</th>
<th>Status Date</th>
<th>Status</th>
<th>WBS Element</th>
<th>Subject Area</th>
<th>Functional Area</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td>11/12/97</td>
<td>2</td>
<td>07/13/88</td>
<td>Active</td>
<td>X.2.13</td>
<td>Manufacturing Facility</td>
<td>Off Gas System</td>
<td>Melt &amp; Dilute</td>
</tr>
</tbody>
</table>

#### Title
Capture and Retention of HLW Materials

#### Description
The relatively high temperatures of the melt-dilute furnace will release significant fractions of cesium, strontium, technetium and other volatile fission products from molten U-Al spent fuel. Activation products will also volatilize and escape the molten alloy. The furnace off gas system must capture and retain the fission products and activation products for what could be considerable time periods before eventual disposal as high level waste. During the entire time period, radioactive releases from the off gas system to the environment must be within regulatory limits.

Risks are likely to come from the elemental form and relatively high temperatures of the solid, gaseous and liquid forms of the various fission and activation products. Special tests will likely be necessary to identify the risks and develop ways to handle them.

#### Risk Category
T-3: New application of existing technology.

#### Risk Facet
Technical Performance

#### Probability of Risk
Very Unlikely

#### Risk Probability Source
Team Engineering Judgement

#### Risk Assessment
Low

#### Consequence of Risk
Negligible

#### Risk Consequence Source
Team Engineering Judgement

#### Basis
The impacts of any modifications to the off gas system which may be necessary to meet performance requirements are expected to be no greater than 5% of project schedule and/or life cycle cost.
<table>
<thead>
<tr>
<th>Technology</th>
<th>Melt &amp; Dilute</th>
<th>Risk Assessment</th>
<th>Risk Category</th>
<th>T-3: New application of existing technology.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Level</td>
<td>Low</td>
<td>Source</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SNF Risk Assessment**

**Record**: Page 2 of 2

**Doors**: 11/12/87 2 07/03/87

**Challenge Group**: (N/A)

**Issue**: At the present time the project will accept this risk.

**Handling Action**

- **Accept**: (N/A)
- **Lowest Acceptable Cost**: 100%

**Estimates for Handling Action**

- **Cost**: (N/A)
- **Short Term Cost**: (N/A)

**DOES NOT CONTAIN UCNI**
### SNF Risk Assessment

<table>
<thead>
<tr>
<th>Title</th>
<th>SNF Risk Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk ID</td>
<td>18</td>
</tr>
<tr>
<td>Origin Date</td>
<td>11/12/87</td>
</tr>
<tr>
<td>Rev No.</td>
<td>2</td>
</tr>
<tr>
<td>Status Date</td>
<td>07/13/98</td>
</tr>
<tr>
<td>Status</td>
<td>Active</td>
</tr>
<tr>
<td>NES Element</td>
<td>X2.13</td>
</tr>
<tr>
<td>Subject Area</td>
<td>Manufacturing Facility</td>
</tr>
<tr>
<td>Functional Area</td>
<td>Off Gas System</td>
</tr>
<tr>
<td>Technology</td>
<td>Melt &amp; Dilute</td>
</tr>
</tbody>
</table>

#### Risk Category: T-3: New application of existing technology.

#### Risk Class: Technical Performance

#### Risk Assessment: LOW

#### Risk Probability Source: Team Engineering Judgement

#### Consequence of Risk: Negligible

#### Risk Consequence Source: Team Engineering Judgement

#### Description:

The relatively large temperature profiles of the melt-dilute furnace off gas system will cause some volatile HLW materials to condense and plate on the walls of the system. Other HLW materials will flow to filters and traps where they are captured. Thus a distribution of radioactivity within the off gas system will grow with time and eventually require retrieval. The intense radiation levels will require remote handling during the retrieval effort.

The cleaning process steps are undefined at this time, and will depend on the concentration and physical form of radionuclides that have plated out. Interactions between the nuclides and the wall materials could also have an effect on the process steps. There is a risk that a first-attempt process and design for a cleaning system will be inadequate.

Because the Melt-Dilute process chemistry is well characterized regarding the solubility of off gas constituents, it is unlikely that a first-attempt process and design for a cleaning system will be inadequate.

The impacts of any modifications to the off gas cleaning system which may be necessary to meet performance requirements are expected to be no greater than 5% of project schedule and/or life cycle cost.
**SNF Risk Assessment**

<table>
<thead>
<tr>
<th>Risk ID</th>
<th>Origin Date</th>
<th>Rev No.</th>
<th>Status Date</th>
<th>Status</th>
<th>WS/Element</th>
<th>Subject Area</th>
<th>Functional Area</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>11/12/97</td>
<td>2</td>
<td>07/13/98</td>
<td>Active</td>
<td>X.2.13</td>
<td>Manufacturing Facility</td>
<td>Off Gas System</td>
<td>Melt &amp; Dilute</td>
</tr>
</tbody>
</table>

**Title:** Cleaning HLW Materials from Off Gas System

**Risk Category:**
T-3: New application of existing technology.

**Risk Factor:**
Technical Performance

**Risk Assessment**
Low

**Rank**
Low

**Handling Action**
Accept

**Status:**
At the present time the project will accept this risk.

**Estimates for Handling Action**

<table>
<thead>
<tr>
<th>Effectiveness</th>
<th>Success Probability</th>
<th>Cost</th>
<th>Start Date</th>
<th>Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>100%</td>
<td>(N/A)</td>
<td>(N/A)</td>
<td>(N/A)</td>
</tr>
</tbody>
</table>

**Hindsight Strategy**
(N/A)
SNF Risk Assessment

<table>
<thead>
<tr>
<th>Title</th>
<th>Meeting $k_e$ Requirements</th>
</tr>
</thead>
</table>

**Description**

$k_e$ must be maintained $\leq 0.95$ and meet the double contingency principle. After some period of time, the waste disposal form will lose configuration control. The disposal form must be designed to meet the $k_e$ requirement for the worst case configuration. This design, however, has not had the benefit of a detailed nuclear criticality analysis. When these detailed analyses are completed, a redesign of the disposal form could be required to meet the $k_e$ requirement.

