Americium/Curium Disposition Life Cycle Planning Study

by

W. N. Jackson

Westinghouse Savannah River Company
Savannah River Site
Aiken, South Carolina 29808

J. Krupa

P. Stutts

S. Nester

R. Ralmesch

MASTER *YAT*

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AMERICIUM/CURIUM DISPOSITION

LIFE CYCLE PLANNING STUDY (U)

Prepared by
Westinghouse Savannah River Company
Savannah River Site
Aiken, South Carolina 29808

Reviewing
Official:

R. H. Hoshens, P. Eng.
(Name and Title)

Date:

4/30/98

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APPROVAL SIGNATURES OF CORE TEAM

W. N. Jackson, Manager
WSRC Systems Engineering Applications -
NMSS & New Missions (EA1B0)

04/30/98
Date

J. Krupa, Team Analyst
Principal Technical Advisor
WSRC Strategic Planning & Integration
(AA1000)

4/30/98
Date

S. R. Nester, Team Analyst
Senior Engineer
WSRC Systems Engineering Application -
NMSS & New Missions (EA1B9)

04/30/98
Date

R. Rainisch, Team Analyst
Principal Engineer
WSRC Systems Engineering Application -
NMSS & New Missions (EA1B9)

4/30/98
Date

P. M. Stutts, Team Analyst
Principal Engineer
WSRC Systems Engineering Application -
NMSS & New Missions (EA1B9)

4/30/98
Date

1.0 EXECUTIVE SUMMARY

At the request of the Department of Energy Savannah River Office (DOE-SR), Westinghouse Savannah River Company (WSRC) evaluated concepts to complete disposition of Americium and Curium (Am/Cm) bearing materials currently located at the Savannah River Site (SRS). Am/Cm-bearing materials at SRS are basically in three groupings: Tank 17.1 solution, Mark 18 target assemblies (Mk18s), and a class of materials referred to as "Slugs/Other".

Removal of all Am/Cm from SRS in Fiscal Year (FY) 2005 is technically possible, with the proper priorities and funding. Removal in FY2007 is more probable, when noting normal time frames for programs of this magnitude.

This study concludes the following:

- All disposition paths evaluated are technically feasible (cutting of Mk18s in RBOF is feasible, but strongly not recommended).
- All disposition paths evaluated have manageable Environmental, Safety & Health (ES&H) and Programmatic Risks (cutting of Mk18s being the least desirable).
- All SRS Am/Cm bearing materials could be removed from SRS prior to the end of FY2005, but some will likely remain until at least FY2007 (primary limiting factors: obtaining programmatic decisions pertaining to funding and priority, i.e. not technical issues).
- If F-Canyon PUREX process Decontamination and Decommissioning (D&D) is initiated, Am/Cm disposition will probably not be a limiting factor (required F Canyon functions could still be available).

This study recommends the following:

- Immediately begin project activities to install a welder in MPPF for packaging glass canisters.
- Continue pre-conceptual activities this FY to support recommended projects.
- Ship the Am/Cm glass product (from Tank 17.1 "Solution") to ORNL from F Canyon, i.e., not using the SRS Receiving Basin for Off-site Fuels (RBOF)
- Consider interim storage at SRS of the glass product from Tank 17.1 "Solution".
- Process Mk18s to glass, i.e., from RBOF storage to F-Canyon for processing and stabilization as glass, then to ORNL.
- Review utilization of F Canyon existing equipment as alternative to installation of a new dissolver.
- Package the Slugs/Other Am/Cm bearing materials at RBOF for direct shipment to ORNL.

Assuming the currently active project/program [~\$80M total cost (shows in "Current Program" below), ~\$30M spent to date] to vitrify Tank 17.1 "Solution" is successful (vitrification complete in FY2002), the following additional funding would be required to complete the disposition of the vitrified material and the other two material types:

	Make Glass (Stabilize)	Package for Shipment/Storage	Transport to ORNL	Storage @ ORNL	TOTAL
Tank 17.1 Solution	Current Project/Program	\$0.7-2.6M	\$2.2-8.9M	\$3.5-14M	\$6.4-25.5M
Mark 18S	\$4-14M	-NA-	\$0.2-0.8M	-NA-	\$4.2-14.8M
Slugs/Other	-NA-	\$0.4-1.6M	\$0.1-0.4M	-NA-	\$0.5-2M
TOTAL	\$4-14M	\$1.1-4.2M	\$2.5-11.1M	\$3.5-14M	\$11.0-42.3M

These are planning level costs over the entire life cycle to place all SRS Am/Cm materials into storage at ORNL and cover incremental costs above current F canyon and ORNL operating/maintenance costs. This scope and funding are not in the 1998 Annual Operating

Plan (AOP) or out year projections. If added, the skilled manpower required would be in competition with current projected projects, which would require a review of priorities. Upon completion of pre-conceptual activities, the planning level scope, costs, schedules and risks within this report would be refined.

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3.0 INTRODUCTION

This study defines the disposition paths recommended for special isotope materials containing significant quantities of Am/Cm currently located at SRS. The materials are in three categories, Am/Cm solution located in F Canyon Tank 17.1, Mark 18 targets (Mk 18s) located in RBOF and a material category referred to as "Slugs/Other" located in RBOF. The recommendations for the Tank 17.1 solution pertain to functions/tasks required after the material is vitrified in F-Canyon's Multi-Purpose Processing Facility (MPPF), a currently active project/program⁽¹⁾. The paths are planning level life-cycle, i.e., they include scopes, costs, schedules and risks to take the Am/Cm material from it's current to final state and are pre-conceptual^(2,3) in nature.

This study also provides recommendations on follow up actions to move the disposition programs forward.

3.1. Background

This study was prepared as a response to a DOE-SR request (Appendix A), with direction provided by WSRC-NMSS (Appendix B), for recommendations to complete disposition of vitrified Tank 17.1 Am/Cm Solution (vitrification via F-Canyon's Multi-Purpose Processing Facility (MPPF)). A primary concern of the study was to resolve the potential impact on current planning schedules for PUREX process D&D, and other D&D activities if the Tank 17.1 solution, stabilized as glass, remained in F Canyon for an extended period of time. Disposition alternatives were to include life cycle functions, include planning level scope, costs, schedules and risks.

The Tank 17.1 vitrified material is being considered for shipment to Oak Ridge National Laboratory (ORNL), as are Am/Cm bearing targets (Mark 18s) and Slugs. Therefore, the scope of the study was expanded to include all SRS Am/Cm bearing materials to insure impacts on ORNL could be properly evaluated, with the benefit of having complete SRS Am/Cm disposition paths. ORNL intends to utilize the Am/Cm bearing materials in their special isotope production programs.

The study was to be completed before the end of April, primarily to enable planning for FY99 and out-year programs and enable timely input to the SRS Spent Nuclear Fuel Management EIS⁽⁴⁾. This timing also meets an objective of the DOE complex wide Nuclear Materials Integration Project⁽⁵⁾ (NMI), to complete a pilot trade study that meets overall NMI Project objectives.

3.2. Approach

A core team was established to develop this study, and was provided independence of site wide organization influence to draw conclusions and make final recommendations. A team of "Domain" experts (see Appendix D) was established to provide the required process detail knowledge and to assist with development of corresponding costs, schedules and risks. A list of reviewers (Appendix E) was also established to supplement domain experts' reviews.

This study was to be performed using the Systems Engineering (SE) approach⁽⁶⁾, covering the entire life cycle of the material. The specific approach selected to evaluate alternatives and assist with decision making was defined within the NMI Project (under development as this study progressed). Using the NMI evaluation approach served several purposes: • assisted development of the NMI evaluation approach, • provided a trade study needed by NMI, • provided another level of independence by using an evaluation process being developed for DOE complex wide utilization, i.e., not SRS site or Division specific.

The following represents the basic process steps followed by the core team:

- Review site specific plans and DOE 2006 plans to establish base disposition paths
- Establish goals/objectives and requirements based on the DOE SR request and NMI Project
- Survey domain experts (sometimes referred to as subject matter experts) to establish baseline path alternatives
- Screen alternatives (section 6.7.10) to eliminate low potentials before proceeding with further analysis
- Evaluate alternatives for dispositioning:
 - Glass from Tank 17.1 Solution (Six paths were evaluated)
 - Mark 18s (Two paths were evaluated)
 - Slugs/Other (The baseline path was evaluated)
- Review NMI Disposition Path Maturity (DPM) process and "score" paths with domain experts
- Further develop scope, costs, schedules and risks based on previous meeting
- Highlight potential sensitivities of the overall approach and review for impacts
- Complete Assessment and Evaluation process to draw conclusions and recommendations (section 4.1)
- Release working draft to domain experts and reviewers for comments
- Review and resolve comments
- Incorporate comments and reissue study "final draft" for comments to a slightly larger audience
- Incorporate final comments as appropriate and issue study Revision 0

4.0 DISCUSSION

The following section overviews goals/objectives of this study, basic process used, several drivers for performing the study and the disposition paths evaluated.

The goals/objectives (section 6.1.4 for details) of this study were based on the NMI Project goals and the requesting DOE-SR letter (Appendix A, with constraints outlined in the WSRC response (Appendix B)). Four areas summarize these goals/objectives:

- Reduce risks
- Minimize costs
- Reduce schedules
- Recommend full life cycle disposition paths

Applying the systems engineering process assisted with identification of issues and focus of the domain experts during reviews. The actual scoring process (being developed for use in the NMI Project) assisted also, but did not provide clear discriminators of the alternatives evaluated in this study.

The 94-1 program⁽⁷⁾ drove the need to stabilize the Tank 17.1 solution, which resulted in the current on going project/program to vitrify the solution to glass. The 94-1 program did not drive the completion of the Tank 17.1 solution disposition path, i.e. the material would be stabilized in glass but left in F Canyon. The four goals/objectives listed above plus the requirements (section 6.3) were considered when making the conclusions and recommendations based on this study.

The "Mark 18s" and "Slugs/Other" are currently located in RBOF and will require removal prior to closure of RBOF. Planning efforts for RBOF closure and the goals/objectives listed above, were also considered when making the conclusions and recommendations.

The following lists disposition paths evaluated for:

Tank 17.1 Solution

- Base Alternative: double containment using MPPF & RBOF with shipment to ORNL
- Alternative #1: double containment using RBOF with shipment to ORNL
- Alternative #2: double containment using MPPF with shipment to ORNL

- Alternative #3: single containment using MPPF with shipment to ORNL
- Alternative #4: double containment using MPPF, with SRS interim storage and periodic shipment to ORNL
- Alternative #5: double containment using MPPF, with SRS interim storage and eventual shipment to a National Repository

Mark 18s

- Base Alternative: double containment using RBOF with shipment to ORNL
- Alternative #1: dissolve in F Canyon, make glass using MPPF, provide single containment via shipping cask loaded in F Canyon railroad tunnel, shipment to ORNL

Slugs/Other

- Base Alternative: double containment using RBOF, shipments to ORNL

Several additional alternatives were identified but screened out from further analysis (see 6.7.10).

4.1. Assessment and Evaluation process

The following is the process utilized to assess and evaluate the disposition paths. The process is based on the NMI process, with additional guidance in the areas of disposition path comparison and recommendations.

1. Establish Goals/Objectives (see section 6.1 of this report)
2. Establish Requirements (see section 6.3 of this report)
3. Perform Disposition Path Maturity (DPM), Programmatic Risk (PR), and ES&H (ES&Hv) Vulnerability assessments.)(Appendix L)
4. Perform cost assessments (CA) for each disposition path being evaluated.
5. Tabulate results from DPM, PR, ES&Hv, & CA.
6. Synthesize DPM, PR, ES&Hv, and CA into a single score.
7. Compare top synthesized scores with Goals/Objectives and Requirements
8. Recommend a disposition path
9. Highlight upper level actions/decisions needed to assist with moving recommendations forward.

The current NMI assessment and evaluation process consists of the following steps:

1. Perform Disposition Path Maturity (DPM), Programmatic Risk (PR), and ES&H Vulnerability (ES&Hv) assessments:
2. Perform cost assessments (CA) for each disposition path being evaluated
3. Tabulate results from DPM, PR, ES&Hv, & CA
4. Compare and evaluate tabulated information
5. Recommend a disposition path for each material type/category

Within the NMI process, DPM, PR and ES&Hv have well defined criteria enabling evaluations across alternatives to be fairly consistent (see Appendix L for criteria). The cost assessment (CA) process is not as prescriptive and leaves a fairly wide latitude for what should be included. Uniform CA across multiple alternatives is accomplished by the core teams' careful comparison of each alternatives specific functions and costs. No specific guidance is provided in the NMI process for performing the final two steps, i.e. the comparison and recommendation steps.

4.2. Discussion of Disposition Paths

This section presents discussions on the disposition paths for each of the three material types, with focus on the recommended disposition path. Overviews of all disposition paths are in section 6.7, with additional details in Appendix I.

4.2.1. Tank 17.1 "Solution" Disposition

The Tank 17.1 "Solution" Disposition path recommended is Alternative #3 (see Section 6.7.4), (see flow chart below).

Alternative Three disposition begins with Am/Cm solution stored in F-Canyon Tank 17.1. The solution is pretreated with oxalic acid to remove transition metals, such as Cr, Ni, and Fe and transferred to a feed tank in the MPPF for vitrification. Vitrification is a batch feed process at the end of which the molten glass drains from the melter into a "canister" (Appendix H, section 9.8.2, Figure 1). The canister is sealed but does not provide a containment boundary. The canisters are lag stored in the MPPF.

The canisters will be retrieved from lag storage in MPPF, seal welded in a contamination control canister (CwP-2) (Appendix H, section 9.8.2, Figure 2.2)) using a welder installed in an MPPF cell. The CwP-2 will be decontaminated and placed in a off-site shipping cask. The shipping cask will be decontaminated and then shipped to ORNL form F Canyon. ORNL will remove the CwP-2s from the shipping cask assembly and store the Am/Cm glass in situ in the CwP-2s. When needed, ORNL will remove a CwP from storage for processing the glass into products.

Functional Flowsheet for Tank 17.1 "Solution" Disposition – Alternative #3

The initial functions of "Store Am/Cm Solution" and "Make Glass" were not evaluated, they were assumed to be successful. The solution has been stored safely for many years and the current project/program to vitrify the solution is currently making significant progress. Assumptions, interfaces, etc. are defined in Appendix I. An overview of the current program is in Appendix F. Interfaces with the "Make Glass" function were considered.

The ORNL functions from "Store @ ORNL" downstream were not evaluated either. The current program at ORNL for making special isotopes will remain into the foreseeable future, therefore all functions with their associated costs, schedules and risks were assumed to be covered by the on going special isotope programs. But, interfaces with the function "Store at ORNL" and any scope required beyond the current special isotope program was considered, i.e. providing additional storage required for some disposition options and any NEPA activities.

Alternative #3 minimizes the handling of the vitrified solution, with resultant reductions of risks, cost, and schedules compared to the other alternatives. The following "technical" scope would require completion:

- Installation of a welder in a MPPF cell
- Approval to make shipments utilizing an existing single containment cask
- Testing to insure contamination limits pertaining to shipments and storage at ORNL may be met
- Installation of additional storage capacity at ORNL
- NEPA evaluations for the extended storage capacity (and time frame) at ORNL

These scope items were considered to be not technically challenging, but schedules could become an issue when considering programmatic decisions on funding and priorities to obtain the required manpower and facilities. The largest cost and highest programmatic risk is with the ORNL functions. Therefore as a backup, interim storage at SRS was evaluated. If the "Transfer and Storage Facility" being considered for installation in L-area is completed, adding the small amount of additional dry storage required for the vitrified tank 17.1 solution would require less funding than the ORNL storage and probably would be simpler from a programmatic view.

The following is a discussion of the technical scope listed above that would require completion.

Installation of Welder

SRTC designed, built, and tested a welder for installation within MPPF for use in sealing the glass canisters. This design could be easily modified for the "contamination control canister" (CWP-2) which has a slightly larger diameter than the glass canisters. This could be a small project handled by the NMSS organization (a Division Managed Modification (DMM)).

In addition, a remote welder capable of providing full penetration welds for use with the MK-42s was installed at Hanford and was successfully used. The design of this equipment, operating procedures, and several individuals involved with the program are still available.

As a backup, welding could be performed in RBOF, but would have to be underwater (adds different complexity compared to welding within MPPF (assuming the same level of contamination control)) and would add complexity to RBOF operations (increases packaging equipment and personnel, and increases shipments to and from RBOF compared to current plans) resulting in additional scope requiring completion prior to RBOF closure.

Approval to make single containment shipments

The plutonium content may be low enough to enable single containment shipments. But, to insure the Pu content does not become a limiting constraint on the quantity of material to be shipped; a "waiver" would be pursued (since the material will be in a glass form). If the "waiver" could not be obtained, double containment could be provided by qualifying the contamination control canister as a "shipping containment vessel" and qualifying the shipping package for double containment (See Section 6.7.3). The SRTC-Packaging Organization is currently investigating various shipping options.

Shipment from F-Canyon to off-site is not a typical canyon function, but is within the facility/operation capabilities. The basic concern is the capability to decontaminate containers leaving MPPF for placement into an off-site shipping cask, and decontamination of the off-site shipping cask. Experience being gained currently through decontamination of MPPF racks may provide enough information to resolve this concern. If not, a simple testing program could resolve the current capabilities and determine where improvements would be beneficial.

As a backup, if the container welded in MPPF could not be decontaminated to acceptable shipping levels (still must meet ORNL acceptable levels) a mechanically sealed qualified shipping container

(msQSC) could be added. (Section 6.7.3 with a additional function of sealing a msQSC prior to leaving F-Canyon).

Installation of additional storage capacity at ORNL

The basic storage design is well known and facilities exist with adequate space to permit installation. But, since the quantity of material is much larger than ever envisioned for the facilities, NEPA evaluations are assumed to be required.

If schedule delays result in ORNL obtaining the required storage space long after it is needed, several SRS options may be pursued:

- Leave material within MPPF (the functions required to move the material will be available even after @PUREX processing capability is eliminated).
- Store in new dry interim storage at SRS (See Section 6.7.4). If the "Transfer Storage Facility" (TSF) is built for handling spent fuel at SRS, then a few additional dry storage modules could be added. If the TSF is not built and the funds to build a limited TSF for interfacing with the dry storage are not allocated, storage at DWPF (in storage areas already built but not to be used (due to "diameter" issues), could be investigated.
- Disposition Tank 17.1 solution to waste via the National Repository (See Section 6.7.5). The designation of the material as "programmatic" would have to be changed before this option is pursued. Once the material is designated as waste, a program to qualify the waste form would be required, and interim storage at SRS would still be required. In addition, ramifications of designating the material as waste would require full investigation, i.e. waste storage requirements are different from material in use or programmatic material.

4.2.2. "Mark 18s" Disposition

Of the two paths evaluated, the "Mark 18s" Disposition path Alternative #1 (see 6.7.8) is recommended (see flow chart below).

Alternative One begins with the Mk 18s stored in RBOF. All Mk 18s are transported to F-Canyon for processing via the onsite transfer cask. Processing involves dissolving the Mk 18s, pretreating the Mk 18 slurry as necessary, storing the slurry in a feed tank, then vitrification via MPPF. The vitrification frit will be adjusted to enable this solution to be vitrified. Vitrification is a batch feed process at the end of which the molten glass drains from the melter into a "canister" (Appendix H, section 9.8.2 Figure 1). The canister is then welded closed. After being loaded into a CwP-1 or 2 (Appendix H, section 9.8.2, Figure 2.1 or 2.2), the CwP-1 (or 2) is lag stored in MPPF. The glass path from solution to ORNL would be one of the alternative cases shown in Sections 6.7.1, 6.7.2, 6.7.3, or 6.7.4. When needed ORNL will remove a CwP form storage and process the glass to products.

The initial function "Store Mk 18 in RBOF" was not evaluated since this is a currently performed function with no major issues. Functions downstream of and including "Make Glass" were not evaluated, since they were identified and evaluated for disposition of Tank 17.1 solution. Interfaces between and with these functions were considered. The primary differences between the Mark 18s and Tank 17.1 are:

- Mark 18s require dissolution to produce the solution feed stream to making glass
- Glass should be shipped to ORNL, even if the glass from tank 17.1 solution feed is interim stored on site. ORNL has storage capacity and capability for glass produced from the Mark 18s (and for all the "slugs/other" materials) but does not have the capacity for all the Tank 17.1 glass.

The Mark 18s Alternative #1 minimizes the ES&H risks associated with cutting into the Mark 18 core (Mark 18s Base Alternative) with resultant reductions of risks, cost, and schedules. No one contacted felt this was an option that should be pursued. Some individuals recalled an earlier attempt at cutting a similar material in RBOF that resulted in a large hut to enable decontamination. Assuming the contamination control was to be the same for both alternatives, the equipment for cutting and packaging under water in RBOF would likely be more complicated and less proven than utilizing a dissolver installed in F Canyon. *Note: Utilization of existing dissolvers and equipment within F Canyon should be evaluated if the decision to process at SRS is made. This would probably decrease costs, schedule and risk.*

The following "technical" scope would require completion:

- Evaluation of Tank 17.1 solution vitrification equipment life expectancy (to insure required equipment is available for the Mark 18s)
- Evaluation of solution produced to enable adjustments in vitrification process (considered minor R&D)
- Installation of an existing dissolver in F Canyon (Used to cost/schedule this alternative, but a backup to be considered would be utilization of existing F Canyon facilities/equipment and staff, by which a substantial reduction in cost and schedule is possible.
- Approval to make shipments utilizing an existing single containment cask (same scope as in the Tank 17.1 disposition selected alternative)
- Testing to insure contamination limits pertaining to shipments and storage at ORNL may be met (same scope as in the Tank 17.1 disposition selected alternative)

As was the case with the Tank 17.1 Solution Disposition Alternative #3, these scope items were considered uncomplicated and very technically feasible, but schedules could become an issue when considering programmatic decisions on funding and priorities to obtain the required manpower and facilities.

The following is a discussion of the technical scope listed above that would require completion.

Evaluation of Tank 17.1 solution vitrification equipment life expectancy

The current project/program for Tank 17.1 solution vitrification ensures equipment life is adequate (or spares are identified) to enable vitrification of the entire Tank 17.1 solution. An evaluation would be required, before final design of the existing project, to insure equipment life would be adequate for the extra material created from dissolving the Mark 18s and or to allow needed spares to be identified.

Evaluation of solution produced to enable adjustments in vitrification process

The solution makeup from dissolving the Mark 18s would need to be compared to the Tank 17.1 solution to determine the proper feed stream adjustments and possible frit adjustments. This would be accomplished by a short R&D program beginning after the current vitrification R&D is complete, and would provide the initial requirements for the process flow sheet and equipment needs for the Mark 18s.

Installation of an existing dissolver in F Canyon

The dissolver and associated equipment was to be installed previously, but the need to disposition the Mark 18s did not justify the expense and manpower. The previous project would need to be rescoped and estimated with current requirements, but no major technical issues were foreseen.

Note: Utilization of existing F Canyon facilities, equipment and staff should be fully investigated. Previous studies and tests indicate a nitric acid flow sheet would enable utilization of existing process equipment. Priority issues for limited skilled manpower would require resolution to fully develop this alternative.

Approval to make shipments utilizing an existing single containment cask & Testing to insure contamination limits pertaining to shipments and storage at ORNL may be met
(Same scope as in the Tank 17.1 disposition selected alternative)

4.2.3. "Slugs/Other" Disposition

The "Slugs/Other" Disposition path recommended is the Base Alternative (see 6.7.9) (flow sheet shown below).

The base case begins with Slugs/Other stored in RBOF and finishes at ORNL. The Slugs/Other are loaded into a CwP-3 (Appendix H, section 9.8.2, Figure 2.3), provided with an internal helium atmosphere, mechanically sealed into an msQSC, (Appendix H, section 9.8.2, Figure 4), and lag stored pending shipment to ORNL. The msQSC will be retrieved and shipped to ORNL, where the CwP-3 will be removed for in situ storage and use. Existing msQSC equipment is utilized to load the package into the off-site shipping cask. When needed, ORNL will remove a CwP from storage and process the slugs/other material into user products.

The initial function "Store Am/Cm Slugs/Other in RBOF" was not evaluated since this is a currently performed function with no major issues. Functions downstream of and including "Store at ORNL" were not evaluated, but interfaces between and with these functions were considered.

No alternatives were identified since the current planning and existing processes met all objectives/goals and requirements. Currently the "Slugs/Other" material is being planned for shipment to ORNL during FY1999.

5.0 CONCLUSION & RECOMMENDATIONS

This section provides an overview of the recommended disposition paths, with conclusions, recommendations and suggested path forward.

5.1. Overview

The following upper level questions and corresponding answers were developed after reviewing all the data, completing the analysis and documenting the study. These are fundamental questions that, when answered, will provide direction to all disposition paths and enable the programs to move forward.

Should the Am/Cm be thrown away?

No.

This question continues to be raised, with the outcome from this study supporting the analysis completed last December⁽⁸⁾ and other studies previous to the December study, i.e. keep the Am/Cm material. The basic reasons being:

The material has been designated as "programmatic", which indicates agreement with stakeholders that the material should be used to support existing and potential future programs.

The ES&H aspects do not discriminate between either storage or disposal.

The cost to store the material is less than to throw it away.

Should the Am/Cm be stored at ORNL?

Yes: Mk 18s (vitrified) & Slugs/Other

Yes: Tank 17.1 solution (vitrified), if SRS does not build a Transfer and Storage Facility

The total quantity of vitrified Mk 18s and "Slugs/Other" can be accommodated by current ORNL storage. Very minimal modifications may be required and the material may be shipped utilizing existing processes and procedures.

Cutting and repackaging the Mk18s is not preferred due to the unknown nature of the material condition (creating contamination potentials and shielding issues if not engineered properly), and the availability of storage at ORNL (currently occupied space must be emptied, storage module D&D'd and new storage installed, therefore about 7 to 10 years before storage is available). Dissolving Mk 18s via a new dissolver was evaluated as a worse case F canyon option to provide the comparison to repackaging and was still preferred. Once the decision to process the Mk 18s is made, a concentrated study of exiting capabilities with F Canyon should be made since it is possible that a nitric acid dissolution (proven previously) may be utilized. This would reduce the costs and schedules for dissolving the Mk 18s appreciably.

Storing the Tank 17.1 vitrified solution at ORNL is about equal overall to storing at SRS, if SRS does not build a Transfer Storage Facility (currently being evaluated). Since the material is envisioned as being used by ORNL, it probably should be stored there. But, if a TSF is built at SRS, the additional cost for dry storage is considerably less initially and over the life cycle then storing at ORNL. Also, if the TSF is built, the concept of adding modules for other materials could become valuable to DOE for storing other assets as the complex is downsized. This capability would probably not be available at ORNL, since their storage would be full.

How fund the recommended disposition paths?

Not evaluated.

Determining funding was not within scope of this study, but projected planning level cash flows are shown to assist with the any cost impact analysis (see figure at the end of this section). Without overstating the obvious, if funding was obtained above the current projected AOP, experienced manpower could become an issue.

Overview continued -

The major scope for dispositioning the Am/Cm materials is in the "material handling area". While technically challenging issues exist, as is true for any task dealing with radioisotope materials, none are as complicated as the current project/program for vitrification of the Am/Cm solution.

The baseline for the "Slugs/Other" is the viable option with no alternatives identified passing simple screening. Currently planning activities should be successful at dispositioning the Slugs/Other to ORNL.

The baseline path currently in the draft EIS and 2006 Plan for dispositioning the Mark 18s is probably not the best approach. The Mark 18s should be dissolved, made into glass, then shipped to ORNL. If a project to install a dissolver is required and project becomes a line item and follows the typical schedule for a line item of this complexity, about five years would be required to complete the project and another six months to process the material to glass. The Mark 18s could be removed from RBOF in about six months by being transferred directly from RBOF to F Canyon, versus the ~ eighteen months in the current RBOF planning schedule for transfer to ORNL. This would reduce the overall RBOF scope required to be completed prior to RBOF closure. F Canyon scope would increase slightly, but all functions needed would still be operational for other currently planned or projected activities. If the Mark 13s had to be removed from RBOF prior to the dissolver project being completed, storage within F canyon could be evaluated (dry or wet). As the dissolving schedule moves further out in time an issue may be created with availability of F Canyon functions if D&D has progressed.

The baseline path for the Tank 17.1 solution was not well defined in the 2006 plan or the EIS, but the intent was shown for the material to be maintained as "programmatic". This material could be safely, economically stored in MPPF until the need to remove from F Canyon was determined. If the material is to be removed from F canyon within the next 5 to 10 years, storage at SRS or ORNL should be developed now. This is an excellent material for consideration as a "National Asset", a class of material being suggested by the NMI project to maintain certain materials for an extended time period beyond currently active programs. Dispositioning this material as "Waste" would add costs, increase the time frame before final decisions could be made, and should require review of stakeholders that are currently knowledgeable that the material has been designated "programmatic", i.e., having value to programs to justify maintaining its availability to current and future programs.

5.2. Conclusion

This study concludes the following:

- All disposition paths evaluated are technically feasible (cutting of Mk18's in RBOF is feasible, but strongly not recommended).
- All disposition paths evaluated have manageable Environmental, Safety & Health (ES&H) and Programmatic Risks (cutting of Mk18s being the least desirable).
- All SRS Am/Cm bearing materials could be removed from SRS prior to the end of FY2005, but some will likely remain until at least FY2008 (primary limiting factors: obtaining programmatic decisions pertaining to funding and priority, i.e. not technical issues).
- If F-Canyon PUREX process Decontamination and Decommissioning (D&D) is initiated, Am/Cm disposition will not be a limiting factor (F Canyon required functions will still be available).
- To enable removal of all Am/Cm from SRS in the minimum time frame (by FY2006) the following would be required immediately:
 - Additional funding (~\$400K) and priority to enable completion of Pre-Conceptual Project activities prior to the end of FY1998.
 - Funding (~\$4M) and priority to enable various R&D and project activities to proceed in FY99.

5.3. Recommendations

This study recommends the following:

- Shipment to ORNL should be from F Canyon, i.e., not using the SRS Receiving Basin for Off-site Fuels (RBOF) and assuming the Am/Cm glass product from Tank 17.1 "solution" is shipped to Oak Ridge National Laboratory (ORNL)
- Interim storage of the Am/Cm glass product from Tank 17.1 "solution" at SRS should be seriously considered.
- The Mk18's should be processed to glass, i.e., sent from RBOF to F-Canyon for processing, then shipped to ORNL.
- The Slugs/Other Am/Cm bearing materials should be packaged at RBOF for direct shipment to ORNL.

5.4. Path Forward Recommendations

To ensure the program moves forward as outlined, obtaining the following agreements and decisions is recommended:

- Agreement to install CwP welder in MPPF during current project (i.e. start project design efforts by 1/1/99)
 - DOE-SR obtains required funding to initiate DMM project
 - DOE-SR directs WSRC to initiate project development by October 1998

- Agreement to develop Mark 18 glass flowsheet as soon as the current development is complete (i.e. starting 1/1/99)
- Decision supporting long term (> 50yrs) storage at ORNL
 - DOE-SR and DOE-OR reach agreement on program scope and funding
 - DOE-OR obtains required funding (\$7M+)
 - DOE-OR directs ORNL to initiate project development, including NEPA reviews, before FY 1999
- Decision supporting processing MK18's earlier (i.e. @ SRS, not @ ORNL)
 - DOE-SR obtains required funding
 - DOE-SR directs WSRC to initiate NEPA Check List development by October 1998
 - DOE-SR directs WSRC to initiate project development by October 1998
- Decision accepting shipments from F-Canyon to ORNL (eliminates F-Canyon to RBOF shipments)
 - Coupon testing initiated early in FY99

The following graphically depicts the schedules developed for a technically possible and minimum expected scenario:

Technically Possible Schedule

FACILITY	FY98			FY99			FY00			FY01			FY02	FY03	FY04	FY05	FY06											
	O	N	D	J	F	M	A	M	J	J	A	S	1	2	3	4	1	2	3	4	1	2	3	4				
F Canyon																												
Tank 17.1 Solution							Welder/Decon Project						Seal Secondary Canister															
Targets Mk 18s							Program Development			Dissolver Installation GPP Project						Dissolve Targets		Produce Glass and Secondary Seal			Ship Glass							
	Ship Mk 18s to F Canyon from RBOF -->																											
Slugs/Other							Pkg. & Ship to ORNL																					
ORNL Storage Project							NEPA Evaluation			Storage Installation Project																		
Costs*																												
Tank 17.1	150						1100						1100						450		1200		1200		500		0	
Mark 18s	50						500						500						2200		2950		500		500		200	
Slugs Other							1000						0						0		0		0		0		0	
ORNL Storage	200						1300						2500						3000		0		0		0		0	
Total	400						3900						4100						5650		4150		1700		1000		200	

* Cost are averages (in thousands of FY 98 dollars) based on estimates (-50% /+100% accuracy)

Minimum Expected Schedule

FACILITY	FY98	FY99	FY00	FY01	FY02	FY03	FY04	FY05	FY06+
	O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S	O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S	O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S	O N D J F M A M J J A S O N D J F M A M J J A S O N D J F M A M J J A S	1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4	1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4	1 2 3 4 1 2 3 4 1 2 3 4	1 2 3 4 1 2 3 4	1 2 3 4
F Canyon									
Tank 17.1 Solution	Welder/Decont Project Seal Secondary Canister								
Targets Mk 18s	Program Development Dissolver Installation Gpp Project Dissolve Targets Make Ship Glass Glass-->								
Slugs/Other	Pkg. & Ship to ORNL Ship Mk 18s to F Canyon From RBOF ---->								
ORNL Storage Project	NEA Reevaluation Storage Installation Project								
Costs*									
Tank 17.1	50	600	600	750	600	200	1200	1200	500
Mark 18s	50	100	150	1200	2000	1700	1100	400	700
Slugs Other		1000	0	0	0	0	0	0	0
ORNL Storage	0	600	1200	1200	2000	2000	0	0	0
Total	100	2300	1950	3150	4600	3900	2300	1600	1200

* Cost are averages (in thousands of FY 98 dollars) based on estimates (-50% /+100% accuracy)

6.0 SYSTEM ENGINEERING PROCESS APPLICATION

The systems engineering approach utilized assesses the potential of a number of alternatives to meet the programmatic requisites for dispositioning the Am/Cm located at SRS. The process was developed for the NMI Project and utilized in development of the U. S. Department of Energy Savannah River *Accelerated Cleanup Plan (Preliminary Draft Plan)*, January 1998. The study was made over a six week time period.

A core team composed of personnel from WSRC-PE&CD Systems Engineering and Site Strategic Planning was created to perform required analyses and document the study (Appendix C). A group of "Domain Experts" (Appendix D), with knowledge and experience representing a wide-range of expertise for handling and processing radioactive materials as well as general engineering applications, was established to support the Core Team. "Reviewers" were established to perform additional reviews of the drafts and final study.

The core team assessed the assigned high-level programmatic functions and requirements and evaluated the need for a formal decision analysis process, i.e. Multi-attribute Decision Analysis (MDA), or Analytical Hierarchy Process (AHP), but decided the paths being evaluated did not require such a process. The team established a number of alternatives that were judged to have a potential for meeting all, or most, of the programmatic requisites. The alternatives were then judged as to propensity for meeting each of the high-level programmatic requisites, and the resulting decisions are highlighted in this study's executive summary and conclusion section.

6.1. Problem Statement

The Am/Cm materials within SRS have been deemed "programmatic". The Am/Cm isotopes are used in the production of Californium-252, which is a neutron source used for radiography, nuclear medicine, and for research. The Am/Cm bearing "target" material and "slug/other" material will be used up by existing envisioned ORNL supported programs. The Am/Cm "solution" material, however, is a quantity large enough to exceed current program needs, and therefore could be considered a "national asset" or reclassified as waste. If the designation of "programmatic" was rescinded, and the material not considered a "national asset", the solution would have to be analyzed to determine how it could be treated as waste. An existing program to vitrify the Am/Cm solution had difficulties with R&D, which created concerns within DOE on the overall existing Am/Cm "solution" program costs and schedules. In addition to perceived complications with the vitrification program, plans for dispositioning all three of the Am/Cm material groups (solution, Mk 18s, slugs/other) are not well enough defined to enable the programs to move forward.

All Am/Cm material located at SRS is envisioned for transfer to ORNL for use in current and future programs. ORNL has enough controlled environment space for the total quantify of material, but modifications will be required to add specific storage modules. The Am/Cm program must also be integrated with a potential near-term ORNL mission that would utilize the same storage/processing space.

The "envisioned" strategy for dispositioning the SRS Am/Cm materials is being evaluated to provide a sound basis for planning the program to remove the materials from SRS and enable their use for future and existing programs. This study is being driven by uncertainties identified by DOE-SR regarding the storage of the product materials at ORNL, the status of the Am/Cm as a programmatic material, and the current disposition program progress. The primary concerns are the potential program impact on F-Canyon closure, overall program costs, and environmental/safety and health (ES&H) vulnerabilities.

6.1.1. Strategy

The strategy for performing this study included:

- establishing a core team within WSRC PE&CD responsible for conducting the study, the intent being some independence from the sponsoring organization (WSRC-NMSS)

- establishing a WSRC and ORNL team of process, project and programmatic knowledgeable experts, referred to as "domain experts"
- establishing a WSRC and ORNL team of reviewers, referred to as "reviewers"
- utilizing an NMI Project Systems Engineer (provided by INEEL) to overview the study and provide guidance on application of NMI evaluation process and independent review of the teams process, and analysis techniques
- utilizing the NMI Project evaluation process (same process being used across DOE complex for material disposition studies) for evaluation of disposition path maturity, programmatic risks and environmental safety & health (ES&H) concerns
- conducting meetings to develop base case and alternative disposition strategies for each material type, focusing on fundamental SE processes to capture the functions, requirements, interfaces, etc..
- utilizing the EM 2006 Plan and current site plans to establish the framework for the base cases being developed
- evaluate using a multi-attribute decision analysis to rank the alternatives relative to their perceived probability of achieving program goals
- applying a graded systems engineering approach to add additional structure to the re-evaluation with resultant benefits
- issuing a draft report about four weeks after the study began to all domain experts and reviewers for their final input
- issuing a final report six weeks after study initiation

6.1.2. Initial State

Am/Cm materials are being stored safely within the Savannah River Site; Tank 17.1 Solution within F Canyon (after currently active project/program will be stored as "glass"), Mark 18s and "Slugs/Other" being stored in RBOF under water.

6.1.3. Final State

All materials identified in this study will have been, processed and converted to a stable physical form, removed from SRS, and placed in storage at CRNL, with some processed by ORNL to forms desired by customers. ORNL will continue storing the material, and periodically removing material from storage for processing to produce isotopes desired by customers.

6.1.4. Goals/Objectives

The goals and objectives are based on the NMI Project goals⁽⁵⁾ and the requesting DOE-SR letter (Appendix A).