The design team assumes that an adjustment of fuel and non-fuel material balance can be made to ensure the disposal form meets the $k_e$ requirements at the expense of an increase in the number of canisters to be produced and disposed. Without detailing the balances needed, the change in the number of disposal forms cannot be quantified at this time. There is a risk that the facility may need additional storage space to accommodate the greater number of disposal forms.

<table>
<thead>
<tr>
<th>Risk Category</th>
<th>S-1: Criticality potential.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk Factor</td>
<td>Technical Performance</td>
</tr>
<tr>
<td>Risk Assessment</td>
<td>Moderate</td>
</tr>
</tbody>
</table>

**Probability of Risk**

Unlikely

**Risk Probability Source**

Team Engineering Judgement

**Consequence of Risk**

Marginal

**Risk Consequence Source**

Team Engineering Judgement

**Basis**

Impacts of any redesign of the disposal form and/or the facility required to meet $k_e$ requirements at the repository are expected to be less than 10% of the project schedule and/or life cycle cost.
## SNF Risk Assessment

<table>
<thead>
<tr>
<th>Title</th>
<th>Handling Action</th>
<th>Basis</th>
<th>Risk Category</th>
<th>Risk Facet</th>
<th>Risk Assessment</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meeting k&lt;sub&gt;a&lt;/sub&gt; Requirements</td>
<td>Mitigate</td>
<td>Perform criticality analysis to establish required dilution of Melt-Dilute disposal form.</td>
<td>S-1: Criticality potential.</td>
<td>Technical Performance</td>
<td>Moderate</td>
<td></td>
</tr>
</tbody>
</table>

### Estimates for Handling Action

<table>
<thead>
<tr>
<th>Effectiveness</th>
<th>Success Probability</th>
<th>Cost</th>
<th>Start Date</th>
<th>Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOW</td>
<td>95%</td>
<td>(TBD)</td>
<td>(TBD)</td>
<td>(TBD)</td>
</tr>
</tbody>
</table>

### Feedback Strategy

(TBD)
### SNF Risk Assessment

<table>
<thead>
<tr>
<th>Risk ID</th>
<th>Origin Date</th>
<th>Rev No.</th>
<th>Status</th>
<th>WBS Element</th>
<th>Subject Area</th>
<th>Functional Area</th>
<th>Technology</th>
<th>Direct Co-Disposal</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>11/10/97</td>
<td>2</td>
<td>Active</td>
<td>Y.1.6</td>
<td>Disposal Form</td>
<td>Nuclear Criticality Safety</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Title:** Meeting $k_e$ Requirements

**Description:**

$k_e$ must be maintained $\leq 0.95$ and meet the double contingency principle. After some period of time, the waste disposal form will lose configuration control. The disposal form must be designed to meet the $k_e$ requirement for the worst case configuration. This design, however, has not had the benefit of a detailed nuclear criticality analysis. When these detailed analyses are completed, a redesign of the disposal form could be required to meet the $k_e$ requirement.

The design team assumes that an adjustment of fuel and non-fuel material balance can be made to ensure the disposal form meets the $k_e$ requirements at the expense of an increase in the number of canisters to be produced and disposed. Without detailing the balances needed, the change in the number of disposal forms cannot be quantified at this time. There is a risk that the facility may need additional storage space to accommodate the greater number of disposal forms.

**Risk Category:** S-1: Criticality potential.

**Risk Factor:** Technical Performance

**Probability of Risk:** Likely

**Risk Probability Source:** Team Engineering Judgement

**Basis:** Since the worst case configuration has not yet been systematically determined and the current design is based upon an assumed configuration, the probability is likely that nuclear criticality analyses will dictate changes in the disposal form.

**Consequence of Risk:** Critical

**Risk Consequence Source:** Team Engineering Judgement

**Basis:** Exceeding $k_e$ requirements will result in rejection of the disposal form by the repository. Redesign of the disposal form and/or the facility are expected to have significant impact on the life cycle cost and schedule of $> 10\%$. 
## SNF Risk Assessment

**Record Page 2 of 2**

<table>
<thead>
<tr>
<th>Task ID</th>
<th>Origin Date</th>
<th>Rev No.</th>
<th>Status Date</th>
<th>Status</th>
<th>WBS Element</th>
<th>Subject Area</th>
<th>Functional Area</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>11/10/97</td>
<td>2</td>
<td>07/13/98</td>
<td>Active</td>
<td>Y.1.6</td>
<td>Disposal Form</td>
<td>Nuclear Criticality Safety</td>
<td>Direct Co-Disposition</td>
</tr>
</tbody>
</table>

**Title:** Meeting \( K_a \) Requirements  

**Risk Category:** S-1: Criticality potential.  

**Risk Focus:** Technical Performance  

**Risk Assessment:** High  

**Risk Rank:**  

### Handling Action: Mitigate  

**Status:**  
Perform criticality analysis to establish configuration requirements for the Direct Co-Disposal form.

<table>
<thead>
<tr>
<th>Estimates for Handling Action</th>
<th>Feedback Strategy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective</td>
<td>Success Probability</td>
</tr>
<tr>
<td>Moderate</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Resources Required:** (TBD)
#### Absence of Radioactive Release Requirements for Disposal Form in Disposal Zone

DOE-RW has not specified requirements pertaining to radioactive release from the Melt-Dilute disposal form after emplacement in the disposal zone.