6.1.4.1 Reduce Risks

- Reduce potential Environmental/Safety and Health risks
- Minimize potential programmatic risks
- Minimize potential technical risks

6.1.4.2 Minimize Costs

- Minimize DOE Complex wide, life-cycle disposition costs
- Minimize production of additional waste products/streams

6.1.4.3 Reduce Schedules

- Ensure canyon D&D schedule is not impacted by Am/Cm disposition
- Minimize schedules where nuclear facilities are utilized
- Minimize the required facilities for Am/Cm disposition

6.1.4.4 Recommend fully integrated management strategies

- Cover complete life-cycle, cradle to grave
- Provide a well documented, sound basis
- Ensure quantities, characteristics, and locations of materials are well known
- Preserve the integrity and credibility of the United States relative to its international agreements
- Identify future use options with recommendations for designation as "programmatic" or "national asset" material(s)
- Identify disposal options

6.2. Functions

"Product" Functions

- Store Am/Cm materials short term at SRS
- Process material through SRS Facilities
- Ship/move material (within Canyon, On-site outside Canyon, off-site)
- Store stabilized material long term
- Process material to end state customer desired form
- Dispose of used products

"Program" Functions

- Obtain logistics modifications to support operation of the chosen disposition option. (Prepare procedures, train personnel, conduct Operational Readiness reviews (ORR, etc.)
- Obtain programmatic decisions/agreements (EIS, ROD, mission approval, funding, etc.)
- Perform capital modifications to facilities to support chosen disposition option.

6.3. Requirements

The following are requirements that the alternative must satisfy in order to meet current programmatic goals.

- Material must be in a solid form⁽⁹⁾ for shipment off-site if the contained material has greater than 20 curie Pu content
- Material must be placed in a form that, at the minimum, will "ensure the continued safe storage of the nuclear materials for the next ten years"⁽¹⁰⁾

6.4. Interfaces

- DOE-EM, NE & ER
- Storage at ORNL and product package (canister package)
- RBOF & F-Canyon

6.5. Assumptions

- The current program for placing Am/Cm solution into glass canisters is successful.
- Material will be placed in a form that, at the minimum, will ensure the continued safe storage of the nuclear materials for 40 years.
- The isotopic content (desired by ORNL) of the solution will be recoverable from the stabilized form
- Current operations continue to cover sunk facility costs, that is costs for this study were estimated as incremental increases over current operations
- An existing shipping cask, that can be handled by SRS and ORNL, can be certified for shipment of the Am/Cm materials from SRS to ORNL in a timely fashion (not impact schedules defined in the disposition paths).
- DOE will be able to remove organizational barriers and establish consensus on the program scope and responsibilities during FY98.

- Funding is allocated in FY99 to complete pre-conceptual planning, conceptual design and begin project execution.

6.6. Issues

- ORNL must evaluate their current Authorization Basis and existing NEPA basis to ensure that no issues pertaining to long term storage exist.
- Canyon decommissioning plans impacted by the continued presence of Am/Cm within F-Canyon, RBOF and/or K/L Reactor Basin. Functions required for removal of vitrified Am/Cm could be "energized" to be available, but as the schedules are extended this could become a major issue.
- Am/Cm is currently designated as "Programmatic Material", and as such should be available for future use, not discarded. If disposal of the material is desired, the designation "Programmatic" will need to be changed with the appropriate approvals, which could add substantial time to the program to disposition the Am/Cm solution.
- One outcome of changing "Programmatic" to "Waste" designation would be RCRA issues that would have to be addressed for continued storage at SRS facilities.
- The quantity of Am/Cm that could be available for reuse is enough to fill current needs for at least 50 years. However, new uses could be developed in the future creating an increased demand for the material. The cost to produce this material in the future would be extremely high (billions of dollars) and therefore it is unlikely that the material would ever be made again.
 - Funding has not been allocated to develop long-term storage and/or disposal.
 - Requirements based on the IMNM EIS and subsequent ROD's could be changed, if the EIS and ROD development process was revisited. This could have a major impact (negative or positive) on potential alternatives and associated costs and schedules.
 - No off-site shipping cask is currently certified for shipment of the Am/Cm materials. A cask will have to be rented (or purchased), and certified for these materials. If any issues arise pertaining to the certification and or rental schedules and costs could be impacted drastically.

6.7. Am/Cm Disposition Path's Overviews

The following overview descriptions were developed by the core team members based on input received from domain experts and reviewers and through analysis of data. These descriptions summarize each disposition path. An expanded review of each case shown below including functions, requirements, interfaces, issues, assumptions, and costs is provided in Appendix I. Each disposition path was reviewed prior to performing the Nuclear Materials Integration (NMI) project Disposition Path Maturity (DPM) evaluations (Appendix L). The descriptions were completed prior to performing Programmatic Risk (PR) Environmental, Safety, and Health (ES&H) evaluations and to conducting the decision analysis.

Overviews of the SRS Am/Cm Tank 17.1 "Solution" disposition paths are provided in Sections 6.7.1 through 6.7.6. The options discussed in Section 6.7.6 disposition the solution to a national repository. All other options disposition the solution to ORNL.

The overviews of the SRS Am/Cm "Mk 18" disposition paths are in Sections 6.7.7 and 6.7.8.

The SRS Am/Cm "Slugs/Other" disposition path is defined in Section 6.7.9.

Additional options considered but screened from further analysis are defined in Section 6.7.10.

NOTE: Options that disposition Am/Cm solutions to ORNL do not evaluate functions beyond "Storage @ ORNL". The storage Operations/Maintenance/D&D, etc. costs and all downstream functions are assumed to be covered by the existing ORNL programs supporting development of special radioisotopes. The scope of providing storage for the "Am/CM Solution" glass canisters is addressed as an incremental increase over current storage capacity at ORNL. The ORNL has adequate storage for the Mk18s (if placed into glass) and "Slugs/Other".

Review of Appendix H will assist the reader with understanding of the following sections.

6.7.1. Tank 17.1 "Solution" Disposition – Base Alternative (double containment, MPPF-RBOF-ORNL)

MPPF Primary, RBOF Secondary Containment, Shipped From RBOF to ORNL

The base alternative for the Americium and Curium (Am/Cm) disposition begins with Am/Cm solution stored in F-Canyon Tank 17.1. The solution is pretreated with oxalic acid to remove transition metals, such as Cr, Ni, and Fe, and is transferred to a feed tank in the Multi-Purpose Processing Facility (MPPF) for vitrification. Vitrification is a batch feed process at the end of which the molten glass drains from the melter into a "canister" (Appendix H, section 9.8.2, Figure 1). The canister is sealed but does not provide a containment boundary. The canisters are lag stored in the MPPF after being loaded into a carrier.

The canisters will be retrieved from MPPF lag storage and placed into a qualified shipping container (CwP-1) (Appendix H, section 9.8.2, Figure 2.1). A cover will be placed on the CwP-1, and the container will be sealed by a full penetration closure weld using a welder installed in an MPPF cell. The CwP-1 then will be lag stored in MPPF. Prior to shipment to RBOF, the CwP-1 will be decontaminated (using existing F-Canyon decontamination area) and placed in an onsite shipping cask. The CwP-1 will be stored in RBOF until shipped to ORNL for subsequent storage and use.

Figure 6.7.1

Functional Flowsheet for Tank 17.1 "Solution" Disposition – Base Alternative

Cost

- Planning level estimated total life-cycle cost = \$92M: (\$80M (existing program) + \$4.6-5.5M (SRS) + \$7M (ORNL expand storage facility)

Enabling Objectives

- Obtain funding for further process and equipment development
- Complete R&D project on schedule
- Design and install welder in F-Canyon
- Design and licensing of containment cask for shipment of Am/Cm to ORNL
- Add storage area to ORNL.
- Current ORNL, radioisotope program continues to be funded
- Fund operation of F Canyon systems required to support Am/Cm disposition

6.7.2. Tank 17.1 "Solution" Disposition – Alternative #1 (double containment, RBOF-ORNL)

MPPF Contamination Control Can, RBOF Primary & Secondary Containment, Shipped From RBOF to ORNL

Alternative One disposition begins with Am/Cm solution stored in F-Canyon Tank 17.1. The solution is pretreated with oxalic acid to remove transition metals, such as Cr, Ni, and Fe and is transferred to a feed tank in the MPPF for vitrification. Vitrification is a batch feed process at the end of which the molten glass drains from the melter into a "canister" (Appendix H, section 9.8.2, Figure 1). The canister is sealed but does not provide a containment boundary. The canisters are lag stored in the MPPF after being loaded into a carrier.

The canisters will be retrieved from lag storage and placed into a container for transport to RBOF via the site transport cask. In RBOF, the canisters will be placed in a container that provides contamination control (CwP-3) (Appendix H, section 9.8.2, Figure 2.2)). A cover will be placed on the CwP-3, and the container sealed by a full penetration closure weld using a welder installed in RBOF. The CwP-3 will be purged of water, back filled with helium, and sealed shut. Next, the CwP-3 will be placed into a mechanically sealed primary shipping container (msQSC) (Appendix H, section 9.8.2, Figure 4), purged of water, back filled with helium, sealed shut and moved to lag storage. The msQSC then will be retrieved, placed in an off-site shipping cask, and shipped to ORNL. ORNL will remove the msQSC from the shipping cask assembly and store the Am/Cm glass in situ in the CwP-3.

Figure 6.7-2
Functional Flowsheet for Tank 17.1 "Solution" Disposition – Alternative #1

Cost

- Planning level estimated total life-cycle cost = \$94M: [\$80M (existing program) + \$5.9-6.9M (SRS) + \$7M (ORNL)]

Enabling Objectives

- Obtain funding for further process and equipment development
- Complete R&D project on schedule
- Design and install welder in RBOF
- Design and licensing of containment cask for shipment of Am/Cm to ORNL
- Add storage area to ORNL
- Use base case
- Fund operation of F Canyon systems required to support Am/Cm disposition

6.7.3. Tank 17.1 "Solution" Disposition – Alternative #2 (double containment, MPPF-ORNL)

MPPF Primary- Cask Secondary Containment ,Shipped From F-Canyon to ORNL

Alternative Two disposition begins with Am/Cm solution stored in F-Canyon Tank 17.1. The solution is pretreated with oxalic acid to remove transition metals, such as Cr, Ni, and Fe and is transferred to a feed tank in the MPPF for vitrification. Vitrification is a batch feed process at the end of which the molten glass drains from the melter into a "canister" (Appendix H, section 9.8.2 Figure 1). The canister is sealed but does not provide a containment boundary. After being loaded into a carrier the canisters are lag stored in the MPPF.

The canisters will be retrieved from lag storage and placed into a shipping container (CwP-1) (Appendix H, section 9.8.2, Figure 2.1). A cover will be placed on the CwP-1, and the container will be sealed by a full penetration closure weld using a welder installed in a MPPF cell. The CwP-1 will be decontaminated and placed in a off-site shipping cask. The shipping cask will be decontaminated and shipped to ORNL. ORNL will remove the CwP-1 from the shipping cask assembly and store the Am/Cm glass in situ in the CwP-1.

Figure 6.7-3

Functional Flow Sheet for Tank 17.1 "Solution" Disposition – Alternative #2

Cost

- Planning level estimated total life-cycle cost = \$92M: [\$80M (existing program) + \$4.4 - \$5.2M (SRS) + \$7M (ORNL)]

Enabling Objectives

- Obtain funding for further process and equipment development
- Complete R&D project on schedule
- Design and install welder in F-Canyon
- Design and licensing of a containment cask for shipment of Am/Cm to ORNL
- Add storage area to ORNL
- Fund operation of F Canyon systems required to support Am/Cm disposition

6.7.4. Tank 17.1 "Solution" Disposition – Alternative #3 (single containment, MPPF-ORNL)

MPPF Contamination Control Can - Shipping Cask Primary Containment, Shipped From F-Canyon to ORNL

Alternative Three disposition begins with Am/Cm solution stored in F-Canyon Tank 17.1. The solution is pretreated with oxalic acid to remove transition metals, such as Cr, Ni, and Fe and transferred to a feed tank in the MPPF for vitrification. Vitrification is a batch feed process at the end of which the molten glass drains from the melter into a "canister" (Appendix H, section 9.8.2, Figure 1). The canister is sealed but does not provide a containment boundary. The canisters are lag stored in the MPPF.

The canisters will be retrieved from lag storage in MPPF, seal welded in a contamination control canister (CwP-2) (Appendix H, section 9.8.2, Figure 2.2)) using a welder installed in an MPPF cell. The CwP-2 will be decontaminated and placed in a off-site shipping cask. The shipping cask will be decontaminated and then shipped to ORNL from F Canyon. ORNL will remove the CwP-2s from the shipping cask assembly and store the Am/Cm glass in situ in the CwP-2s. When needed, ORNL will remove a CwP from storage for processing the glass into products.

Figure 6.7-4

Functional Flow Sheet for Am/CM "Solution" Disposition – Alternative #3

Cost

- Planning level estimated total life-cycle cost = \$91M: \$80M (existing program) + \$4M - \$4.8M (SRS) + \$7M (ORNL)

Enabling Objectives

- Obtain funding for further process and equipment development
- Complete R&D project on schedule
- Design and install welder in MPPF
- Design and licensing of a containment cask for shipment of Am/CM to ORN.
- Add storage area at ORNL
- Current ORNL, radioisotope program continues to be funded
- Fund operation of F Canyon systems required to support Am/CM disposition

6.7.5. Tank 17.1 "Solution" Disposition - Alternative #4 (double containment, SRS Interim storage-ORNL)

Interim SRS Glass Storage, Transfer to ORNL As Needed

Alternative Four begins with Am/Cm solution stored in F-Canyon Tank 17.1. The solution is pretreated with oxalic acid to remove transition metals, such as Cr, Ni, and Fe and transferred to a feed tank in the Multi-Purpose Processing Facility (MPPF) for the vitrification process. Vitrification is a batch feed process at the end of which the molten glass drains from the melter into a "canister" (Appendix H, section 9.8.2, Figure 1). The canister is sealed but does not provide a containment boundary. After being loaded into a carrier the canisters are lag stored in the MPPF.

The canisters will be retrieved from lag storage in the MPPF, seal welded into a primary shipping container (CwP-2), (Appendix H, section 9.8.2, Figure 2.1). and returned to MPPF for lag storage until L-Basin is ready to receive them. The CwP-2 will be transferred by on-site shipping cask from F-Canyon to L-Basin.

In L-Basin the CwP-2 will be loaded into an msQSC, provided with a Helium atmosphere and sealed. Storage will be in the dry cask area until transport to ORNL on an as needed basis.

Figure 6.7-5

Flow chart: Tank 17.1 Solution - Interim Dry Cask Storage

Cost

- Planning level estimated total life-cycle cost = \$86 M: \$80 M (existing program) + \$5.5M - \$6.9M (SRS welder, Spent fuel storage, canister and transport)

Enabling Objectives

- Obtain funding for further process and equipment development
- Complete R&D project on schedule
- Design and install welder in F-Canyon
- Obtain NEPA coverage for storage in L Basin and dry spent fuel storage casks
- Obtain handling SNF canister handling equipment for ORNL
- Add Dry Storage near L-Basin
- Add storage area to ORNL
- Fund operation of F Canyon systems required to support Am/Cm disposition

6.7.6. Tank 17.1 "Solution" Disposition - Alternative #5 (double containment, SRS interim storage-National Repository)

The Am/Cm Tank 17.1 "Solution" waste case begins with Am/Cm solution stored in F-Canyon Tank 17.1. The solution is pretreated with oxalic acid to remove transition metals, such as Cr, Ni, and Fe and transferred to a feed tank, then vitrification via MPPF. Vitrification is a batch feed process at the end of which the molten glass drains from the melter into a "canister", (Appendix H, section 9.8.2, Figure 1). The canister is sealed but does not provide a containment boundary. After being loaded into a carrier, the canister is lag stored in the MPPF.

The canisters are retrieved from lag storage in the MPPF, seal welded into a contamination control container (CwP-2) (Appendix H, section 9.8.2 Figure 2.2), and returned to MPPF for lag storage until L-Basin is ready to receive them. The CwP-2 will be transferred by onsite shipping cask from F-Canyon to L-Basin.

In L-Basin the CwP-2 will be loaded into a Spent Nuclear Fuel canister, provided with a Helium atmosphere, welded closed, lag stored and finally transported to the repository (MGDS).

Figure 6.7-6

Functional Flow Sheet for Tank 17.1 "Solution" Disposition – Waste Alternative

Cost

- Planning level estimated total life-cycle cost = \$120M: \$80M (existing program) + \$11M - \$51.6M (SRS, Glass waste qualification cost and welder) + \$4.9-6.2M (Spent fuel storage, canister and transport) + \$2.4 - 3.34M (Incorporation into repository)

Enabling Objectives

- Obtain funding for further process and equipment development
- Complete R&D project on schedule
- Design and install welder in MPPF
- Obtain NEPA coverage for storage in L Basin and dry spent fuel storage casks
- Obtain funding to qualify glass for the repository
- Add Dry Storage near L-Basin
- Fund operation of F Canyon systems required to support Am/Cm disposition

6.7.7. "Mark 18" Disposition – Base Alternative (double containment, RBOF-ORNL)

Cut Mk 18's in RBOF Basin and Ship to ORNL

The base case for the Am/Cm Target (Mk 18) disposition begins with Mk 18's stored in RBOF. The Mk 18's are removed from their storage containers, then shortened by cutting in the RBOF basin. The fuel core is placed in a contamination control container (CwP-3), (Appendix H, section 9.8.2, Figure 2.3), provided with a helium atmosphere and sealed shut. Two CwP-3's are installed in an msQSC prior to mechanically sealing the msQSC. Two msQSC's are loaded into an onsite shipping cask. The onsite shipping cask assembly is then placed in an off-site transport cask that provides secondary containment for shipment. Shipment is to ORNL for subsequent storage and use.

Figure 6.7-7

Am/Cm "Mark 18" Disposition – Base Alternative

Cost

- Planning level estimated total life-cycle cost = \$20M: \$0M (existing program) + \$17M (SRS) + \$3M (ORNL)

Enabling Objectives

- Obtain funding for further process and equipment development
- Design and install Mk 18 cutting and packaging equipment in RBOF
- The design and licensing of transport cask for shipment of Am/CM to ORNL
- Add storage area to ORNL
- Fund operation of F Canyon systems required to support Am/Cm disposition

6.7.8. "Mark 18" Disposition – Alternative #1 (make glass, single containment, MPPF-ORNL)

Transfer to F-Canyon and Dissolve for Vitrification, Ship to ORNL

Alternative One begins with the Mk 18s stored in RBOF. All Mk 18s are transported to F-Canyon for processing via the onsite transfer cask. Processing involves dissolving the Mk 18s, pretreating the Mk 18 slurry as necessary, storing the slurry in a feed tank, then vitrification via MPPF. The vitrification frit will be adjusted to enable this solution to be vitrified. Vitrification is a batch feed process at the end of which the molten glass drains from the melter into a "canister" (Appendix H, section 9.8.2 Figure 1). The canister is then welded closed. After being loaded into a CwP-1 or 2 (Appendix H, section 9.8.2, Figure 2.1 or 2.2), the CwP-1 (or 2) is lag stored in MPPF. The glass path from solution to ORNL would be one of the alternative cases shown in Sections 6.7.1, 6.7.2, 6.7.3, or 6.7.4. When needed ORNL will remove a CwP from storage and process the glass to products.

Figure 6.7-8

Am/Cm "Mark 18" Disposition – Alternative #1

Cost

- Planning level estimated total life-cycle cost = \$7.6: [\$0M (existing program) + \$7.1-8.1 (SRS) – \$1M (ORNL cost reductions from not having waste stream associated with removal of AI)]

Enabling Objectives

- Obtain funding for further process and equipment development
- Complete R&D project on schedule
- Install appropriate tanks and jumpers in F-Canyon to support Mk 18 dissolution
- Design and install welder in F-Canyon
- Design and licensing of a containment cask for shipment of Am/CM to ORNL
- Add storage area to ORNL
- Fund operation of F Canyon systems required to support Am/CM disposition

6.7.9. "Slugs/Other" Disposition – Base Alternative (double containment, RBOF-ORNL)

Package Slugs In RBOF and Ship To ORNL

The base case begins with Slugs/Other stored in RBOF and finishes at ORNL. The Slugs/Other are loaded into a CwP-3 (Appendix H, section 9.8.2, Figure 2.3), provided with an internal helium atmosphere, mechanically sealed into an msQSC, (Appendix H, section 9.8.2, Figure 4), and lag stored pending shipment to ORNL. The msQSC will be retrieved and shipped to ORNL, where the CwP-3 will be removed for in situ storage and use. Existing msQSC equipment is utilized to load the package into the off-site shipping cask. When needed, ORNL will remove a CwP from storage and process the slugs/other material into user products.

Figure 6.7-9

"Slug/Other" Disposition – Base Alternative

Cost

- Planning level estimated total life-cycle cost = \$1M: \$1M (SRS) + \$0M (ORNL costs covered by other programs)

Enabling Objectives

- Obtain funding for equipment development.
- The design and licensing of off-site shipping cask for shipment of Am/CM to ORNL.
- Add storage area to ORNL

6.7.10. Potential Alternatives not Evaluated

The following scenarios were developed but not considered any further for disposition of Am/Cm Solution, Mk 18s, and Slugs/Other:

No Action: For a no action case, Am/Cm solution would remain in Tank 17.1, "Mk 18s" and "Slugs/Other" would remain in RBOF. A no action alternative was considered for Tank 17.1 solution in the IMNM EIS and rejected. Therefore, it was not considered in this analysis. If the solution was not removed, it would pose the additional problem that accountable materials with significant potential for environmental release would be left in F Canyon, potentially delaying its transition to cold status. In order to shut down RBOF, the Mk 18s and Slugs/Other would have to be removed. Therefore, leaving these materials in RBOF was not considered.

Packaging of Mk18s at Hanford (PNNL): In the past, SRS Mk-42 targets were transported from RBOF to PNNL, where they were cut and packaged for shipment to ORNL and then processed at ORNL. Indications are that there is no interest for performing such an activity for the Mk18s, and the equipment used for the Mk-42s is no longer in service. As currently packaged, the Mk18s would fit in several existing shipping casks (either a NLI 1/2 or NAC LWT cask), but an evaluation of the Mk18s would be required to determine if they would require repackaging before being shipped off-site. Repackaging would involve many risks identified for cutting the Mk18s, which is another reason this option was not considered further.

Direct Shipment of Mk 18s to ORNL: Direct shipment of Mk 18s to ORNL from RBOF may be physically possible, but very impracticable. The internal cavity of an NLI 1/2 or NAC LWT cask is 178 inches long while the current configuration is 168 inches long uncut, which leaves minimal area for shielding on the ends, and minimal space if an additional packaging container becomes required around the current Mk18 storage configuration. Discussions with ORNL personnel indicated that they would have no way to store the material -- a new shield block would be required (the current block has selves with slightly more than 4 in inside diameter while the currently packaged Mk18s are 5.7 inches in diameter). An evaluation of the Mk18s would be required to determine if they would require repackaging before being shipped off site. Significant modifications, would also be required for the ORNL processing facility for cutting, since the current cells are 7'X7'X8'. Funding, NEPA, and current ORNL program missions would require extensive evaluation before proceeding. For these reasons, this alternative was not evaluated.

Vitrification of "Slugs/Other": The Slugs/Other materials could be sent from RBOF to the F-Canyon for processing using the Mk18s proposed pathway, i.e., processed, vitrified, then shipped. But, no significant issue exists with shipping the Slugs/Other material to ORNL, and the material may be stored and processed using existing ORNL facilities. Shipping direct to ORNL is the least complicated pathway. For these reasons, this alternative was not evaluated.

7.0 ACRONYMS, ABBREVIATIONS AND DEFINITIONS

²³³ U	Uranium isotope 233
²⁴¹ Am	Americium isotope 241
Am	Americium
Cm	Curium
CwP-1	Container with Pintle, approved shipping container
CwP-2	Container with Pintle, contamination control container
CwP-3	Container with Pintle, CwP-2 with method to remove water
D&D	Decontamination and Decommissioning
DNFSB	Defense Nuclear Facilities Safety Board
DOE	Department of Energy
DOE-SR	Department of Energy – Savannah River Office
DU	Depleted Uranium
EC	Evaluation Criteria
ES&H	Environmental/Safety and Health
DWPF	Defense Waste Processing Facility
HEPA	High-Efficiency Particulate Air
HLW	High-Level Waste
INMN	Interim Management of Nuclear Materials
LCC	Life-Cycle Cost
lag	Interim or "lag time" storage during a process
M	Million
MPPF	Multi-Purpose Processing Facility
msQSC	Mechanically Sealed Qualified Shipping Container
NMSS	Nuclear Materials Stabilization and Storage
ORNL	Oak Ridge National Laboratory
Pu	Plutonium
R & D	Research and Development
RBOF	Receiving Basin for Off-Site Fuel
PE&CD	Projects, Engineering, and Construction Division
PSC	Primary Shipping Container
ROD	Record of Decision
SRS	Savannah River Site
SRTC	Savannah River Technology Center
U	Uranium
UV	Utility Value
WCB	Welded Contamination Barrier
WF	Weight Factor
WIPP	Waste Isolation Pilot Plant
WSRC	Westinghouse Savannah River Company

8.0 REFERENCES

1. Am/Cm Line Item Project S-5997.
2. Department of Energy Order 430.1, "Life-cycle Asset Management"
3. Westinghouse Savannah River Co., "Key Activities for Successful Execution (KASE) of Projects at Savannah River Site", WSRC-IM-96-167
4. SRS Spent Nuclear Fuel Management Environmental Impact Statement (DOE/EIS-0279D)
5. John C. Tseng, DOE-Acting Director Nuclear Materials Stabilization Task Group, Office of Nuclear Material and facility Stabilization, "Project Management Plan for Environmental Management Nuclear Material Integration", February 10, 1998 Revision 0

6. Systems Approach to Functions and Requirements, Instructor Guide, Rev. 0, WSRC-PE&C Training course TR721B.
7. Americium/Curium Disposition, Scoping Level Alternative Re-evaluation (U), Revision 0, December 11, 1997.
8. Defense Nuclear Facilities Safety Board, *Recommendation 94-1 To The Secretary of Energy*, May 26, 1994
9. Code of Federal Regulations, Part 10, Chapter 71, *Packaging and Transportation of Radioactive Materials*.
10. Am-Cm Vitrification Development Program Plan, Rev. 0, Document # SRC-AMC-97-011, 11/97

Appendix A

9.0 APPENDICES

9.1. Appendix A: "Americium/Curium (Am/Cm) Disposition Study" Anderson

Letter, John E. Anderson to J. Frank Jordan, January 30, 1998

Department of Energy
Savannah River Operations Office
P.O. Box A
Aiken, South Carolina 29802

FEB 4 1998

JAN 30 1998

Mr. J. Frank Jordan, Vice President
and General Manager
Nuclear Material Stabilization and Storage Division
Westinghouse Savannah River Company
Aiken, South Carolina 29808

Dear Mr. Jordan:

SUBJECT: Americium Curium (Am/Cm) Disposition Study

Westinghouse Savannah River Company is requested to perform additional studies on the disposition of the Am/Cm solution in F-Canyon. Ongoing problems with the vitrification program has lead to questions concerning alternative approaches to stabilization and or disposition of this material. The purpose of the study is to provide the Department of Energy with the necessary information including costs (life cycle and cash flow), risks (environmental, technical and programmatic) and schedule duration's to determine a sound disposition path for this material. Please provide the study by April 1, 1998, to support critical programmatic decisions at both the Savannah River Site and Oak Ridge National Laboratory during the month of April.

The primary alternatives in this study should include, but not limited to, disposition to High Level Waste as liquid waste and vitrification in F-Canyon's Multi Purpose Processing Facility (MPPF) as either waste or future use material. Options within the Defense Waste Processing Facility alternative must meet the current Waste Acceptance Criteria for the existing High Level Waste facilities utilized. Options within the MPPF glass alternative are not constrained by the need to disposition other materials via the selected Am/Cm process. To be a viable option, the phased canyon strategy's F-Canyon deactivation schedule must not be delayed or extended to accommodate Am/Cm disposition. All viable options shall include evaluation of all functions or steps required to disposition the material, such as stabilization, storage, shipment, etc.

Please contact me or S. W. McAlhany of my staff at 952-4802, if you or your staff have any questions.

Sincerely,

A handwritten signature of John E. Anderson in dark ink.

John E. Anderson
Acting Assistant Manager for Material
and Facility Stabilization

NMSD:SWM:cc

UD-98-0038

cc: J. W. French, WSRC, 703F
S. Evans, WSRC 703-F
M. R. Beckmeyer, WSRC, 703F

Appendix B

9.2. Appendix B: "Americium/Curium (Am/Cm) Disposition Study (U)" Jordan

Letter, J. Frank Jordan to John E. Anderson, February, 1998

Westinghouse
Savannah River Company
Aiken, SC 29808

MAR 12 1998

NMS-98-0020
Retention: 2 yrs.
RSM: 10413

Mr. John E. Anderson, Acting Assistant Manager
for Material and Facility Stabilization
Savannah River Operations Office
U.S. Department of Energy
Aiken, SC 29808

Dear Mr. Anderson:

AMERICIUM CURIUM (Am/Cm) DISPOSITION STUDY (U)

Ref.: Letter, J.F. Jordan from J. E. Anderson, "Americium Curium (Am/Cm) Disposition Study", dated 11/30/98.

At your request, Westinghouse Savannah River Company (WSRC) has initiated additional studies on the disposition of the Americium Curium (Am/Cm) solution presently stored in the F-Canyon facility. The Am/Cm Project Team has identified viable options to successful vitrification of the Am/Cm solution and are actively pursuing development of the flowsheet parameters; the options and the evaluative process for selection of the preferred option are contained in Revision 1 of the Am/Cm Vitrification Development Program Plan that will be presented to the Department of Energy and the Defense Nuclear Facility Safety Board. The various options for successful vitrification will be discussed in the study that you have requested but not evaluated in the study.

The Nuclear Materials Stabilization and Storage Division (NMS&S) of WSRC has commissioned the Project Engineering and Construction Division (PE&CD) to conduct a structured assessment of the life cycle requirements for dispositioning vitrified Am/Cm materials. NMS&S personnel will serve as subject matter experts but the structured assessment will be led by PE&CD personnel who offer a level of independence and are more skilled in the "Engineering Approach". A draft of this study will be completed by April 1, 1998, and the study is expected to be completed by April 17, 1998. The focus of this study will be to evaluate and examine the disposition path for the material; this assumes success of the approved project plan to vitrify Am/Cm in the F-Canyon Multi-Purpose Processing Facility (MPPIF). Costs (life cycle and cash flow), risks (environmental, technical, and programmatic), and schedule duration will be key parameters/considerations used in this assessment.

Appendix C

9.3. Appendix C: Core Team for developing the Am/Cm Disposition Life-Cycle Planning Study

William N. Jackson
Westinghouse Savannah River Company

Team Function: Team Lead
Expertise: Management, Systems Engineering, Mechanical Engineering

Overview

- + Currently WSRC- Project Engineering & Construction Division-Systems Engineering (SE) Manager, NMSS & New Missions Support (EA1B9), responsible for supporting projects and new mission areas while managing diverse technical staff and developing SE processes
- + B.S. Mechanical Engineering, continued education in SE processes
- + Ten + years mgt. experience: R&D, projects and mission develop arenas
- + Ten years experience in plant operations/maintenance, equipment design/development/fabrication/installation and startup for new and retrofitted radioisotope processing facilities
- + Obtain, integrate & project annual budgets, & develop out year projections

Experience: **WSRC-PE&CD – Systems Engineering Mgr. (1/92-Present)**

- + Mgr. supporting development of tech. baselines, new mission areas, and projects in support of NMS&S and Site Strategic Planning Divisions
- + Supporting development of site wide systems engineering processes
- + Currently assisting development of DOE material disposition path process
- + Assisted Development of FDD/SDD process and support tools
- + Developed / applied "Strategic Planning Process"
- + Interfaced with DOE-HQ, INEL, ORNL, LANL, LLNL, and Hanford to: develop various reports/strategies in support of complex wide material disposition programs and new mission areas, required funding and AOP budget projections/revisions/tracking
- + Participated in TWRS systems capability assessment at Hanford

WSRC-SRTC Research Engineering Mgr. (4/89-1/92)

- + Established regularly scheduled project review meetings to define researchers' requirements and monitor staff progress on projects/tasks
- + Participated in ORNL "Lithium Process Replacement Project" Readiness Review
- + Provided tech. consultation on the SRS "235-F Neptunium Line Project"
- + Participated in two TQFRs (HB-Line & SRTCs Laboratory Services Section)

E.I. du Pont de Nemours & Co. Process Engineer (6/77 – 4/89)

- + Toured, attended meetings and participated in various equipment/facility design/development project efforts at LLNL, ORNL, LANL, INEL, ORNL, Hanford, Rocky Flats and England's Sellafield & Aldermaston sites
- + Supervised test facility and design personnel, focus on Tritium support areas
- + Reviewed and developed cost estimates, requirements, scopes of work, and designs for nuclear material production and shipping equipment/casks (Gloveboxes, slab tanks, calciners, agitators, valves, Pumps, incinerators, transfer devices, etc.)
- + From 1982 to 1989, located in Wilmington, DE, supporting SRS projects
- + Founding director of "American Glovebox Society", currently ~ 300 members

Appendix C

Joseph F. Krupa Westinghouse Savannah River Company

Team Function: Core Team Member

Expertise: Actinide Separations, Radiochemistry, Life-Cycle Analysis

- Overview**
- + Currently WSRC Principal Technical Advisor, Strategic Planning and Integration Department, providing economic analyses to the Spent Fuel Storage Division for decision processes for management of SRS aluminum clad spent nuclear fuel, and providing cost analysis expertise to the Nuclear Material Integration Task Team
 - + B.Sc. in Chemistry, U.S. Air Force Academy; M.Sc. in Chemistry (AEC fellow), University of California, Berkeley; M.E. Ch.E, University of Idaho
 - + 25 years experience in nuclear related analysis and operations
 - + Developed Fluorinel flowsheet calculation and process control methodology (for dissolution of spent Naval fuel) from bench experiments to hot plant startup
 - + Participated in seven national task teams related to Nuclear Weapons Complex issues

- Experience:**
- WSRC-SPID Principal Technical Advisor (12/92 to Present)**
- + Developed life-cycle cost study to support a study of the nonproliferation impacts of spent nuclear fuel reprocessing and the SRS SNF EIS
 - + Provided life-cycle cost analysis and technical expertise to the SRS spent nuclear fuel decision process and evaluation of privatization opportunities
 - + Developed studies on SNF life-cycle costs, spent fuel storage, plutonium discard limit implementation, nuclear materials disposition and complex-wide nuclear material disposition issues.

- Nuclear Engineer, U.S. DOE-SR (3/87 -12/92)**
- + DOE Nuclear Materials Manager.
 - + Coordinated and reviewed technical planning studies
 - + Participated in task forces on capital asset management, reconfiguration siting (lead for transportation), and plutonium discard limits.

- Senior Scientist, Idaho Chem.Processing Plant (3/77-3/87)**
- + Developed process control method and Fluorinel process flowsheet and reagent addition computer programs (George Westinghouse bronze award 1985).
 - + Modeled process dissolution criticality permitting deletion of a major system, and substantial waste reduction.
 - + Operated Fluorinel Dissolution Pilot Plant. Startup engineer for Fluorinel
 - + Lead for NRC funded experimental program to evaluate post-accident (nuclear) radio-iodine sampling and measurement equipment.
 - + Performed studies of actinide and fission product extraction coefficients for dihexyl, N,N, diethyl carbaryl methylene phosphonate

- Analytical Engineer, United Technologies (3/74-3/77)**
- + Analyzed pilot plant scale steam reformer data for fuel cell hydrogen generation

- Nuclear Res. Off., 1155 Tech.Ops Sqdn, USAF, (1/70-1/74)**
- + Performed tracer and carrier-based radiochemical analysis.

Appendix C

Steven R. Nester Westinghouse Savannah River Company

Team Function: Core Team Member
Expertise: Electrical Engineering, Systems Engineering

Overview **Currently Senior Engineer with Systems Engineering**, responsible for leading pre-conceptual project development, engineering analysis, and feasibility studies.
B.S. Electrical Engineering from the University of Illinois at Chicago
Eight years engineering and project leadership experience at DOE's Savannah River Site

Experience: Systems Engineer – Nuclear Materials January 13, 1998 to present

Currently performing studies for disposition paths for various nuclear materials.

IPI Coordinator – Tritium NNR August 1, 1997 to January 12, 1998

Performed the Installed Process Instrumentation (IPI) coordinator function for NNR-Tritium.

Lead Engineer – HLW GPP/CE Projects May 1, 1996 to August 1, 1997

HLW GPP/CE Lead for Systems Engineering. Duties included coordinating all Systems engineers on all HLW GPP/CE projects for facilities including H-Area Tank Farm, ETF, and ITP.

Responsible for the following:

- developing, completing, issuing, and revising of all Task Requirement & Criteria Documents, Functional Acceptance Criteria, and some Plant Modification Travelers.
- planning and securing work for Systems Engineering, along with resources
- ensuring Systems Engineering satisfies financial and scheduling commitments with the HLW Project Management and Project Controls organizations.
- working with Design Authority personnel, including cognizant engineers in order to develop and ensure the quality and accuracy of technical baseline documents generated by Systems Engineering.
- initiating & tracking Activity Codes allotted for Systems Engineering Support.
- initiating all HAD Reviews of HLW projects.
- ensuring completion of technical reviews for all projects.

Systems Engineer February 5, 1990 to May 1, 1996

DWPF and Late Wash Support

Provided design and cognizant-type support to facilitate startup and operation of DWPF and Late Wash. Deliverables included: Redundant I/O analysis of DWPF drawings, close-out of C-Punchlist items, generation and implementation of DCF's, walkdown packages, preventative maintenance plans.

Reactors and Separations

Developed process and instrument guides for Separations shift technical engineers. (ex. FB Line Mechanical Line)

Developed functional performance requirements and design criteria for projects throughout the Savannah River Site; K Reactor, Separations, RBOF facility, F and H Tank Farms, ITP Facility, ETF Facility.

Led effort to apply CAPTOR software to breaker / fuse coordination studies for Reactor Restart in February 1990.

Appendix C

Reuben Rainisch Westinghouse Savannah River Company

Team Function: Core Team Member
Expertise: Nuclear Engineering, Mechanical Engineering, Systems Engineering

Overview + Currently WSRC – Project Engineering & Construction Division-Systems Engineering (SE) Principal Engineer (1989 to Present)
+ B.S. Marine Engineering, University of Michigan, Ann Arbor, Michigan
+ M.S. Nuclear Engineering, University of Michigan, Ann Arbor, Michigan
+ Nuclear Engineer, University of Michigan, Ann Arbor, Michigan (This is an advanced degree that included 30 credit hours of course work beyond the Master of Science degree)
+ Twenty Five years of nuclear engineering experience: Radiological And Shielding Analysis, Conceptual Design Of Non-Reactor Nuclear Facilities, TMI, Unit 2 Recovery Effort, Decommissioning Projects, and Engineering In Association With The Design Of Nuclear Power Plants.