- **For the first 1000 years,** there is no need for a requirement. DOE-RW requires the disposal package to "substantially" contain all radioactivity. The project interprets this to mean no radioactivity will escape the disposal package for 1000 years. Because DOE-RW will design the outermost container to meet the "substantial" containment requirement, there is no requirement or impact on the Melt-Dilute disposal form.

- **Between 1000 and 10,000 years,** there may be a need for a requirement pertaining to radioactive release rate from the disposal form. For this time period, 10CFR80 gives requirements for radionuclides escaping the repository engineered barrier. Per §60.113(a)(1)(ii)(B), the release rate of any radionuclide "...shall not exceed one part in 100,000 per year of the inventory of that radionuclide calculated to be present at 1,000 years following permanent closure," but not exceeding 10CFR20 limits.

DOE-RW has not allocated the repository toto requirements to the various types of DOE SNF disposal forms. The absence of a firm requirement means that design of the Melt-Dilute disposal form proceeds at risk.

The Melt-Dilute disposal form development program will measure radioactive release rates for various disposal environments. A repository performance assessment will use the measured rates to determine if the repository meets the in toto release requirements of 10CFR80 with Melt-Dilute disposal forms emplaced.

If the repository cannot meet the in toto requirement for radioactive release, a redesign of the Melt-Dilute disposal form will be necessary to achieve lower release rates.
## SNF Risk Assessment

<table>
<thead>
<tr>
<th>Title</th>
<th>Risk Category</th>
<th>Risk Factor</th>
<th>Risk Assessment</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absence of Radioactive Release Requirements for Disposal Form in Disposal Zone</td>
<td>D-1: Undefined, incomplete or unclear functional requirements</td>
<td>Technical Performance</td>
<td>High</td>
<td></td>
</tr>
</tbody>
</table>

### Handling Action
- **Transfer**

**Notes:**
This risk captures the possibility of a new requirement being imposed upon the SNF disposal form by DOE-RW. Therefore, the risk is transferred to DOE-RW.

### Estimates for Handling Action

<table>
<thead>
<tr>
<th>Effectiveness</th>
<th>Success Probability</th>
<th>Cost</th>
<th>Start Date</th>
<th>Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>(N/A)</td>
<td>(N/A)</td>
<td>(N/A)</td>
<td>(N/A)</td>
<td>(N/A)</td>
</tr>
</tbody>
</table>

**Failure Strategy**
(N/A)

**Resources Required**
(N/A)
SNF Risk Assessment

Absence of Radioactive Release Requirements for Disposal Form in Disposal Zone

Risk ID: 23
Origin Date: 11/11/87
Rev No: 2
Status: Active
YSS Element: Y.1.7
Subject Area: Disposal Form
Functional Area: Engineered Barriers
Technology: Direct Co-Disposal

Title: Absence of Radioactive Release Requirements for Disposal Form in Disposal Zone

Description:
DOE-RW has not specified requirements pertaining to radioactive release from the Direct Co-Disposal form after emplacement in the disposal zone.

- For the first 1000 years, there is no need for a requirement. DOE-RW requires the disposal package to "substantially" contain all radioactivity. The project interprets this to mean no radioactivity will escape the disposal package for 1000 years. Because DOE-RW will design the outermost container to meet the "substantial" containment requirement, there is no requirement or impact on the Direct Co-Disposal form.

- Between 1000 and 10,000 years, there may be a need for a requirement pertaining to radioactive release rate from the disposal form. For this time period, 10CFR60 gives requirements for radionuclides escaping the repository engineered barrier. Per §60.113(e)(1)(ii)(B), the release rate of any radionuclide "...shall not exceed one part in 100,000 per year of the inventory of that radionuclide calculated to be present at 1,000 years following permanent closure,..." but not exceeding 10CFR20 limits.

DOE-RW has not allocated the repository in toto requirements to the various types of DOE SNF disposal forms. The absence of a firm requirement means that design of the Direct Co-Disposal form proceeds at risk.

The Direct Co-Disposal form development program will measure radioactive release rates for various disposal environments. A repository performance assessment will use the measured rates to determine if the repository meets the in toto release requirements of 10CFR60 with Direct Co-Disposal forms emplaced.

If the repository cannot meet the in toto requirement for radioactive release, a redesign of the Direct Co-Disposal form will be necessary to achieve lower release rates.

The relatively high surface area of SNF assemblies within the Direct Co-Disposal form makes this risk greater than the similar risk for the Melt-Dilute disposal form.

Risk Category: D-1: Undefined, incomplete or unclear functional requirements
Risk Factor: Technical Performance
Risk Assessment: High
Consequence of Risk: Critical
Risk Consequence Source: Team Engineering Judgement

The project assumes that redesign of the Direct Co-Disposal form will not be necessary to meet a release rate limit. Instead, three other actions are possible, and any one of them will likely cause overruns exceeding 10%.