Experience: **WSRC-PE&CD – Systems Engineering, Principal Engineer. (10/89 to Present)**
+ Radiological Engineering Assignment (Safety Engineering Dept.): Perform Shielding Analysis And Source Terms Analysis, Radiological Design Criteria, Radiological Design In Association With The Immobilization Of Plutonium Materials
+ Conceptual Design Of Non-Reactor Nuclear Facilities: Conducting Engineering Studies, And Preparing Design Criteria. Projects included Interim Storage of Spent Nuclear Fuel and Storage of Vitrified Waste
+ Decommissioning Of Nuclear Facilities: Preparing Facility Characterization And Scope Of Work Reports
+ SRTC Assignment: Preparing Hazard Assessment Documents (HADs), and Coordination of Hazards Assessment Efforts
+ Regulatory Compliance Assignment: Identification of Standards that apply to DOE facilities in the functional area of nuclear safety

Burns and Roe, Inc., Principal Nuclear Engineer (1976 to 1989)
+ Three Mile Island, Unit 2 Recovery Effort Assignment (Middletown Pennsylvania 1983 to 1989): Acquisition, interpretation and analysis of data relating to conditions inside the damaged reactor vessel. Characterization of the extent of reactor and core damage. Shielding analysis.
+ Major contributor to a DOE project involving feasibility studies for using the Western New York Nuclear Service Center for solidifying the high level nuclear waste stored at the site (West Valley Demonstration Project)
+ Major contributor to the Shippingport Atomic Power Station Decommissioning Project. Assessment of one piece removal of the reactor vessel/internals.
+ Nuclear Engineering in association with the design of light water reactors (PWR Type). Design of reactor balance of plant, design of containment system, shielding analysis, and Site Suitability Source Term Analysis.

Combustion Engineering, Senior Physicist & Senior NSSS Engineer (1972 to 1976)
+ Study of core power performance aspects, and the interrelationship between the operating modes and operating margins. Responsibility for the development of an algorithm designed to provide core operating margin information. Supported the design of CE System 80 Nuclear Steam Supply System.

Appendix C

Paul Stutts Westinghouse Savannah River Company

Team Function: Core Team Member

Expertise: Facility Acceptance, Start Up, Acceptance and Operations. B.S Physics, University of Tenn. Chattanooga.

Overview

- Currently WSRC- Project Engineering & Construction Division-Systems Engineering (SE), Principal Engineer NMSS & New Missions Support, supporting projects and new mission areas.
- Seven years in the Projects Engineering and Construction Division, Systems Engineering, performing Lead functions in project transition and facility acceptance tasks.
- Twenty years in commercial power, including six years in nuclear facility management positions. Performed duties in Technical Support (System Engineering) and task management, Preventive Maintenance program management, QA oversight/monitoring of Plant (Systems) Engineering activities up to and including recommending operational readiness, management of overall plant operational activities (i.e. all systems operations, maintenance, and testing activities), and consultant to nuclear utilities in the areas of Configuration Management and Baseline Engineering, Startup, and Maintenance Program Development.

Experience: July 1990 to Present – WSRC Savannah River Company

Performed the following Lead Engineer functions for Systems Engineering:

- Replacement High Level Waste Evaporator Project including development of Project Turnover Plan, Functional Acceptance Criteria document and Test Plans
- Consolidated Incineration Facility SE Team tasks
- Chairman of the Systems Engineering Functional Acceptance Criteria committee
- Project Team coordination, development, and implementation of Title III Acceptance program.
- Coordination, development, and issue of Project Turnover Plans for Analytical Laboratory projects
- Drafting the first Project Verifications and Acceptance procedure for the DWP Facility.

January 1970 to June 1989:

- Bectel/IMC International, (Contract) Browns Ferry Nuclear Plant, Decatur AL. Baseline Design Engineer. Performed operability reviews, safety evaluations, and developed special post modification system performance tests to verify design basis.
- Houston Power and Light/Illini Tech., South Texas Project Nuclear Generating Station, Bay City, Tx.. Work Control Coordinator. Point of contact for priority variations and scheduling adjustments according to critical path during power ascension testing of Unit 2 and normal operations of Unit 1.
- Browns Ferry Nuclear Plant, TVA, Quality Assurance. Responsible for monitoring system engineering performance when evaluating systems for operational readiness.
- Bellefonte Nuclear Plant, TVA, Hollywood, AL. Manager responsible for overall administration/implementation of the preventive maintenance program and coordination of interfacing groups including Maintenance and Engineering, Quality Control Engineering, Division of Nuclear Construction, and Technical Support Services. Assistant to the Technical Support (Systems Engineering) Manager for task management and interfacing engineers with the Nuclear Steam Supply System (NSSS) Vendor, System Engineers, Construction Management, and Plant Maintenance Management. As Shift Operations Manager was responsible for operational supervision and coordination of all plant activities (i.e. all systems operations, maintenance, and testing).
- Paradise Steam Plant, TVA, Drakesboro, Ky. Directed the operation of a once-through supercritical, fossil fueled, 1100 megawatt electrical power generating unit. Supervised unit startup, operation and shutdown. Interfaced and coordinated work with maintenance sections to ensure maximum unit availability. Administered upgrade accreditation exams for operations personnel, assisted in instruction of student classes, and acted as Training Representative.

Appendix D

9.4. Appendix D: Team Domain Experts for Am/Cm Disposition Life-Cycle Planning Study

1. Chuck Alexander
Oak Ridge National Laboratory

Mr. Alexander received his Master of Science Degree in Nuclear Engineering from North Carolina State University. He has worked at the Oak Ridge National Laboratory from October 1976 to the present. During this time the focus of Mr. Alexander's responsibilities has been on waste partitioning and transmutation, fuel cycle analyses, heavy element production and recovery, integral cross section measurements, special isotope projects, general isotope production and recovery, and the ORNL Mark 42 Program.

2. T. Andes, Fuel Handling Engineering,
Westinghouse Savannah River Co
3. Spencer J. Brady, Principal Environmental Engineer
Westinghouse Savannah River Co. - Nuclear Materials Stabilization & Storage Division

Mr. Brady is a registered Professional Engineer with 19 years progressive experience in environmental project management, engineering and marketing in the nuclear, fossil fuel and waste incineration industries. His academic credentials include an MS in Civil Engineering, a BS in Geology, both from the University of Pittsburgh, along with graduate studies in Management and Finance at Carnegie-Mellon University. Mr. Brady began working at SRS in 1991 as a Project Manager on the Consolidated Incineration Facility and is currently responsible for managing the environmental permitting effort for the Actinide Packaging and Storage Facility. Mr. Brady is a former officer in the Air and Waste Management Association and is certified as a Registered Environmental Manager by the National Registry of Environmental Professionals. Prior to joining WSRC, Mr. Brady held positions of increasing responsibility at Westinghouse Electric Corp., Consolidation Coal Company and Consolidated Natural Gas Corporation.

4. S. Brooks,
Westinghouse Savannah River Co. - SFSE
5. Emory D. Collins, Senior Technical Advisor,
Oak Ridge National Laboratory- Chemical Technology Division

Mr. Collins is a chemical engineer with a B.S. ChE from Auburn University and graduate studies at the University of Tennessee. He is a member of the American Institute of Chemical Engineers, Sigma Xi, a former member of the American Nuclear Society, and a Professional Engineer in the State of Tennessee. Mr. Collins' career at ORNL began in 1965 in the Chemical Technology Division where he has served in various technical and technical management roles, most recently as Isotope Technology Program Manager and Section Head. Mr. Collins has been involved in numerous technical projects in the isotope production and radiochemical engineering fields.

6. R. Gromada,
Westinghouse Savannah River Co. -EFS/P&J
7. M. Hackney
Westinghouse Savannah River Co., Operations Support Lead, Receiving Basin for Offsite Fuel (RBOF),
Spent Fuel Storage Division

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Mr. Hackney is a mechanical engineer with a B.S.M.E. from West Virginia University. His career began in 1983 at the Savannah River Site where he has served in various management, engineering and supervisory roles.

8. Mohan Jerath
Westinghouse Savannah River Co., NMS&S-Engineering

Mr. Mohan Jerath has a B.S. degree in Mechanical Engineering and M.S. from University of Wisconsin. Mr. Jerath's career at SRS started in 1985 and has served in various technical and management positions in NMS&S. Prior to working at SRS, he had worked as a consulting engineer for 12 years for commercial, public and DOD installations in the Southeast. He has considerable experience in construction oversight, design, maintenance, startup and testing of various facilities and projects in Separations Engineering. He is a registered professional engineer in the State of Georgia. He has won several awards on site for using innovative methods for solving problems.

9. R. H. Jones, Trade Studies
Westinghouse Savannah River Co. - Nuclear Materials Stabilization & Storage Division
10. John E. Marra, Program Manager, Stabilization Process Development
Westinghouse Savannah River Co. - Savannah River Technology Center

Dr. Marra has a B.S. degree in Ceramic Science and a B.A. degree in Chemistry from the New York State College of Ceramics at Alfred University. He also holds a Ph.D. in Ceramic Engineering from The Ohio State University. Dr. Marra's career at SRS began in 1987 and he has served in various technical and management positions within the Savannah River Technology Center and the High Level Waste Management Division. He has considerable experience in the treatment of actinide materials. Dr. Marra is a Fellow of The American Ceramic Society and currently serves on the Board of Trustees and Executive Committee of the Society. He is the author of more than 30 technical papers.

11. William H. Martin, Am-Cm Design Authority Manager
Westinghouse Savannah River Co. - Nuclear Materials Stabilization & Storage Division

Defense Waste Vitrification Development, Naval Fuels Analytical Support & Processing, Mr. Martin is a chemist/manager with a B.S. Chemistry from Auburn University. He is a member of the American Chemical Society (ACS) and the National Management Association (NMA) where he is a Certified Manager (CM) through the Institute of Certified Professional Managers (ICPM). Mr. Martin's career began at the SRS in 1969 in the Analytical Laboratories Department and progressed through the Separations, Naval Fuels, High Level Waste Management, Savannah River Laboratory, and now with the Nuclear Materials Stabilization and Storage Division. He has held various technical and managerial roles involving the original Californium MPPF Processing, the Americium-241 MPPF Processing, PUREX Analytical Support, Highly Enriched Uranium Processing, and High Level Waste Storage & Treatment culminating with his most recent assignment as Design Authority for the Am-Cm Stabilization Project.

12. Erich Opperman, Manager, Packaging and Transportation Group
Westinghouse Savannah River Co. - Savannah River Technology Center

Responsible for design, testing, and certification of Type B transportation packaging since 1989. Mr Opperman has BS degrees in Physics and Mathematics, and an MS in Nuclear Engineering and has been actively involved in transportation packaging work for over 12 years. Mr Opperman has chaired ANS sessions on packaging, and has been selected to participate in numerous DOE appointed committees investigating radioactive material packaging design issues. Currently Mr Oppermans group

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is directly responsible for 5 DOE HQ Certified Type B packaging designs, 1 DOE AL Weapons packaging design, and leads the Commercial Light Water Reactor (CLWR) Transportation Program.

13. Donald R. Schilling
Idaho National Engineering Laboratory

Donald R. Schilling is an Engineering Fellow with Lockheed Martin Idaho Technologies at INEL. Mr. Schilling has a BS in EE from Drexel University. He is a member of the NMI Project Team providing systems engineering for the TRU material Team. He has provided SE for the Plutonium Focus Area (PFA), he was a principle author of the PFA Technology Summary (Rainbow Book) and he wrote the system requirements section for the NMSTG's, Project 94-1. Don teaches SE at the INEEL, has 20 years experience as a systems analyst, project leader, section head in the energy and aerospace industry, and has developed courses for ORNL and Hanford.

14. J. Thomas
Westinghouse Savannah River Co. - Nuclear Materials Stabilization & Storage Division

15. Bob Wham
Oak Ridge National Laboratory

Appendix E

9.5. Appendix E: Reviewers for Am/Cm Disposition Life-Cycle Planning Study

N. E. Barnett, Mgr.	WSRC: NMSS: Engineering & Technical Support (SE2230)
G. W. Becker	WSRC: Strategic Programs & Planning Department (AA1000)
J. S. Bellamy	WSRC: NMSS: Engineering & Technical Support (SE2230)
J. Bigelow	ORNL
A. W. Bower III, Mgr.	WSRC: NMSS/Project Integration (SL1000)
D. E. Buxton	WSRC: NMSS/F Canyon Facility (SG1200)
F. Cadek, Mgr.	WSRC: PECD/Systems Engineering (EA1B0)
T. G. Campbell	WSRC: NMSS/Engineering & Technical Support (SE2230)
J. D. Cohen, Mgr.	WSRC: SRTC/Engineered Equipment & Systems (L8000)
E. Collins	ORNL
J. E. Dickenson	WSRC: NMSS/Engineering & Technical Support (SN0000)
J. P. Duane, Mgr.	WSRC: NMSS/Trade Studies (SP1700)
R. A. Eubanks	WSRC: NMSS/H Canyon Systems Engineering (SE1810)
J. S. Evans, Mgr.	WSRC: NMSS/Separations Engineering (SE1000)
J. W. French	WSRC: NMSS/Engineering & Technical Support (SN0000)
M. Ferreu	ORNL
W. N. Jackson	WSRC: PECD/Systems Engineering (EA1B9)
G. V. Klipa	DOE-SR: Program Planning & Integration (5221100000)
J. Knauer	ORNL
W. H. Martin	WSRC: NMSS/Programs: AM/CM (SE1100)
R. S. Matthews	WSRC: NMSS/Trade Studies (SP1700)
S. W. Mcalhaney	DOE-SR: Materials & Facility Stabilization (5221000000)
V. C. Minardi, Mgr.	WSRC: NMSS/NMP Programs (SP1000)
A. P. Mock, Mgr.	WSRC: NMSS/F Canyon Engineering/Area Support (SE1600)
E. Moore	WSRC: Strategic Programs & Planning Department (AA1100)
L. M. Papouchado, Mgr.	WSRC: SRTC/Waste Mgmt. & Env. Technology (L3000)
J. Rushton	ORNL
T. F. Severynse	WSRC: NMSS/Trade Studies (SP1700)
R. W. Williams, Mgr.	WSRC: NMSS/Project Integration Actinide Verification (SL1200)

Appendix F

9.6. Appendix F: Am-Cm Vitrification Development Program Plan Overview

The Savannah River Technology Center (SRTC) has been working to develop a physical system to vitrify a nitric acid surrogate solution representative of material awaiting processing in F-Canyon. Details of the test program are provided in the Am-Cm Vitrification Development Program Plan (reference document, SRT-AMC-97-0111). The project to date has tested, evaluated, and redesigned the original "bushing" melter concept of 1994 through several iterations. "Bushing" melters designated as Melter 1, Melter 2, Melter 2A and Melter 2B have been installed and tested at the TNX Am-Cm Pilot Facility in 672-T. The Cylindrical Induction Melter (CIM) is the newest design to be evaluated in the Am-Cm development series.

The Cylindrical Induction Melter system installed at TNX is a pilot demonstration version of a more robust and remotely operable system to be installed in the Multipurpose Processing Facility (MPPF). The CIM system is located in 672-T. It consists of an inductively heated Pt-Rh containment vessel, two induction heating systems and power supplies, a control system, a chiller, and a simple off-gas filtering system. The difference between the CIM and previously tested Am-Cm systems is this Pt-Rh melter vessel is heated by induction and the previous bushing melters were direct fired.

An oxalate precipitate produced from the Am-Cm solution will be batched to the melter containing a carefully measured amount of glass forming frit. Volatilization products and other offgases will be swept into a semi-circular slotted hood positioned above the top of the CIM vessel, then drawn through a moisture separator and high efficiency particulate air (HEPA) filter before being exhausted to the stack. The glass flows from the bottom of the Pt-Rh vessel by gravity through an inductively heated Pt-Rh drain tube into a steel canister. A separate water chiller provides cooling water to the induction coils and heat stations to prevent overheating.

While the batch process using the CIM technology is the baseline process and has shown good results in initial tests, additional vitrification options are being investigated. The primary goal of this work is to evaluate the feasibility of performing 'in-can' vitrification of the Am-Cm material. In the 'in-can' concept, the material is processed in the containment vessel, eliminating the need for pouring. Low temperature glass compositions are being investigated in order to decrease the cost of the vessel (i.e., if melting temperatures can be reduced to <1150C, it may be possible to utilize a vessel constructed of Inconel-690 as opposed to the use of Pt-Rh using the current glass formulations). One of the concepts being investigated will use an oxalate precipitate feed and a Frit 165 (a well characterized DWPF frit) glass composition. A second alternative being investigated involves a process developed by the Russians using silica gel to absorb the Am-Cm material. In this process, the SiO₂ gel with the absorbed material is dried and/or calcined in a rotary calciner. The resultant calcined product could then be incorporated into a glass composition. These concepts will provide alternatives should the difficulty be encountered with the current baseline process.

Appendix G

9.7. Appendix G -- Off-Site Transportation -- Packaging Considerations

INTRODUCTION

All of the Am/Cm Disposition Alternatives ultimately include off-site shipment of immobilized materials to ORNL, with the exception of one option that dispositions Tank 17.1 solution to glass and then to the National Repository. This Appendix includes: (a) An assessment of key regulatory requirements that the shipments must satisfy; (b) Identification of actions needed to satisfy key regulatory requirements; and; (c) some planning of the off-site shipment campaign.

ASSUMPTIONS:

1. The Am/Cm glass form placed in a canister in combination with a welded steel container should enable approval for shipping the Am/Cm in a single containment cask (E. Opperman, SRTC Packaging) (See report Section 6.7.4).
2. If double containment is required for shipping, several options exist. (See Appendix H, Section 9.8.2). For the Base Case, Alternative 1, and Alternative 2, it is assumed that the primary shipping containers (CwP-1 or msQSC) can be qualified and licensed as forming the primary containment around the Am/Cm glass canisters. The qualification of the primary containment vessels, and subsequent evaluations of the shipping package (using a cask designed and approved for single confinement) would enable the project to ship the Am/Cm materials off-site.

BASIS

Geometry

1. The inner cavity of the NLI cask is 178" Long x 12.63" ID (Reference 1). It is assumed that other spent fuel type casks will have similar cavities. Therefore, existing casks will be capable of physically holding the material. A loading basket will have to be designed and built for holding the canisters in the cavity.
2. The canisters within the primary shipping containers (CwP-1 or msQSC) will be loaded into the cask in a single column (axial configuration). The NLI cask cavity will be able to accommodate eight (8) canisters. The eight (8) packaged canisters will take up approx. 136 inches. This will leave 42 inches for additional shielding that may be required at the ends, or near the cask opening.
3. The column loading in the cask will satisfy the ORNL can unloading method.

Shielding (Dose Rates)

1. Shipping the Am/Cm will require casks that include both neutron and gamma shields. The NLI cask incorporates both neutron and gamma shields. The shielding configuration of the NLI cask includes: depleted uranium, lead, and borated water.
2. Scooping shielding calculations performed for the NLI cask (reported in Reference 2) show that if the diameter of the glass within the canister does not exceed 2 inches, the 2 meter (distance from cask surface) dose rate requirement of less than 10 mrem/hour is met.

Containment:

1. Regulatory requirements in 10CFR71.63 call for a second containment for shipments containing more than 20 Ci of plutonium. Assuming eight (8) canisters per shipment, the 20 Ci limit will probably be exceeded. Even six canisters would probably exceed the 20 Ci limit. But, for shipments of Am/Cm in glass form it is still not clear if the second container would need to undergo the certification required for double containment. The SRS packaging group is evaluating this.

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2. Based on plutonium measurements of Tank 17.1 contents performed on 2/93, the tank holds 3,090 Curies of plutonium (Ref. 3). Pretreatment of the tank contents will remove a significant portion of the plutonium. Up to 80% (Ref. 4 & 5) of the plutonium may be removed during pretreatment. However, the exact plutonium retention in the glass is still undergoing review, and not yet known. There will also be some in-growth of Pu-240 due to decay of Cm-244. This additional activity is estimated at 170 Curies (by 2/02). The activity per glass canister also depends on the number of canisters that will be produced. It is estimated that the Am/Cm vitrification effort will result in the production of between 150 to 200 glass canisters (Ref. 1). Preliminary estimates based on 30% plutonium retention show that the activity per canister may range from 4.7 to 6.5 Ci/can. This implies that including more than 3 to 4 glass canisters per shipment may result in the plutonium activity exceeding the 20 Curies threshold.
3. The current plan is to ship the Am/Cm materials to ORNL in single containment casks. Spent fuel type casks (like the NLI cask) are single containment casks. It is further planned to include up to eight (8) glass canisters in each off-site shipment. Based on geometry considerations this can be achieved. If shipments incorporating eight (8) canisters exceed the 20 Curies/shipment plutonium threshold, the plan to ship in a single containment cask may be defended by argument presented under Assumptions (Item 1). If not, another containment level will be required and is shown in several options. The entire shipping package would then require qualification.

Thermal Limits

The overall heat load of the contents of Tank 17.1 is estimated at 8,000 watt (Ref. 1, H. Martin). This implies that the heat load per canister will range from 40 watt/can (for 200 canisters) to 53 watt/can (for 150 canisters). The maximum decay heat load for a shipment of eight (8) glass canisters is estimated at ~420 watts. A survey of a number of spent fuel casks shows that the dissipation of 420 watts of decay heat can be readily accommodated and that decay heat is not an issue. The decay heat limit of the NLI cask is 750 watts (E. Apperson, SRTC Packaging).

COST:

1. The typical leasing cost for a cask is \$57,000 for a 10 day period. There is a charge of \$4,000/day for increasing the lease time beyond 10 days.
2. The cask lease fee for 12 shipments per year is approximately \$500,000.
3. The cost for trucking the loaded cask to ORNL and the empty cask back to SRS is \$2,400 (round trip).
4. The cost for buying a cask is approximately \$3 Million.
5. The cost for re-qualifying a cask, i.e. from single containment to double containment would be ~\$ 1.5 Million. (Assumes cost of container and it's design are zero, i.e. complete)

REFERENCES:

1. US Nuclear Regulatory Commission, Certificate of Compliance for Radioactive Material Packages, Certificate Number 9010. This Document provides a description of the NLI Cask.
2. WSRC, Inter-Office Memorandum (All-In-1) from Robert L. Frost to Richard J. Gromada, Titled: Am/Cm, dated 12/19/95. This memorandum reports the results of a 1-D scoping shielding analysis for Am/Cm packaging.
3. WSRC Document #NMP-PRG-961887, titled: Material Control and Accountability Analysis for F-Canyon Am/Cm Process, by T. G. Clark, dated 11/20/96.
4. WSRC Document #WSRC-TR-96-0228-TL, titled: Material Balance Calculations for Am/Cm Pretreatment Flowsheet. By: F. G. Smith, III, dated 7/29/96.
5. Personal communications R. Rainisch (PE&CD, SE) and Herb Martin (NMSS), March 1998

Appendix H

9.8. Appendix H: Representative Figures.

9.8.1. Legend

Canister

Container with Pintle (CwP) [note: pintle used for lifting]

- CwP-1 = qualified container per shipping requirements,
- CwP-2 = not a qualified container per shipping requirements, only provides contamination control
- CwP-3 = a CwP-2, with crimped tube(s) used to remove water and add helium

Mechanical Sealed Qualified Shipping Container (msQSC)

Shipping Cask

Appendix H

9.8.2. Packaging Figures

Appendix H

9.8.3. Mark 18 Packaging Figures

9.8.4. Tank 17.1 Disposition Functional Flow Paths
Appendix H

Am/Cm Tank 17.1 Solution Disposition Alternatives

9.8.5. Mark 18 Disposition Functional Flow Paths
Appendix H

Appendix H

9.8.6. Slugs/Other Disposition Functional Flow Paths

Appendix I

9.9. Appendix I – Expanded Base Cases and Alternatives

Introduction

This appendix provides an expanded review of the Am/Cm Disposition Path overviews shown in Section 6.7.1 through 6.7.9. This review begins with an intermediate look at the primary functions by means of a premise listing, a schedule, process rates, costs breakdowns and repetition of the objectives to be met that would enable the case under review to move forward. Each primary function is then further broken out into a more detailed review by means of including the sub-functions, requirements, interfaces, issues, assumptions and costs.

9.9.1. Tank 17.1 "Solution" Disposition - Base Case

Flow chart: Base Case

Primary Functions - Base Case

- 9.9.1.1 Make glass
- 9.9.1.2 Weld the glass canisters in Containers Qualified per Shipping Requirements (CwP-1)
- 9.9.1.3 Transport the CwP-1's to RBOF
- 9.9.1.4 Store CwP-1's in RBOF
- 9.9.1.5 Ship to ORNL via RBOF
- 9.9.1.6 Store material at ORNL

Premise: Base case

- All operations are remotely controlled.
- The Am/Cm in solution is immobilized by vitrification.
- The glass is sealed in stainless steel canisters.
- The glass form (canisters) provide no containment function and may require qualified primary and secondary containment for shipping.
- The CwP-1s provide a qualified primary containment function (full penetration weld) around the vitrified Am/Cm.
- Welding and leak testing are performed within the F-Canyon Multi-Purpose Process Facility (MPPF).
- A Helium atmosphere is provided internal to the primary containment vessel.
- Existing canyon equipment is utilized to transport the CwP-1s through the canyon, decontaminate the CwP-1s, and load the CwP-1s into the on-site shipping cask.
- Transport of the CwP-1s to RBOF is by rail.
- At the Receiving Basin for Off-site Fuel (RBOF) existing equipment is utilized to remove the CwP-1s from the on-site shipping cask, and to place the CwP-1s in lag storage.

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- The CWP-1s remain in lag storage in RBOF until ready for shipment to ORNL.
- Prior to leaving RBOF the CWP-1s are decontaminated and loaded into a qualified off-site shipping cask for transport to ORNL.
- ORNL receives the off-site shipping cask, unloads the cask, and stores the CWP-1s.
- The off-site shipping cask is either returned to SRS, or to the company from which it was leased (Depending on cask ownership, and/or leasing arrangements).

Schedule

- Glass production of Am/Cm to start 7/01 and end between 1/02 to 3/02 (basis: Current Planning Agreements).
- Deactivation PUREX is assumed to begin 10/1/02.
- Round trip for off-site casks to ORNL and back to RBOF is approximately 2 weeks.
- ORNL is to receive all shipments by 2006.
- The qualification and NRC approval, of a double containment cask (if necessary) for shipment of Am/Cm canisters to ORNL may take 3 to 5 years.

Rates

- Canister production to be 25 per month. (Assuming 200 canisters produced from 7/01 to 3/02).

Cost

- R&D, Project, Operations/Maintenance costs (no D&D) to place canisters/carriers into racks -- \$80M
- Design and installation of welder in MPPF -- \$1.7M
- Design and installation of storage space at ORNL -- \$7M
- Shipment from F Canyon to RBOF -- \$150K to \$300K
- If materials are not removed from RBOF before scheduled RBOF closure, storage costs will be \$10K per week. Since no impact is expected, no cost is included.
- Shipment to ORNL -- \$1.2M to \$2M
- The qualification and approval, of a double containment cask (if necessary) for shipment of Am/Cm canisters to ORNL -- \$1.5M
- The acquisition of a double containment cask (if necessary) for shipment of Am/Cm canisters to ORNL -- \$3.0M
- Operational cost of ORNL not included -- Considered an ongoing operation.
- Operational cost for F-Canyon is estimated as within normal operating costs.

Issues

- Establish if off-site shipment of Am/Cm materials to ORNL requires a single or double containment cask. Containment requirements depend on package plutonium contents (up to 20 Curies of plutonium can be shipped in a single containment package).
- In order not to affect D&D of the F-Canyon, the goal is to remove all the Am/Cm materials (CWP-1s) from F-Canyon as soon as possible.
- If vitrified material remains in F Canyon after D&D of PUREX is completed (current schedule is FY03) any additional D&D must consider functions needed to remove material from the canyon. If the required functions to remove the Am/Cm are scheduled for D&D, the costs and risks associated with keeping these functions available will probably be allocated to the Am/CM removal project/program.

Enabling Objectives

- Obtain funding for further process and equipment development
- Complete R&D project on schedule
- Design and install welder in F Canyon
- Add storage area to ORNL
- Fund operation of F Canyon systems required to support Am/Cm disposition

Appendix I

9.9.1.1. Function: Make Glass- Tank 17.1 "Solution"- Base Case

Sub-Functions

- Perform Pretreatment of Tank 17.1 oxalic acid (remove transition metals, such as Cr, Ni, and Fe)
- Transfer solution from Tank 17.1 to feed tank in Multi-Purpose Processing Facility (MPPF)
- Feed solution to melter and combine with flow of glass frit
- Charge melter & Vitrify dissolved solids
- Treat off-gas stream if needed
- Drain molten glass from bottom of melter into "canister"
- Seal "canister"
- Transfer sealed canister to "carrier"
- Transfer loaded carrier to "rack" and lag store
- Perform MC&A (calorimeter measurement)

Requirements:

- Glass product shall be nitric acid soluble (Only process available to ORNL)
- Glass chemistry and canister design are to interface with ORNL {ORNL equipment will be used to handle canisters}
- Glass shall be capable of being "broken up" into chunks {Enables increased surface exposure to nitric acid, which decreases the dissolution time. ORNL proposed process: cut open canister, drill vertically into glass, break up within canister, dump out of canister and crush glass chunks to further decrease size}
- Dissolution at ORNL time goal: Two (2) days or less per canister {If greater than two days costs become prohibitively high}
- During dissolution, silica shall drop out of solution and remain behind in dissolution vessel {Silica creates problems if carried downstream in ORNL process}
- Minimize potential RCRA issues, i.e. minimize lead content
- Operations are to be performed remotely and shall be encompassed under each facility Authorization Basis {Minimize expected worker radiation exposure during operations}

Note: Verification of product recovery is being performed by WSRC-SRTC sending glass samples to ORNL for testing.

Interfaces

- MPPF equipment (manipulators, turntables, racks, crane, etc.) and new CwP-1 welder installation.
- ORNL chemical and equipment characteristics

Issues:

- Glass loading affects ability to vitrify
- Design and install canister seal/containment welder is not in the budget
- Canyon Authorization Basis deals with Americium Curium in 17.1. Moving the material into a process environment may require USQD be performed to determine mitigating factors. Potential cost impact exists for mitigation factors.
- Pu content may effect shipping.
- Making glass assumes an 80% reduction in Pu content. If less than 20 curies may not stay that way. Short half life allows Pu 240 & 241 to creep back in from decay
- Technical Maturity of Americium/Curium vitrification process (R&D)

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Assumptions

- It is assumed that the plutonium content per shipment exceeds 20 Curies. The amount of plutonium per shipment depends on a number of factors, these are: (a) The amount of plutonium removed during pretreatment; (b) The total number of glass canisters produced; and (c) The number of glass canisters per shipment. When the plutonium content per shipment exceeds 20 Curies the shipping package is required to incorporate a primary and secondary containment.
- The above assumption must take into account the total number of canisters to be produced. Currently the number of canisters is thought to be in the 150 - 200 range.
- An off-site shipping cask may be designed/modified so that it will accept the desired number of canisters without exceeding the casks radiation shielding requirements.
- Project rebaseline being performed 1stQuarter FY99, will conclude \$80M is correct and will not be exceeded.

Schedule

- Operations will start 7/01 and end between 1/02 to 3/02. (Basis: Current Planning Agreements)

Cost:

- The overall Cost is \$80M. This Includes all R&D, Project, Operations/Maintenance costs (no D&D) to place canisters/carriers into racks

9.9.1.2. Function: Weld the glass canister(s) in the CwP-1s - Tank 17.1 "Solution" - Base Case

Sub-functions

- Remove canister from lag storage racks
- Load canister into unsealed CwP-1
- Load unsealed CwP-1 into welder
- Full penetration weld the CwP-1s
- Charge CwP-1s with Helium gas
- Perform leak test
- Remove sealed CwP-1 from welder and place in slug basket.
- Repeat functions above, until slug basket is loaded with CwP-1s

Requirements

- The system shall be capable of transferring a full carrier/slug basket with up to 5 canisters within the MPPF cells.
- CwP-1s shall be qualified as a primary containment barrier.
- ORNL preference; Canister with helium atmosphere so helium leak test may be performed (aids in meeting current SAR)
- CwP-1s shall have a handle/pintle and fit ORNL equipment.
- CwP-1s outside diameter shall not exceed 4" and length shall not exceed 34", including pintle. (ORNL chutes are 4" ID.)
- Welder modification must be acceptance tested and completely operational when MPPF modifications and current project are complete.

Interfaces

- MPPF and F-Canyon handling equipment
- Am/Cm Vitrification project.

Appendix I

Issues

- Welder designed by SRTC does not accommodate a full penetration weld.
- There is no Helium supply in the MPPF.
- Room for operation and storage in the MPPF is limited.
- The MPPF is a high contamination area, and welding in this environment to produce a clean surface may be hard. A mitigating approach would be to enclose the welded CwP-1 in an outer mechanically sealed Qualified Shipping Container (msQSC) outside of MPPF.

Assumptions

- CwP-1 is to provide a qualified primary containment function for shipping.
- Helium is to be used for leak testing purposes.
- Up to two (2) canisters are loaded into each CwP-1.
- Existing F-Canyon equipment is compatible with CwP-1 and/or carrier/slug basket design.
- Existing RBOF equipment is compatible with CwP-1s.

Schedule

- Welder modification must be acceptance tested and complete by 1/01.
- Welding of CwP-2s should be completed before the start of F-Canyon deactivation to make D&D a non issue, otherwise D&D may require "engineering/better planning" to insure functions are available.

Cost:

- Design and installation of the welder and weld qualification will add another \$1.7M.

9.9.1.3. Function: Transport CwP-1s to RBOF - Tank 17.1 "Solution"- Base Case

Sub-functions

- Decontaminate CwP-1s and slug basket.
- Perform radiation survey.
- Load slug basket with CwP-1s into on-site shipping cask
- Complete appropriate paper work, (Railroad dispatch material control and accountability forms).

Requirements

- All operations including movement of CwP-1s, decontamination, radiation survey and loading of the on-site shipping cask shall be remotely controlled. {Minimize expected worker radiation exposure during operations}
- Transport shall comply with on-site shipping requirements/regulations, 19Q Manual - Radioactive Material Packaging Certification and Authorization Requirements
- Decontaminate CwP-1s to 45,000 dpm/100 cm² (Beta Gamma) and TBD dpm/100 cm² (Alpha) to qualify for on-site shipment. {RBOF requirement prior to acceptance criteria in to the facility}.
- All canisters shall be removed from F Canyon prior to deactivation of the following functions; canyon decontamination cell, crane, and additional functions required for storing material in MPPF.

Interfaces

- RBOF schedule
- On-site shipping requirements.

Issues

- Level of radiation is high due to material being handled.
- Present capability of F-Canyon to Decontaminate a vessel to a very low level is limited.

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- The tasks has not been performed with this material. The F-Canyon Railroad Tunnel has no provision for filling the cask with water. It is not clear if the shipments will include filling the cask with water, or not. Water may be needed to meet shielding requirements.

Assumptions:

- The loading operation meets the authorization basis limitations.
- Decontamination waste streams remain within operating basis.
- Approximately 8,000 gallons/batch of decontamination liquids is collected by the High Activity Waste System.
- It is assumed that six (6) glass canisters (3 CwP-1s) can be included in each on-site shipment.
- Canyon deactivation may begin in 2002 and end in 2006. It is assumed that all CwP-1s can be removed before the end of F-Canyon deactivation. Functions required of crane and decontamination area are assumed to remain open until the end of F-Canyon deactivation.

Cost

- \$150K - \$300K for shipment from F Canyon to RBOF dependent on number of canisters.

Schedule

- Start transfer of CwPs to RBOF ASAP (in order not to interfere with F-Canyon and RBOF deactivation and closure dates).

9.9.1.4. Function: Store in RBOF- Tank 17.1 "Solution"- Base Case

Sub-functions

- Perform radiation survey of cask, while on rail car.
- Unload On-Site Cask and stage cask for underwater unloading of slug basket with CwP-1s
- Unload CwP-1s and place in lag storage
- Decontaminate slug basket and return it to F-Canyon

Requirements

- Meet RBOF Material Acceptance Criteria.
- Shipping package has to meet U.S. Department of Transportation, Title 49, CFR Parts 100 through 189, DOE Order 5480.3, and NRC Regulations, Title 10, CFR, Part 71.
- Handling of Am/Cm materials shall be remotely controlled.
- All material will have to be shipped out by RBOF closure date in 2006.

Interfaces

- F-Canyon schedule
- ORNL Schedule

Issues

- ORNL requirements are not fully defined.
- Final number and design of CwP-1s is not detailed.

Assumptions

- Each CwP-1s contains 2 canisters and RBOF gets 3 CwP-1s per shipment.
- Only minor modifications and little if any training will be required to handle the material.
- Heat load does not become an issue.

Schedule

- 24 hours are required to have a cask emptied and waiting on smear to return to canyon. RBOF closure date is 2006.

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Cost

- If storage delays RBOF decommissioning the cost is \$10K per week.

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9.9.1.5. Function: Ship to ORNL via RBOF- Tank 17.1 "Solution"-Base Case

Sub-functions:

- Stage off-site cask for shipping.
- Leak Test CwP-1s
- Place CwP-1s in cavity of off-site cask.
- Seal the package in the wet pit, transfer to dry pit, and decontaminate package.
- Load package on flat bed truck and prepare for shipment.

Requirements:

- Leak Test CwP-1s: To meet "Special Shipment" the vessel qualified as a "containment" vessel, must be leaked tested within one year of shipment.
- Shipping package has to meet U.S. Department of Transportation, Title 49, CFR Parts 100 through 189, DOE Order 5480.3, and NRC Regulations, Title 10, CFR, Part 71
- The loading of the off-site shipping cask is to be remotely controlled.
- CwP-1s and associated pintle are to be centered in the shipping sleeve for retrieval by ORNL equipment.
- The off-site shipping cask will have to satisfy: (a) Shielding requirements; (b) Containment requirements; and (c) Heat generation rate.
- RBOF will be available until 2006 and all materials stored in the facility will have to be removed by this date.
- Decontaminate casks to 2,200 dpm/100 cm² (Beta Gamma), TBD dpm/100 cm² (Alpha) to qualify for Off-Site Shipment.

Interfaces

- ORNL facility, equipment and schedule
- NRC & DOT - Shipping Cask Qualification

Issues

- It is not clear if the off-site shipping cask (package) for Am/Cm canisters will require double or single containment. Containment requirements will depend on package plutonium contents (up to 20 Curies of plutonium can be shipped in a single containment package). The plutonium content of the canisters is not known at this stage. Tank 17.1 is estimated to contain a total of approximately 2.5 kg of various plutonium isotopes. However, it is not known: (a) How much of the plutonium will be removed during pretreatment; and (b) The exact number of canisters to be produced. Single containment casks may be available and can be leased. However, double containment casks are not readily available. This may result in the following: (a) A new double containment cask will have to be developed and licensed (a major undertaking); or (b) the number of canisters included in each off-site shipment will have to be limited.
- The design and licensing of a double containment cask for shipment of Am/Cm to ORNL may take 4 years complete and cost \$4 Million.
- The number of canisters that can be loaded in a single cask also depends on shielding considerations. The Am/Cm canisters are highly radioactive, and loading too many canisters in a single cask may result in excessive dose rates around the cask. The acceptable number for a particular cask will have to be established by analysis.
- There are no shipping facilities available after RBOF shuts down
- The ORNL receiving requirements and acceptable CwP-1 requirements are not firm

Assumptions

- Cask certified for transportation of Am/Cm canisters is obtained. This may include the leasing of an existing cask or the certification of a new cask.