The three actions are:
- DOE-RW will redesign its waste overpack to be more robust, with ≥ 10,000 year life before breach. Cost burdens will pass to the Direct Co-Disposal option.
- DOE-RW will redesign the repository to achieve compliance with the release limit. This could include reducing the number of Direct Co-Disposal forms in the disposal zone.
- SRS will store the Direct Co-Disposal forms in a dry environment for an indefinite period until resolution of the radioactivity release issue.
<table>
<thead>
<tr>
<th>Risk ID</th>
<th>Origin Date</th>
<th>Rev No.</th>
<th>Status Date</th>
<th>Status</th>
<th>WBS Element</th>
<th>Subject Area</th>
<th>Disposal Form</th>
<th>Functional Area</th>
<th>Technology</th>
<th>Direct Co-Disposal</th>
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<tr>
<td>23</td>
<td>11/11/97</td>
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<td>Active</td>
<td>Y.1.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SNF Risk Assessment**

**Title:** Absence of Radioactive Release Requirements for Disposal Form in Disposal Zone

**Handling Action:** Transfer

**State:**

This risk captures the possibility of a new requirement being imposed upon the SNF disposal form by DOE-RW. Therefore, the risk is transferred to DOE-RW.

**Estimates for Handling Action**

<table>
<thead>
<tr>
<th>Effectiveness</th>
<th>Success Probability</th>
<th>Cost</th>
<th>Start Date</th>
<th>Completion Date</th>
</tr>
</thead>
<tbody>
<tr>
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<td>(N/A)</td>
<td>(N/A)</td>
<td>(N/A)</td>
<td>(N/A)</td>
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</tbody>
</table>

**Feedback Strategy:** (N/A)

**Reasons:** (N/A)
### SNF Risk Assessment

<table>
<thead>
<tr>
<th>Risk ID</th>
<th>Origin Date</th>
<th>Rev No.</th>
<th>Status Date</th>
<th>Status</th>
<th>WBS Element</th>
<th>Subject Area</th>
<th>Disposal Form</th>
<th>Functional Area</th>
<th>Technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>11/10/97</td>
<td>1</td>
<td>07/13/98</td>
<td>Active</td>
<td>Y.1.7</td>
<td>Engineered Barriers</td>
<td>Melt &amp; Dilute</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Title:** Absence of Design Requirements for Disposal Form for 50+ Years Prior to Emplacement

**Description:** The project has not specified requirements pertaining to the integrity of the Melt-Dilute disposal form for interim storage, for transportation, and for handling at the repository prior to emplacement in the disposal zone. Instead, the project has assumed that normal design requirements and practices for nuclear component handling and storage will suffice.

If this assumption proves later to be invalid, rework of the disposal form could be necessary. Redesign of the manufacturing process could also be required.

**Risk Category:**
- **D-1:** Undefined, incomplete or unclear functional requirements

**Risk Factor:**
- Technical Performance

**Probability of Risk:**
- Very Unlikely

**Risk Probability Source:**
- Team Engineering Judgement

**Consequence of Risk:**
- Negligible

**Risk Consequence Source:**
- Team Engineering Judgement

- Should a canister fail unexpectedly, remedial action would be to replace the canister. Any canister, regardless of design robustness, is vulnerable to failures of various types. The remedial action would open the failed canister, withdraw the disposal form, and seal it within another canister.

- Remedial action would be a minor threat to cost and schedule, requiring a day or so to complete. No redesign would be necessary.
## SNF Risk Assessment

<table>
<thead>
<tr>
<th>Risk ID</th>
<th>Origin Date</th>
<th>Rev No.</th>
<th>Status Date</th>
<th>Status</th>
<th>WSIS Element</th>
<th>Subject Area</th>
<th>Functional Area</th>
<th>Risk Category</th>
<th>Risk Factor</th>
<th>Risk Assessment</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>24</td>
<td>11/10/97</td>
<td>1</td>
<td>07/13/98</td>
<td>Active</td>
<td>Y.1.7</td>
<td>Disposal Form</td>
<td>Engineered Barriers</td>
<td>D-1: Undefined, incomplete or unclear functional requirements</td>
<td>Technical Performance</td>
<td>Low</td>
<td></td>
</tr>
</tbody>
</table>

**Title:**
Absence of Design Requirements for Disposal Form for 50+ Years Prior to Emplacement

**Handling Action:**
Accept

**Basis:**
At the present time the project will accept this risk.

**Estimates for Handling Action**

<table>
<thead>
<tr>
<th>Effectiveness</th>
<th>Success Probability</th>
<th>Cost</th>
<th>Start Date</th>
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**Feedback Strategy:**
(N/A)

**Resources Required:**
(N/A)
**SNF Risk Assessment**

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<thead>
<tr>
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<th>Rev No.</th>
<th>Status Date</th>
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<td>Engineered Barriers</td>
<td>Direct Co-Disposal</td>
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</tbody>
</table>

**Title:** Absence of Design Requirements for Disposal Form for 50+ Years Prior to Emplacement

**Description:**

The project has not specified requirements pertaining to the integrity of the Direct Co-Disposal form for interim storage, for transportation, and for handling at the repository prior to emplacement in the disposal zone. Instead, the project has assumed that normal design requirements and practices for nuclear component handling and storage will suffice.

If this assumption proves later to be invalid, rework of the disposal form could be necessary. Redesign of the manufacturing process could also be required.

**Risk Category:** D-1: Undefined, incomplete or unclear functional requirements

**Risk Factor:** Technical Performance

**Risk Probability Source:** Team Engineering Judgement

**Risk Assessment:** Low

**Consequence of Risk:** Negligible

**Risk Consequence Source:** Team Engineering Judgement

**Basis:**

Should a canister fail unexpectedly, remedial action would be to replace the canister. Any canister, regardless of design robustness, is vulnerable to failures of various types. The remedial action would open the failed canister, withdraw the disposal form, and seal it within another canister.