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- Prepare Safety Analysis Report for off-site shipping package (SAR), and obtain approval from DOT is complete.
- ORNL has new storage room available and equipment and personnel are ready for receipt

Schedule

- RBOF will be available until 2006
- Rate From time the off-site cask is received at RBOF, it can be ready to return to ORNL in 72 hour.

Cost

- The qualification and approval, of a double containment cask (if necessary) for shipment of Am/Cm canisters to ORNL -- \$1.5M
- The acquisition of a double containment cask (if necessary) for shipment of Am/Cm canisters to ORNL -- \$3.0M
- Cask rental and shipment costs for 150-200 canisters at eight per shipment -- \$1.2-2.0M

9.9.1.6. Function: Store material at ORNL- Tank 17.1 "Solution"- Base Case

Sub-functions

- Perform contamination survey.
- Unload off-site shipping cask from truck flatbed.
- Remove cask lid and spacer.
- Place unloading lid on the cask. This provides for a small opening (pie shaped) through which cask contents are unloaded.
- Place Transfer Cask on top of off-site cask (Transfer cask has a special pick-up tool that allows Pulling one CwP-1 at a time out of the cask into the transfer cask)
- Use Transfer Cask to unload CwP-1s into hot cells.

Requirements

- Unloading and storage operations are performed remotely.
- CwP-1s are shipped to ORNL and stored in hot cell, must have pintle on one end.
- The CwP-1s received and stored at ORNL for this "Base Case" shall meet long term storage criteria.
- Dimensions of equipment received shall interface with ORNL handling storage facilities.

Interfaces

- ORNL facility, equipment and schedule
- SRS facility shipping schedule
- NRC & DOT - Shipping Cask Qualification

Assumptions

- The higher heat loading to the storage facility is within the operating basis, and can be handled with minor modifications to existing ventilation systems.
- Neutron source terms will not present a significant issue.
- If the material can be shipped, ORNL can accept it.

Issues

- There is no ORNL Acceptance Criteria in writing.
- Multiple interfaces implies probable schedule delays.

Schedule

- RBOF will be available until 2006
- Rate from time the off-site cask is received at RBOF, it can be ready to return to ORNL in 72 hour.

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- Following ~4days from arrival @ ORNL cask can be ready for off-site shipment to SRS.
- ORNL will take shipments until year 2006.

Cost

- New facility storage area will cost \$7M assuming Pu238 project shares part of cost.
- On site operations are on going and add no additional cost

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9.9.2. Tank 17.1 "Solution" Disposition - Alternative One

Flow chart: Alternative One

Primary functions - Tank 17.1 Solution - Alternative One

- 9.9.2.1 Make glass
- 9.9.2.2 Transport glass canisters to RBOF
- 9.9.2.3 Weld glass canister(s) in CwP-3
- 9.9.2.4 Enclose CwP-3(s) in (msQSC)
- 9.9.2.5 Store in RBOF
- 9.9.2.6 Ship to ORNL via RBOF
- 9.9.2.7 Store material at ORNL

Premise: Alternative One

- All operations are remotely controlled
- The Am/Cm in solution is immobilized by vitrification
- The glass is sealed in stainless steel canisters in the F-Canyon Multi-Purpose Process Facility (MPPF).
- The canisters are decontaminated in F-Canyon and transported to the Receiving Basin for Off-Site Fuel (RBOF).
- The canisters provide no containment function and must have a primary and secondary containment for shipping.
- Existing F-Canyon equipment is utilized to place the canisters in slug baskets, transport through the canyon, decontaminate the canisters, and load canisters into the on-site shipping cask.
- At the Receiving Basin for Off-Site Fuel (RBOF) existing equipment is utilized to remove the canisters from the on-site shipping cask.
- The on-site shipping cask is returned to F-Canyon.
- Welding equipment installed in RBOF performs seal welding of CwP-3s
- A Helium atmosphere is provided internal to the CwP-3s.
- Leak testing and decontamination of CwP-3s are performed within the RBOF.
- The welded containment vessel is placed in a Mechanical Sealed (bolted) Qualified Shipping Container.
- RBOF lag stores the msQSC until ready for shipment to ORNL.
- RBOF loads the msQSC into a qualified Off-Site shipping cask for transport to ORNL.
- The Off-Site transport cask into which the msQSC are placed is qualified as a secondary containment for shipment.
- ORNL receives the Off-Site shipping cask, unloads the msQSC, stores the msQSC, and returns the off-site shipping cask to SRS.

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Schedule

- Glass production of Am/Cm to start 1/01 and end between 1/02 to 3/02 (basis: Current Planning Agreements)
- Deactivation of the PUREX may start on 10/1/02. In order not to affect D&D of F-Canyon, the goal is to remove all the Am/Cm materials (glass canisters) from F-Canyon as soon as possible.
- Round trip for Off-Site casks to ORNL and back to RBOF is about 2 weeks
- ORNL is to receive all shipments (including Mark 18s) by FY2006.

Rates

- Canister production to be 25 per month. (Assuming 200 canisters produced from 7/01 to 3/02).

Cost

- R&D, Project, Operation/Maintenance costs (no D&D) to place canisters/carriers into racks -- \$80M
- Shipment to RBOF -- \$150K to \$300K
- Design and installation of a welder in RBOF - \$3
- Operational cost of F-Canyon and RBOF not included -- Ongoing operation for glass
- Shipment to ORNL -- \$1.2 to \$2M
- The qualification, approval, and licensing of a double containment cask (if necessary) for shipment of Am/Cm canisters to ORNL -- \$1.5M
- The acquisition of a double containment cask (if necessary) for shipment of Am/Cm canisters to ORNL - \$3.0M
- Design and installation of storage space at ORNL -- \$7M
- Operational cost of ORNL not included -- Ongoing operation.

Issues

- Establish if off-site shipment of Am/Cm materials to ORNL requires a single or double containment cask. Containment requirements depend on package plutonium contents (up to 20 Curies of plutonium can be shipped in a single containment package).

Enabling Objectives

- Obtain funding for further process and equipment development
- Complete R&D project on schedule
- Design and install welder in RBOF
- Add storage area to ORNL
- Fund operation of F Canyon systems required to support Am/Cm disposition.

9.9.2.1. Function: Make Glass - Tank 17.1 Solution Disposition - Alternative One

See Function 9.9.1.1 - Make Glass - Base Case

9.9.2.2. Function: Transport glass canisters to RBOF - Tank 17.1 Solution Disposition - Alternative One

Sub-functions

- Remove canister from lag storage racks
- Repeat functions above, until a slug basket is loaded with 5 to 6 canisters
- Decontaminate canisters and slug basket
- Perform radiation survey
- Load slug basket into on-site shipping cask
- Complete appropriate paper work, (Railroad dispatch material control and accountability forms).

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Requirements

- All operations including movement of canisters, decontamination, radiation survey and loading of the on-site shipping cask shall be remotely controlled. (Minimize expected worker radiation exposure during operations).
- The system shall be capable of transferring a full carrier/slug basket with up to 6 canisters within the MPPF cells.
- Transport shall comply with on-site shipping requirements/regulations, 19Q Manual - Radioactive Material Packaging Certification and Authorization Requirements
- Decontaminate canisters to less than 45,000 dpm/100 cm² (Beta Gamma) and TBD dpm/100 cm² (Alpha) to qualify for on-site shipment. {RBOF requirement for acceptance criteria into the facility}.
- All canisters shall be removed from F-Canyon prior to deactivation of the following functions: Canyon decontamination cell, crane, and additional functions required for storing material in MPPF.

Interfaces

- MPPF and F Canyon handling equipment
- Am/Cm Vitrification project
- RBOF schedule
- On-site shipping requirements

Issues

- Level of radiation is high due to material being handled.
- Present capability of F-Canyon to Decontaminate a vessel to a very low level is limited.
- The tasks have not been performed with this material. The F Canyon Railroad Tunnel has no provision for filling the cask with water. It is not clear if the shipments will include filling the cask with water, or not. The need for water is based on shielding requirements.

Assumptions:

- The loading operation meets the authorization basis limitations.
- Slug basket is used as canister carrier and loaded into site CD cask.
- Decontamination waste streams remain within operating basis.
- Approximately 8,000 gallons/batch of decontamination liquids is collected by the High Activity Waste System.
- It is assumed that six (6) glass canisters can be included in each on-site shipment.
- Canyon deactivation begins in 2002 and ends in 2006. It is assumed that all canisters can be removed before the end of F-Canyon deactivation. Functions required of crane and decontamination area are assumed to remain open until the end of F-Canyon deactivation.

Cost

- Shipment to RBOF -- \$150K - \$300K

Schedule

- Start transfer of CwPs to RBOF ASAP (in order not to interfere with F-Canyon and RBOF deactivation and closure dates).

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9.9.2.3. Function- Weld Glass Canisters in CwP-3 - Tank 17.1 Solution Disposition - Alternative One

Sub-functions

- Perform radiation survey of cask, while on rail car.
- Unload On-Site Cask and stage cask for underwater unloading of slug basket with canisters
- Unload canisters and place in lag storage
- Load every two canisters into an unsealed CwP-3
- Load unsealed CwP-3 into welder
- Seal weld the CwP-3 and Charge with Helium gas
- Perform leak test
- Remove sealed CwP-3 from welder and place in msQSC.

Requirements

- Welder must be compatible with under water environment, RBOF equipment , canister and CwP-3 design
- ORNL preference; CwP-3 with helium atmosphere so helium leak test may be performed (aids in meeting current SAR)
- CwP-3 shall have a handle/pintle and fit ORNL equipment.
- CwP-3 outside diameter shall not exceed 4" and length shall not exceed 34", including pintle. (ORNL chutes are 4" ID).

Interfaces

- RBOF schedule
- RBOF remote handling equipment
- On-site shipping requirements

Issues

- No experience with welding in RBOF
- Welding will require special training of workers
- Impact of storing multiple potentially leaky canisters in terms of contamination on RBOF operations.
- The design of the welder is still pre-conceptual
- A NEPA checklist would be required

Assumptions

- The welding can be performed under water.
- The CwP-3 is to provide a confinement function.
- Helium is to be used for leak testing purposes.
- Two canisters are loaded into each CwP-3.
- The weld of the CwP-3 is not a full penetration weld.
- Radiation levels do not constitute a handling problem for RBOF or ORNL.

Schedule

- The welder must be installed, acceptance tested, and complete by 3/02.

Cost:

- The cost of the welder is estimated at \$3M.

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9.9.2.4. Function: Enclose CwP-3(s) in msQSC - Tank 17.1 Solution Disposition - Alternative One

Sub-functions

- Place two CwP-3 into each msQSC
- Place cover on msQSC and torque bolts
- Stage msQSCs for lag storage.

Requirements

- All operations are to be remotely controlled
- The msQSCs shall meet ORNL equipment interfaces (i.e., pintle for handling).

Interfaces

- RBOF schedule
- RBOF remote handling equipment.

Issues

- ORNL will have to develop the means for opening the msQSCs while still in the shipping cask, so that CwP-3s can be unloaded
- The design of the CwP-3s and msQSCs is still pre-conceptual.

Assumptions

- Each msQSC contains two (2) CwP-3s
- Canister contamination is low enough to achieve a low level contamination of the CwP-3s.

Schedule

- RBOF will be available until 2006.

Cost

- Operations assumed to be within RBOF operating costs.
- Cost of msQSCs is assumed to be ~\$5K each -- \$90-130K

9.9.2.5. Function: Store in RBOF- Tank 17.1 Solution Disposition - Alternative One

Sub-functions

- Place msQSCs in lag storage.

Requirements

- Handling of Am/Cm materials shall be remotely controlled
- All material will have to be shipped out by RBOF closure date estimated at 2006.

Interfaces

- RBOF schedule

Issues

- Perform criticality and radiation analysis prior to lag storage at RBOF
- Final number and design of mechanically sealed containers (msQSCs) is not defined.

Assumptions

- Each msQSC contains two (2) CwP-3s and ORNL gets two (2) msQSCs per shipment.

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Schedule

- RBOF closure date is 2006.

Cost

- If decommissioning of RBOF is delayed, operating cost is \$10K per week.

9.9.2.6. **Function: Ship to ORNL via RBOF - Tank 17.1 Solution Disposition - Alternative One**

See Tank 17.1 Solution Disposition - Base Case- Function 9.9.1.5

9.9.2.7. **Function: Store material at ORNL - Tank 17.1 Solution Disposition - Alternative One**

See Tank 17.1 Solution Disposition - Base Case- Function 9.9.1.5

Exceptions:

Requirements

- The msQSCs shipped to ORNL shall interface with Cask handling/unloading equipment.
- CwP-3 shipped to ORNL and stored in hot cell must have pintle on one end.

Assumptions

- ORNL will handle CwP-3 because canister contamination will be high.

Issues

- Seal welded CwP-3 may not satisfy long term storage requirements.

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9.9.3. Tank 17.1 "Solution" Disposition - Alternative Two

Flow chart: Alternative Two

Primary functions -- Alternative Two

- 9.9.3.1 Make glass
- 9.9.3.2 Weld glass canister(s) in CwP-1(s)
- 9.9.3.3 Store in F-Canyon
- 9.9.3.4 Ship to ORNL via F-Canyon
- 9.9.3.5 Store material at ORNL

Premise: Alternative Two

- All operations are remotely controlled.
- The Am/Cm in solution is immobilized by vitrification.
- The glass is sealed in stainless steel canisters.
- The glass form (canisters) provide no containment function and may require qualified primary and secondary containment for shipping.
- The CwP-1s provide a qualified primary containment function (full penetration weld) around the vitrified Am/Cm.
- Welding and leak testing are performed within the F-Canyon Multi-Purpose Process Facility (MPPF).
- A Helium atmosphere is provided internal to the primary containment vessel.
- MPPF equipment is utilized to place the CwP-1s in storage in the MPPF cell.
- Existing canyon functions and equipment will be available (e.g., crane, decon cell, railroad tunnel, air locks, etc.).
- ORNL receives the Off-site shipping cask, unloads the cask, and stores the CwP-1s as a unit.
- The off-site shipping cask is either returned to SRS, or to the company from which it was leased (Depending on cask ownership, and/or leasing arrangements).

Schedule

- Glass production of Am/Cm to start 7/01 and end between 1/02 to 3/02 (basis: Current Planning Agreements).
- Deactivation of the F-Canyon will start on 10/1/02. In order not to affect D&D of the F-Canyon, the goal is to remove all the Am/Cm materials (CWP-1s) from F-Canyon as soon as possible.

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- Round trip for off-site cask to ORNL and back to F-Canyon is approximately two (2) weeks.
- ORNL will receive all shipments by 2006.
- The qualification and NRC approval, of a double containment cask (if necessary) for shipment of Am/Cm canisters to ORNL may take 3 to 5 years.

Rates

- Canister production will be 25 per month. (Assuming 200 canisters produced from 7/01 to 3/02).

Cost

- R&D, Project, Operations/Maintenance costs (no D&D) to place canisters/carriers into racks - \$80M
- Design and installation of welder in MPPF - \$1.7M
- Operational cost of F-Canyon not included - Ongoing operation.
- The qualification and approval, of a double containment cask (if necessary) for shipment of Am/Cm canisters to ORNL -- \$1.5M
- The acquisition of a double containment cask (if necessary) for shipment of Am/Cm canisters to ORNL -- \$3.0M.
- Shipment to ORNL - \$1.2 to \$2M
- Storage at ORNL - \$7M

Issues

- Establish if off-site shipment of Am/Cm materials to ORNL requires a single or double containment cask. Containment requirements depend on package plutonium contents (up to 20 Curies of plutonium can be shipped in a single containment package).
- Decontamination performed at F-Canyon may require an additional enclosure (building) due to weather.
- F Canyon cask handling equipment may need modification
- Addition of another railroad spur may be required depending on F-canyon schedule impact.

Enabling Objectives

- Obtain funding for further process and equipment development
- Complete R&D project on schedule
- Design and install welder in F Canyon
- Buy/adapt F Canyon crane handling component/capabilities
- Add storage area to ORNL
- Fund operation of F Canyon systems required to support Am/Cm disposition.

9.9.3.1. Function - Make Glass - Tank 17.1 Solution Disposition - Alternative Two

See Function 9.9.1.1 - Make Glass - Base Case

9.9.3.2. Function - Weld glass canister(s) in CwP-1 (s) - Tank 17.1 Solution Disposition - Alternative Two

See Function 9.9.1.2 - Tank 17.1 Solution Disposition - Base Case

9.9.3.3. Function - Store in F Canyon - Tank 17.1 Solution Disposition -Alternative Two

Sub-functions

- Place CwP-1 and carriers in lag storage rack in MPPF.

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Requirements

- All operations including movement, decontamination, radiation survey and storage of CwP-1 shall be remotely controlled. (Minimize expected worker radiation exposure during operations).
- Deactivation of the F-Canyon will start on 10/1/02. In order not to affect D&D of the F-Canyon, the goal is to remove all the Am/Cm materials (CwP-1) from F-Canyon as soon as possible.

Interfaces

- F-Canyon schedule.

Issues

- Perform radiation shielding analysis to assess impact on operating areas dose rates.

Assumptions

- The loading operation meets the authorization basis limitations.
- Functions required of crane and decontamination area are assumed to remain open until the end of F-Canyon deactivation.

Cost

- Costs are assumed to be within F Canyon operating costs

Schedule

- Maintain in storage until all materials are shipped to ORNL.

9.9.3.4. Function - Ship to ORNL via F Canyon - Tank 17.1 "Solution" Disposition - Alternative Two

Sub-functions:

- Stage Empty Truck Cask outside of F Canyon.
- Transfer Truck Cask to Rail Car.
- Move Loaded Rail Car into F-Canyon Railroad Tunnel.
- Leak Test CwP-1s.
- Decontaminate CwP-1s
- Place CwP-1s in cavity of off-site cask.
- Move Rail Car with Loaded Cask out of F-Canyon.
- Decontaminate cask
- Transfer Off-Site Cask From Rail Car To Truck Flat Bed And Prepare For Shipment.
- Ship by Truck to ORNL

Requirements:

- Shipping package has to meet US Department of Transportation, Title 49, CFR Parts 100 through 189, DOE Order 5480.3, and NRC Regulations, Title 10, CFR, Part 71.
- The loading of the off-site shipping cask is to be remotely controlled.
- A cradle must be provided to prevent cask tip over during up ending operation.
- Crane(s) shall be capable of horizontal cask movement and up ending.
- The capability to attach rigging and chokers as well as bolt removal and torque (including but not limited to cask top bolts) shall be provided.
- Cask wash down, pressurization and leak testing capabilities shall be available in F Canyon railroad tunnel.
- Decontaminate casks to 2,200 dpm/100 cm² (Beta Gamma), TBD (Alpha), to qualify for Off-Site Shipment.

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- The off-site shipping cask will have to satisfy: (a) Shielding requirements; (b) Containment requirements; and (c) Heat generation rate.
- CwP-1 and associated pintle are to be centered in the shipping sleeve for retrieval by ORNL equipment.
- Rigging and chokers must be provided

Interfaces

- ORNL facility, equipment and schedule.
- NRC & DOT - Shipping Cask Qualification.