Remedial action would be a minor threat to cost and schedule, requiring a day or so to complete. No redesign would be necessary.
## SNF Risk Assessment

<table>
<thead>
<tr>
<th>Risk ID</th>
<th>Origin Date</th>
<th>Rev No.</th>
<th>Status Date</th>
<th>Status</th>
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<td>Y.1.7</td>
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<td>Engineered Barriers</td>
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</table>

### Title
Absence of Design Requirements for Disposal Form for 50+ Years Prior to Emplacement

### Handling Action
- **Accept**

**Details**
At the present time the project will accept this risk.

### Risk Category
- **D-1:** Undefined, incomplete or unclear functional requirements

### Risk Facet
- **Technical Performance**

### Risk Assessment
- **Low**

### Closure Criteria
- **(N/A)**

### Estimates for Handling Action

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**Resources Required**
- **(N/A)**

**Feedback Strategy**
- **(N/A)**
# SNF Risk Assessment

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<th>Risk Category</th>
<th>Risk Source</th>
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<td>Melt &amp; Dilute</td>
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**Title:** Uncertainty in Waste Acceptance Criteria

**Description:** The MGDS WAC is currently preliminary and does not provide specific limits for various criteria (e.g., allowable free water in canister, particulate waste forms, pyrophiles, etc.). There is a risk that the Melt-Dilute disposal form will not meet final MGDS WAC requirements.

**Probability of Risk:** Unlikely

**Risk Source:** Team Engineering Judgement

**Consequence of Risk:** Negligible

**Risk Source:** Team Engineering Judgement

If the disposal form fails to meet final MGDS WAC requirements, then a redesign of the disposal form, or the addition of equipment or testing to the manufacturing process, may be required. Impact to the project is estimated to be less than 5% of the life cycle cost or schedule.
## SNF Risk Assessment

<table>
<thead>
<tr>
<th>Risk ID</th>
<th>Origin Date</th>
<th>Rev No.</th>
<th>Status Date</th>
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</table>

### Title
Uncertainty in Waste Acceptance Criteria

#### Handling Action
**Accept**

**Basics**
At the present time the project will accept this risk. However, to ensure this remains a Low risk, the project should track MGDS WAC studies scheduled for completion in FY98.

#### Estimates for Handling Action

<table>
<thead>
<tr>
<th>Effectiveness</th>
<th>Success Probability</th>
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**Resources Required**
N/A

**Risk Category**
D-1: Undefined, incomplete or unclear functional requirements

**Risk Facet**
Technical Performance

**Risk Assessment Rank**
Low

**Closure Criteria**
N/A

**Fallback Strategy**
N/A
### SNF Risk Assessment

<table>
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<td>Technical Performance</td>
<td>Unlikely</td>
<td>Team Engineering Judgement</td>
<td>Negligible</td>
<td>Team Engineering Judgement</td>
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</table>

**Description**

The MGDS WAC is currently preliminary and does not provide specific limits for various criteria (e.g., allowable free water in canister, particulate waste forms, pyrophorics, etc.). There is a risk that the Direct Co-Disposal form will not meet final MGDS WAC requirements.

**Basis**

Because the current design eliminates free water, particulates, pyrophorics, etc., from the final disposal form, it is unlikely that the Direct Co-Disposal form will fail to meet final MGDS WAC requirements.

**Consequence**

If the disposal form fails to meet final MGDS WAC requirements, then a redesign of the disposal form, or the addition of equipment or testing to the manufacturing process, may be required. Impact to the project is estimated to be less than 5% of the life cycle cost or schedule.
<table>
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<th>Risk ID</th>
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<td>Y.1.11</td>
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<td>D-1: Undefined, incomplete or unclear functional requirements</td>
<td>Direct Co-Disposal</td>
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</table>

**SNF Risk Assessment**

**Title:** Uncertainty in Waste Acceptance Criteria

**Handling Action:** Accept

**Basis:** At the present time the project will accept this risk. However, to ensure this remains a Low risk, the project should track MGDS WAC studies scheduled for completion in FY98.

**Estimates for Handling Action**

<table>
<thead>
<tr>
<th>Effectiveness</th>
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<th>Completion Date</th>
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<tbody>
<tr>
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</table>

**Closure Criteria:** (N/A)

**Fallback Strategy:** (N/A)

**Resources Requested:**

(N/A)
## SNF Risk Assessment

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<tr>
<td>Peak Clad Temperature Limitation Compliance</td>
<td>D-5: Numerous or unclear assumptions</td>
<td>Technical Performance</td>
<td>High</td>
<td></td>
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</tbody>
</table>

**Description:**

Loaded canisters must meet a locally imposed peak cladding temperature limit of 250°C for interim storage. In addition, the MGDS WAC imposes a peak cladding temperature limit of 350°C for SNF loaded in “multi-element canisters that will not be unloaded prior to emplacement.” (Ref. 9, Criterion 2.4.21). Currently, there are no analyses to demonstrate compliance with either requirement. There is a risk that this temperature limit may not be met.

**Probability of Risk**

- Very Unlikely

**Risk Probability Source**

- Team Engineering Judgement

**Basis:**

The low thermal power of the DOE SNF and the ability to “mix-and-match” low and high thermal power elements makes it very unlikely that the canistered SNF will challenge the temperature limits.

**Consequence of Risk**

- Critical

**Risk Consequence Source**

- Team Engineering Judgement

**Exceeds:**

Possible consequences for the Direct Co-Disposal form are:

- Limit amount of SNF loaded in canister.
- Additional controls may be required during canister loading (hot elements vs. cold elements).

Because of the potential for reduced loading in the Direct Co-Disposal form, the impacts of these consequence are expected to be greater than 10% of the project life cycle cost.
### SNF Risk Assessment

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</table>

**Title:** Peak Clad Temperature Limitation Compliance

**Risk Category:** D-5: Numerous or unclear assumptions

**Risk Focus:** Technical Performance

**Risk Assessment:** High

**Mitigation Strategies Include:**
- Complete thermal analysis to show compliance with the 250°C limit.
- Address the 350°C limit if necessary.

**Feedback Strategy:** (TBD)

**Estimates for Handling Action**

- **Effectiveness:**
  - Low: 75%
- **Success Probability:** (TBD)
- **Cost:** (TBD)
- **Start Date:** (TBD)
- **Completion Date:** (TBD)

**Resources Required:** (TBD)
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<tr>
<th>Title</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Description</td>
<td>The TSS Preconceptual Design Report imposes a self protection requirement that radiation from SNF disposal forms must exceed 100 rem/hr at a distance of 0.9 meters (Ref. 4, § 3.1.2.2.8). Lacking detailed radiation analyses, it is assumed that the SNF Direct Co-Disposal form will meet this self protection requirement. There is a risk that some fuel elements will not meet HEU self-protection requirements.</td>
</tr>
<tr>
<td>Risk Category</td>
<td>D-1: Undefined, incomplete or unclear functional requirements</td>
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<tr>
<td>Risk Factor</td>
<td>Technical Performance</td>
</tr>
<tr>
<td>Risk Assessment</td>
<td>Moderate</td>
</tr>
<tr>
<td>Consequence of Risk</td>
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</tr>
<tr>
<td>Risk Consequence Source</td>
<td>Team Engineering Judgement</td>
</tr>
<tr>
<td>Details</td>
<td>Because of low burnup or long cooling periods, it is likely that the Direct Co-Disposal form will not meet the 100 rem/hr. self-protection requirement. If self protection requirements cannot be met, then additional security system enhancements will be required for the loaded canister storage area in the TSS. It is estimated that these changes could be implemented with less than a 5% impact on project life cycle cost and schedule.</td>
</tr>
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</table>
## SNF Risk Assessment

<table>
<thead>
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<th>Risk ID</th>
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<td>Radiation Shielding</td>
<td>Direct Co-Disposal</td>
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</table>

### Title
Meeting Self Protection Requirements

### Handling Action
**Mitigate**

**Basis**
Add security features as required by 10CFR73.

### Risk Category
**D-1: Undefined, incomplete or unclear functional requirements**

### Risk Focus
- **Technical Performance**
- **Risk Assessment**
- **Rank**
  - Moderate

### Closure Criteria
(TBD)

### Estimation for Handling Action

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### Feedback Strategy
(TBD)

### Resources Required
(TBD)
### SNF Risk Assessment

**Title:** Performance of R&D on Project Critical Path

**Description:** R&D for the SNF disposal form and for the manufacturing facility are on or near the project's critical path. It is assumed that completion of R&D can occur within the normal project schedule. There is risk that normal R&D iterations can invalidate this assumption.

<table>
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<tr>
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<th>Origin Date</th>
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<td>Manufacturing Facility</td>
<td>Project Management</td>
<td>Direct Co-Disposal</td>
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</tbody>
</table>

**Risk Category:** D-5: Numerous or unclear assumptions or modification basis.

**Risk Facet:** Programmatic

**Risk Probability Source:** Team Engineering Judgement

**Probability of Risk:** Likely

**Risk Probability Source:** Team Engineering Judgement

**Consequence of Risk:** Critical

**Risk Consequence Source:** Team Engineering Judgement

Normal R&D iterations can have severe negative impacts on project cost and schedule. For the Co-Disposal alternative, impact is expected to be more on project schedule rather than cost.
### SNF Risk Assessment

<table>
<thead>
<tr>
<th>Risk ID</th>
<th>Origin Date</th>
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<td>Project Management</td>
<td></td>
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</table>

#### Title
Performance of R&D on Project Critical Path

#### Handling Action
Mitigate

#### Basis
The project has been phased so that there is a design only project followed by a construction project. This will limit the financial liability that could be incurred if the R&D does not support the project assumptions. Additionally, the R&D efforts have been prioritized to focus early work on the most likely areas of concern.

#### Estimates for Handling Action

<table>
<thead>
<tr>
<th>Effectiveness</th>
<th>Success Probability</th>
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#### Closeout Criteria
(TBD)

#### Fallback Strategy
(TBD)
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<tr>
<th>Risk ID</th>
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<th>Subject Area / Functional Area</th>
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<td>Disposition of Scrap Waste</td>
<td>Melt &amp; Dilute</td>
<td>X.2.2</td>
<td>Manufacturing Facility / Characterization</td>
<td>A-55</td>
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<td>Direct Co-Disposal</td>
<td>X.2.2</td>
<td>Manufacturing Facility / Characterization</td>
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<tr>
<td>08</td>
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<td>Non-Fuel Products Received in SNF</td>
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<td>Unlikely</td>
<td>Team Engineering Judgement</td>
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</table>

**Description**

Disposition of non-fuel (scrap) waste forms which are not classified as high-level waste is currently undefined. The project assumes that these wastes can be handled with existing SRS processes. There is a risk that some unforeseen scrap waste may be received that existing SRS processes cannot handle.

12/9/97

The risk assessment team does not anticipate the receipt or generation of any non-fuel scrap waste which will not be included in the Melt-Dilute waste form. Consequently, this risk was deleted from the assessment.

**Consequence of Risk**

Negligible

If the scrap non-fuel waste does not meet the acceptance criteria of existing SRS processes, a process modification within this project would be required. This could include a new mission scope for the Melt-Dilute system to include processing this material. Life cycle cost and schedule impacts for this new mission scope should not exceed 5% of the estimate.
### SNF Risk Assessment

**Title:** Disposition of Scrap Waste

**Description:**
Disposition of non-fuel (scraps) waste forms which are not classified as high level waste is currently undefined. The project assumes that these wastes can be handled with existing SRS processes. There is a risk that some unforeseen scrap waste may be received that existing SRS processes cannot handle.

12/9/97

The risk assessment team does not anticipate the receipt or generation of any non-fuel scrap waste which will not be included in the Direct Co-Disposal waste form. Consequently, this risk was deleted from the assessment.

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<table>
<thead>
<tr>
<th>Risk ID</th>
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<td>Deleted</td>
<td>X.2.2</td>
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<td></td>
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<td></td>
<td>I-1: Multiple system interfaces.</td>
<td>Disposition</td>
<td>Low</td>
<td>Team Engineering Judgement</td>
<td>Team Engineering Judgement</td>
</tr>
</tbody>
</table>

#### Notes:
- Unlikely
- A review of all fuel types has not revealed any non-fuel scrap which cannot be handled by existing SRS processes.

- If the scrap non-fuel waste does not meet the acceptance criteria of existing SRS processes, a process modification within this project would be required. This could include a new mission scope for the Direct Co-Disposal system to include processing this material. Life cycle cost and schedule impacts for this new mission scope should not exceed 5% of the estimate.
## Identification of LEU Limits

**Title:**
Identification of LEU Limits

**Description:**
SRS is designing the Melt-Dilute disposal form to contain < 20% ^{235}U. It is assumed that the disposal form will meet the MGDS WAC requirement for \( k_{\infty} \leq 0.95 \) throughout the disposal zone. There is a risk that future repository performance assessments could invalidate this assumption and require lower ^{235}U contents.

**Revision Date:**
December 9, 1997

The risk assessment team did not believe this to be a valid risk since the final dilution levels for the Melt-Dilute disposal form have yet to be determined. The final dilution level will be established based upon criticality studies either ongoing or planned. Other criticality concerns are covered by Risk ID 20. Consequently, this risk was deleted from the assessment.

<table>
<thead>
<tr>
<th>Risk Category</th>
<th>Risk Probability Source</th>
<th>Probability of Risk</th>
<th>Risk Consequence Source</th>
<th>Risk Consequence</th>
<th>Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>D-1: Undefined, incomplete or unclear functional requirements.</td>
<td>Team Engineering Judgement</td>
<td>Very Unlikely</td>
<td>Team Engineering Judgement</td>
<td>Negligible</td>
<td>Should LEU limits differ from anticipated, the facility will be required to add more canister disposal forms during operations. This could result in longer facility operating periods, more canisters, and higher costs for interim storage and repository disposal. This is expected to have less than a 5% impact on life cycle cost and schedule.</td>
</tr>
</tbody>
</table>
## SNF Risk Assessment

<table>
<thead>
<tr>
<th>Risk ID</th>
<th>Origin Date</th>
<th>Rev No</th>
<th>Status Date</th>
<th>Status</th>
<th>WBS Element</th>
<th>Subject Area</th>
<th>Functional Area</th>
<th>Technology</th>
<th>Risk Category</th>
<th>Risk Facet</th>
<th>Risk Probability</th>
<th>Risk Probability Source</th>
<th>Risk Assessment</th>
<th>Rank</th>
</tr>
</thead>
</table>

### Non-Fuel Products Received in SNF

**Description**

There may be some unknown non-fuel related materials received in the SNF which could result in a disposal form which is unacceptable to the repository. The current TSS design will detect a range of anticipated non-fuel materials and disposition these unacceptable materials. There is a risk that the current design cannot detect all non-fuel materials, and consequently, the process would not be pre-certified by DOE-RW.

12/9/97

The risk assessment team judged this risk to be non-credible due to the characterization of incoming SNF inventories. Consequently, this risk was deleted from the assessment.

### Consequence of Risk

**Consequence of Risk**

Negligible

**Consequence Source**

Team Engineering Judgement

**Basis**

The facility may produce one or two of these unacceptable disposal forms during the operating lifetime. These disposal forms would be handled and dispositioned on an ad hoc basis with minimal impact on the facility life cycle cost and schedule.
SNF Risk Assessment

Title: Confinement Versus Containment of Melt-Dilute Furnace Cell

Description:
The current design for furnace cell uses a confinement approach instead of containment. The confinement approach uses (1) an off gas system to capture radioactivity that releases directly from the melted SNF, and (2) once-through air ventilation system with filtration and traps in the exhaust stream to capture any leaked radioactivity before ventilation air release to the environment. The current design does not yet have a systematic safety analysis to demonstrate acceptability of the confinement approach for normal, off-normal and accident conditions involving the furnace process.

There is a risk that an unforeseen design basis accident or other unresolved safety question could overcome the confinement design and force the use of a containment approach. Such a swing could have serious impacts on technical scope, operating philosophy, cost and schedule.

12/9/97

The Melt-Dilute process, as currently designed, will be inside a cell and will have confinement inside the cell. The fuel assemblies will be diluted with depleted uranium metal to reduce the enrichment. If cesium is released from the metal during operations, it will deposit inside the cell on the walls. This would necessitate clean up of the cell, and these concerns are part of the current design.

Based upon extensive SRS experience with nuclear processes, the risk assessment team believed it unreasonable to expect that a containment, versus confinement, system would be mandated for the Melt-Dilute process. Consequently, this risk was deleted from the assessment.

Record Page 1 of 1
Treating HLW Materials from Off Gas System to Meet Acceptance Criteria

Description
Handling is undefined for HLW materials cleaned from the walls of the off gas system. The handling options are twofold: 1) placement within the SNF disposal form canisters, or 2) transfer to the HLW tank farm for eventual vitrification by DWPF.

Whichever handling option the project chooses, the HLW materials form and concentration will likely require treatment to meet the option's acceptance criteria. Neither the handling option's acceptance criteria nor the treatment process is defined at this time. The project assumes that a treatment process, when defined, can be included with minimal impacts to current design. There is a risk that a treatment process with first-of-a-kind features will be required which could invalidate the assumption.

1) The treatment system could be first-of-a-kind. Extensive research and development might be necessary to prove the process, adding significant cost and schedule to the project.

2) Adding a treatment process to the project scope could seriously impact cost and schedule, even if it is a conventional, proven process.

12/9/97

At one time option 1) was a possibility, but because of uncertainties with regard to compliance with the MGDS WAC, it is no longer being considered. The risk assessment team felt concerns with regard to option 2) were adequately addressed by Risk ID 16. Consequently, this risk was deleted from the assessment.
### Imposed Self Protection Requirements

<table>
<thead>
<tr>
<th>Title</th>
<th>Description</th>
<th>Probability of Risk</th>
<th>Risk Probability Source</th>
<th>Consequence of Risk</th>
<th>Risk Consequence Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imposed Self Protection Requirements</td>
<td>The Melt-Dilute disposal form may not meet the self protection requirement of 100 rem/hr at a distance of 0.9 meters (Ref. 4, § 3.1.2.2.6). It is assumed that DOE-RW will not impose this requirement on the canistered SNF received at the repository. Instead DOE-RW will avoid the need for extensive physical security at the repository by building a primary disposal form with HLW vitrified waste which will meet this self protection requirement. There is a risk that DOE-RW will impose the self protection requirement on the canistered SNF disposal form.</td>
<td>Unlikely</td>
<td>Team Engineering Judgement</td>
<td>Negligible</td>
<td>Team Engineering Judgement</td>
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</tbody>
</table>

12/9/97

The risk assessment team judged this risk to be non-credible for the following reasons:
- the MGDS WAC does not currently require self protection for DOE SNF, and there is no reason to believe that regulations will be mandated to impose that requirement;
- the Melt-Dilute disposal form will always be diluted to LEU such that self protection for non-proliferation is not required.

Consequently, this risk was deleted from the assessment.

DOE-RW may need to add security to the disposal facility site to ensure non-proliferation. This additional security will increase the disposal fee, estimated to be less than 5% of the life cycle cost for canistered SNF.
### SNF Risk Assessment

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<tbody>
<tr>
<td>D-1</td>
<td>11/10/97</td>
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<td>12/09/97</td>
<td>Deleted</td>
<td>Y.1.8</td>
<td>Disposal Form</td>
<td>Melt &amp; Dilute</td>
<td>Radiation Shielding</td>
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<td>Undefined, incomplete or unclear technical performance</td>
<td>Team Engineering Judgement</td>
<td>Likely</td>
<td>Team Engineering Judgement</td>
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<td>A-2: Defined, complete or clear technical performance</td>
<td>Moderate</td>
<td>Negligible</td>
<td>Team Engineering Judgement</td>
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</table>

#### Title
Meeting Self Protection Requirements

#### Description
The TSS Preconceptual Design Report imposes a self protection requirement that radiation from SNF disposal forms must exceed 100 rem/hr at a distance of 0.9 meters (Ref. 4, § 3.1.2.2.8). Lacking detailed radiation analyses, it is assumed that the SNF Melt-Dilute disposal form will meet this self protection requirement. There is a risk that the off gas system will remove activation and fission products to the extent that this radiation level will not be met.

12/9/97

The risk assessment team judged this risk to be non-credible for the following reasons:
- the MGDS WAC does not currently require self protection for DOE SNF, and there is no reason to believe that regulations will be mandated to impose that requirement;
- the Melt-Dilute disposal form will always be diluted to LEU such that self protection for non-proliferation is not required.

Consequently, this risk was deleted from the assessment.

### Consequence of Risk

- **Negligible**
- **Likely**

#### Basis
- Either the disposal form or the furnace process could be redesigned to add or retain more radiation materials to meet self protection requirements (such as putting Cs back into the product or keeping it from off gassing in the process).

If self protection requirements cannot be met, then additional security system enhancements will be required. It is estimated that these changes could be implemented with less than 5% impact on life cycle cost and schedule.
<table>
<thead>
<tr>
<th>Field</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>SNF Risk Assessment</td>
<td></td>
</tr>
<tr>
<td>Title</td>
<td>Uncertainty Regarding Disposal Form Classification</td>
</tr>
<tr>
<td>Description</td>
<td>According to the MGDS WAC, SNF is defined as &quot;...fuel that has been withdrawn from a nuclear reactor following irradiation, the constituent elements of which have not been separated by reprocessing.&quot; The design approach assumes that the Melt-Dilute disposal form will still be classified as SNF, and that the certification criteria for SNF will apply. There is a risk that the Melt-Dilute disposal form will not be classified as SNF after it has gone through the proposed disposal form process. If the disposal form is not classified as SNF, but is instead classified as HLW, then it is assumed that existing ASTM standards and the MGDS WAC for HLW apply, and that those standards and criteria are no more rigorous than those for SNF or vitrified HLW. There is a contingent risk that if the disposal form is classified as non-vitrified HLW, the Melt-Dilute process may have to be changed to accommodate more rigorous standards and/or criteria.</td>
</tr>
<tr>
<td>12/6/97</td>
<td></td>
</tr>
<tr>
<td>The risk assessment team judged this risk to be non-credible since the Melt-Dilute process does not alter the constituents of the U-Al SNF. Consequently, this risk was deleted from the assessment (Ref. Assumption 3).</td>
<td></td>
</tr>
</tbody>
</table>