Issues

- It is not clear if the off-site shipping cask (package) for Am/Cm canisters will require double or single containment. Containment requirements depend on package plutonium contents (up to 20 Curies of plutonium can be shipped in a single containment package). The plutonium content of the canisters is not known at this stage. Single containment casks are generally available and can be leased. However, double containment casks are not readily available. The qualification, licensing, and acquisition of a double containment cask for shipment of Am/Cm materials may cost \$4.5M, and may take 3 to 5 years.
- Canyon operating staff will be required for loading and shipping until process is completed.
- Decontamination shed may be needed.
- It may take up to two weeks to decontaminate the CwP-1s and to load the off-site cask.

Assumptions

- Extent of F Canyon crane upgrade or modification is minor.
- Cask certified for transportation of Am/Cm canisters is obtainable. This may include the leasing of an existing cask or the certification of a new cask.
- ORNL has new storage room available and equipment and personnel are ready for receipt of Am/Cm Materials.
- It is assumed that Am/Cm operations will not interfere with D&D.
- Current 50 Ton crane will have adequate capacity
- All operations for decontamination and cask handling may be performed with the existing crane and facilities with minor modification.

Schedule

- One full day is required for F Canyon to prepare the cask for loading.
- Two full days are required to prepare a cask for shipment.

Cost

- The qualification and approval, of a double containment cask (if necessary) for shipment of Am/Cm canisters to ORNL -- \$1.5M
- The acquisition of a double containment cask (if necessary) for shipment of Am/Cm canisters to ORNL -- \$3.0M.
- Shipment to ORNL -- \$1.2-2.0M

9.9.3.5. Function - Storing @ ORNL- Tank 17.1 "Solution" Disposition - Alternative Two

See Function 9.9.1.6 - Tank 17.1 Solution Disposition - Base Case

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9.9.4. Tank 17.1 "Solution" Disposition - Alternative Three

Flow chart: Tank 17.1 Solution Disposition - Alternative Three

Primary functions - Tank 17.1 Solution Disposition - Alternative Three

- 9.9.4.1 Make glass
- 9.9.4.2 Weld glass canister(s) in CwP-2
- 9.9.4.3 Store in F-Canyon
- 9.9.4.4 Ship to ORNL via F-Canyon
- 9.9.4.5 Store material at ORNL

Premise: Alternative three

- All operations are remotely controlled.
- The Am/Cm in solution is immobilized by vitrification.
- The glass is sealed in stainless steel canisters in the F-Canyon Multi-Purpose Process Facility (MPPF).
- The canisters provide no containment function and will need a primary and secondary containment for shipping.
- Two (2) canisters are placed in each CwP-2 container, and welding equipment installed in MPPF performs seal welding of the CwP-2s.
- A Helium atmosphere is provided internal to the CwP-2s, and leak testing is performed.
- The CwP-2s provide a primary containment
- MPPF equipment is utilized to store the CwP-2s in the MPPF cell until ready for shipment to ORNL.
- Existing canyon functions and equipment will be available (e.g., crane, decon cell, railroad tunnel, air locks, etc.).
- Outside the F-Canyon building, the off-site shipping cask will be decontaminated, off-loaded from the rail car, and loaded onto the flatbed truck.
- The off-site transport cask into which the CwP-2s are placed is qualified as a secondary containment for shipment.
- ORNL receives the Off-site shipping cask, unloads and stores the CwP-2s as a unit while returning the off-site shipping cask to SRS.

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Schedule

- Glass production of Am/Cm to start 7/01 and end between 1/02 to 3/02 (basis: Current Planning Agreements)
- Deactivation of the F-Canyon will start on 10/1/02. In order not to affect D&D of the F-Canyon, the goal is to remove all the Am/Cm materials (glass canisters) from F-Canyon as soon as possible.
- Round trip for off-site canisters to ORNL and back to F-Canyon is about 2 weeks
- ORNL to receive all shipments (including Mark 18s) by 2006.

Rates

- Canister production to be 25 per month. (Assuming 200 canisters produced from 7/01 to 3/02).

Cost

- R&D, Project, Operation/Maintenance costs (no D&D) to place canisters/carriers into racks -- \$80M
- Design and installation of welder -- \$1.3M
- Operational cost of F-Canyon not included - Ongoing operation.
- The qualification, approval, and licensing of a double containment cask (if necessary) for shipment of Am/Cm canisters to ORNL -- \$1.5M
- The acquisition of a double containment cask (if necessary) for shipment of Am/Cm canisters to ORNL -- \$3.0M
- Shipment to ORNL -- \$1.2M - \$2M
- Design and installation of storage space at ORNL -- \$7M
- Operational cost at ORNL not included -- Ongoing operation.

Issues

- Establish if off-site shipment of Am/Cm materials to ORNL requires a single or double containment cask. Containment requirements depend on package plutonium contents (up to 20 Curies of plutonium can be shipped in a single containment package).
- Decontamination performed at F-Canyon may require an additional enclosure (building) due to weather
- Addition of another railroad spur may be required depending on F-canyon schedule impact.

Enabling Objectives

- Obtain funding for further process and equipment development
- Complete R&D project on schedule
- Design and install welder in F Canyon
- Add storage area to ORNL
- Fund operation of F Canyon systems required to support Am/Cm disposition.

9.9.4.1. Function: - Make Glass - Tank 17.1 Solution Disposition - Alternative Three

See Function 9.9.1.1- Tank 17.1 Solution Disposition - Base Case

9.9.4.2. Function: Weld glass canister(s) in CwP-2 - Tank 17.1 Solution Disposition - Alternative Three

See Function 9.9.1.2 - Weld the glass canister(s) in the CwP-1s - Base Case

Exception:

Sub-functions

- Seal weld the CwP-2

Cost

- Welder installation -- \$1.3M

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9.9.4.3. Function - Store the in F Canyon - Tank 17.1 Solution Disposition - Alternative Three

See Function 9.9.3.3 - Store in F Canyon - Tank 17.1 Solution Disposition -Alternative Two

Exception:

Sub-functions

- Place CwP-2 carriers in lag storage rack in MPPF.

9.9.4.4. Function - Ship to ORNL via F-Canyon - Tank 17.1 Solution Disposition - Alternative Three

Sub-functions:

- Stage off-site cask for shipping.
- Transfer Truck Cask to Rail Car.
- Move Loaded Rail Car into F-Canyon Railroad Tunnel
- Leak Test CwP-2s
- Move Carriers with CwP-2s out of MPPF and decontaminate at F-Canyon Decontamination Station.
- Load CwP-2s into Cask.
- Move Rail Car with Loaded Cask out of F-Canyon
- Transfer Cask from Rail Car to Truck Flat Bed and prepare for shipment.

Requirements:

- Leak Test the CwP-2s. To meet "Special Shipment" the vessel qualified as a "containment vessel", must be leaked tested within one year of shipment.
- Shipping package has to meet U.S. Department of Transportation, Title 49, CFR Parts 100 through 189, DOE Order 5480.3, and NRC Regulations, Title 10, CFR, Part 71
- The loading of the off-site shipping cask is to be remotely controlled.
- A cradle must be provided to prevent cask tip over during up ending operation.
- Crane(s) shall be capable of horizontal cask movement and up ending.
- The capability to attach rigging and chokers as well as bolt removal and torque (including but not limited to cask top bolts) shall be provided.
- Cask wash down, pressurization and leak testing capabilities shall be available in F Canyon railroad tunnel.
- Decontaminate casks to 2,200 dpm/100 cm² (Beta Gamma), TBD (Alpha), to qualify for Off-Site Shipment.
- The off-site shipping cask will have to satisfy: (a) Shielding requirements; (b) Containment requirements; and (c) Heat generation rate.
- The CwP-2s and associated pintle are to be centered in the shipping sleeve for retrieval by ORNL equipment.
- Rigging and chokers must be provided

Interfaces

- ORNL facility, equipment and schedule
- NRC & DOT - Shipping Cask Qualification

Issues

- It is not clear if the off-site shipping cask (package) for Am/Cm canisters will require double or single containment. Containment requirements depend on package plutonium contents (up to 20 Curies of plutonium can be shipped in a single containment package). The plutonium content of the canisters is not known at this stage. Single containment casks are generally available and can be leased. However, double containment casks are not readily available.

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The qualification, licensing, and acquisition of a double containment cask for shipment of Am/Cm materials may cost \$4.5M, and may take 3 to 5 years.

- The number of canisters that can be loaded in a single cask also depends on shielding considerations. The Am/Cm canisters are highly radioactive, and loading too many canisters in a single cask may result in excessive dose rates around the cask. The acceptable number for a particular cask will have to be established by analysis.
- The ORNL receiving requirements and acceptable CwP-2s requirements are not firm.
- It may take up to two weeks to decontaminate the CwP-1s and to load the off-site cask.

Assumptions

- Cask certified for transportation of Am/Cm canisters is obtained. This may include the leasing of an existing cask or the certification of a new cask.
- Prepare Safety Analysis Report for off-site shipping package (SARP), and obtain approval from DOT is complete.
- ORNL has new storage room available and equipment and personnel are ready for receipt.
- It is assumed that Am/Cm operations will not interfere with D&D.
- Current 50 Ton crane will have adequate capacity
- All operations for decontamination and cask handling may be performed with the existing crane and facilities with minor modification.

Schedule

- One full day is required for F Canyon to prepare the cask for loading.
- Two full days are required to prepare a cask for shipment.

Cost

- The qualification and approval, of a double containment cask (if necessary) for shipment of Am/Cm canisters to ORNL -- \$1.5M
- Shipment to ORNL -- \$1.2M - \$2M

9.9.4.5. Function - Store material at ORNL- Tank 17.1 Solution Disposition - Alternative Three

See Function 9.9.1.6 - Store material at ORNL - Base Case

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9.9.5. Tank 17.1 "Solution" Disposition - Alternative Four - Interim Dry Cask Storage

Flow chart: Tank 17.1 Solution- Interim Dry Cask Storage

The Tank 17.1 "Solution" waste case begins with Tank 17.1 Solution stored in F-Canyon Tank 17-1. The solution is pretreated to remove transition metals such as Cr, Ni, and Fe and transferred to a feed tank in the Multi-Purpose Processing Facility (MPPF) for the vitrification process. Vitrification is a batch feed process at the end of which the molten glass drains from the melter into a "canister. The canister is sealed but does not provide a containment boundary. After being loaded into a carrier the canisters are lag stored in the MPPF. The canisters are retrieved from lag storage in the MPPF, seal welded into an contamination control canister (CwP-2) (Appendix H, section 9.8.2 Figure 2.2), and returned to MPPF for lag storage until L-Basin is ready to receive. The CwP-2 will be transferred by onsite shipping cask from F-Canyon to L-Basin. In L-Basin the CwP-2 will be loaded into an msQSC, provided with a Helium atmosphere, sealed, dry stored and finally transported to ORNL. For the Purpose of this document, all alternate means of accomplishing the end state of storage at ORNL emanate from the base case glass production in Section 6.7.1.

Premise : Tank 17.1 Solution Disposition - Alternative Four

- The Am/Cm in solution/slurry is immobilized by vitrification.
- Any Tank 17.1 Solution case may be utilized.
- Existing canyon functions and equipment will be available (e.g., crane, decon cell, railroad tunnel, air locks, etc.).
- Decontamination of the onsite shipping cask prior to leaving F-Canyon is minimal (i.e., wipe down)
- Decontamination and shipment activities within F-Canyon do not impact other F-Canyon operations and/or schedules.
- Once in L-Basin the CwP -2 will be loaded into and SNF canister and dry stored until ready for shipment to ORNL.
- Dry Spent Fuel Storage will be created at L Reactor

Primary functions - Tank 17.1 Solution Disposition - Alternative Four

- 9.9.5.1 Make Glass
- 9.9.5.2 Weld the glass canister(s) in CWP-2(s)
- 9.9.5.3 Store the CWP-2s in F-Canyon
- 9.9.5.4 Ship to L Basin via F-Canyon
- 9.9.5.5 Load CWP-2 into msQSC
- 9.9.5.6 Store msQSC at L Reactor (Dry Storage)
- 9.9.5.7 Ship To ORNL
- 9.9.5.8 Store at ORNL

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Schedule

- All Am/Cm and PU solutions to be out of canyon by year 2002.
- Glass production of Am/Cm to start 7/01 and end between 1/02 to 3/02 (basis: Current Planning Agreements)
- Mk 18 glass production to start 1/02 to 3/02 and finish 7/02 to 9/02
- ORNL to receive all shipments including Mark 18s by 2006

Rates

- Canister production to be 25 per month. (Assuming 200 canisters produced from 7/01 to 3/02).

Issues

- Decontamination performed at F-Canyon may require an additional enclosure (building) due to weather
- Addition of another railroad spur may be required depending on F-canyon schedule impact.

Enabling Objectives

- Obtain funding for further process and equipment development
- Complete R&D project on schedule
- Design and install welder in F-Canyon
- Obtain NEPA coverage for storage in L Basin and msQSC storage casks
- Add storage area to ORNL
- Fund operation of F Canyon systems required to support Am/Cm disposition.

Cost

- R&D, Project, Op/Maint costs (no D&D) to place canisters/carriers into racks. - \$80M
- Design and installation of welder. - \$1.3M
- Operational cost of F Canyon not included - Ongoing operation.
- On site shipment \$150K - \$100K
- Cost of msQSCs -- \$90-130K
- Dry storage of 30-58 msQSCs --\$1.3 - \$1.7M
- The qualification and approval, of a double containment cask (if necessary) for shipment of Am/Cm canisters to ORNL -- \$1.5M
- The acquisition of a double containment cask (if necessary) for shipment of Am/Cm canisters to ORNL -- \$3.0M
- Design and installation of storage space at ORNL -\$7M
- Operational cost of ORNL not included - Ongoing operation.
- Shipment to ORNL -- \$1.2M - \$2M

9.9.5.1. **Function: Make Glass - Tank 17.1 Solution Disposition - Alternative Four**

See Tank 17.1 Solution - Base Case Function 9.9.1.1

9.9.5.2. **Function: Weld the glass canister(s) in the CWP-2 - Tank 17.1 Solution Disposition - Alternative Four**

See Tank 17.1 Solution Alternative Three Function 9.9.4.2

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9.9.5.3. Function: Store the CWP-2s in F-Canyon - Tank 17.1 Solution Disposition - Alternative Four

See Tank 17.1 Solution Alternative Three Function 9.9.4.3

Exception: Schedule- Store until L Basin is ready to receive

9.9.5.4. Function: Ship to L Basin via F-Canyon - Tank 17.1 Solution Disposition - Alternative Four

See Tank 17.1 Solution Alternative Three Function 9.9.4.4

Exceptions:

Interfaces

- L Basin Schedule

Schedule

- Start transfer to L Basin in October 2001

9.9.5.5. Function: Load CWP-2 into msQSC - Tank 17.1 Solution Disposition - Alternative Four

Sub-Functions

- Load CWP-2 into msQSC
- Dry msQSC
- Backfill msQSC with helium
- Seal msQSC
- Leak test
- Decontaminate msQSC

Requirements

- Loaded msQSC must meet criteria for dry storage.

Interfaces

- New SNF packaging function schedule
- New SNF packaging equipment

Issues

- Equipment and method for handling msQSC has not been analyzed

Assumptions

- The handling of msQSCs versus SNF canisters does not create significant impact

Schedule

- Earliest available date for starting to de-inventory glass from L Basin is after reduction of receipts, about 2010.
- Latest de-inventory of glass after SNF de-inventories from L Basin about 2013.

Cost

- Operations cost is within envelope of new SNF packaging facility costs

9.9.5.6. Function: Store containers at L Reactor (Dry Storage) - Tank 17.1 Solution Disposition - Alternative Four

Sub-functions

- Load msQSCs into transfer cask

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- Transfer cask from L Reactor to Storage Pad
- Load msQSC into concrete storage cask

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Requirements

- msQSC must meet dry storage head and radiation (field) requirements
- msQSC must meet transfer radiation requirements

Interfaces

- Transfer Cask
- Storage Cask

Issues

- Radiation field from msQSC canister
- Compatibility of msQSC with spent fuel handling equipment

Assumptions

- msQSCs loaded six to a cask

Schedule

- Glass canisters will be loaded into storage canisters between 2006 and 2013.

Cost

- Concrete storage casks cost \$400K. For 38-50 msQSCs -- \$1.3-1.7M
- Movement costs are within the operational costs of the SNF packaging and storage activity.

9.9.5.7. Function: Ship to ORNL - Tank 17.1 Solution Disposition - Alternative Four

See Tank 17.1 Solution Disposition - Base Case- Function 9.9.1.5

9.9.5.8. Function: Store at ORNL - Tank 17.1 Solution Disposition - Alternative Four

See Tank 17.1 Solution Disposition - Base Case- Function 9.9.1.6

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9.9.6. Tank 17-1 "Solution" Disposition - Alternative Five: Treat Glass as Waste

Flow chart: Tank 17.1 Solution Disposition - Waste Case

The Tank 17.1 "Solution" waste case begins with Tank 17.1 Solution stored in F-Canyon Tank 17-1. The solution is pretreated with oxalic acid to remove transition metals, such as Cr, Ni, and Fe and transferred to a feed tank in the Multi-Purpose Processing Facility (MPPF) for the vitrification process. Vitrification is a batch feed process at the end of which the molten glass drains from the melter into a "canister". The canister is sealed but does not provide a containment boundary. After being loaded into a carrier the canisters are lag stored in the MPPF. The canisters are retrieved from lag storage in the MPPF, seal welded into an contamination control canister (CWP-2) (Appendix H, section 9.8.2 Figure 2.2), and returned to MPPF for lag storage until L-Basin is ready to receive. The CWP-2 will be transferred by onsite shipping cask from F-Canyon to L-Basin. In L-Basin the CWP-2 will be loaded into a Spent Nuclear Fuel canister, provided with a Helium atmosphere, sealed, lag stored and finally transported to the repository. (MGDS). For the Purpose of this document, all alternate means of accomplishing the end state of disposal at the MGDS emanate from the base case glass production in Section 6.7.1.

Premise : Tank 17.1 Solution Disposition - Alternative Four

- The Am/Cm in solution/slurry is immobilized by vitrification.
- Any Tank 17.1 Solution case may be utilized.
- Existing canyon functions and equipment will be available (e.g., crane, decon cell, railroad tunnel, air locks, etc.).
- Decontamination of the onsite shipping cask prior to leaving F-Canyon is minimal (i.e., wipe down)
- Decontamination and shipment activities within F-Canyon do not impact other F-Canyon operations and/or schedules.
- Once in L-Basin the CWP-2s will be loaded into and SNF canister and dry stored until ready for shipment to ORNL.

Primary functions - Tank 17.1 Solution Disposition - Alternative Five

- 9.9.6.1 Make glass
- 9.9.6.2 Weld the glass canister(s) in CWP-2(s)
- 9.9.6.3 Store the CWP-2s in F-Canyon
- 9.9.6.4 Ship to L Basin via F-Canyon
- 9.9.6.5 Load CWP-2s into SNF Canister
- 9.9.6.6 Store containers at L Reactor (Dry Storage)
- 9.9.6.7 Ship containers to Repository (MGDS)

Schedule

- All Am/Cm and PU solutions to be out of canyon by year 2002.
- Glass production of Am/Cm to start 7/01 and end between 1/02 to 3/02 (basis: Current Planning Agreements)
- Mk 18 glass production to start 1/02 to 3/02 and finish 7/02 to 9/02
- ORNL to receive all shipments including Mark 18s by 2006

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Rates

- Canister production to be 25 per month. (Assuming 200 canisters produced from 7/01 to 3/02).

Issues

- Decontamination performed at F-Canyon may require an additional enclosure (building) due to weather
- Addition of another railroad spur may be required depending on F-canyon schedule impact.

Enabling Objectives

- Obtain funding for further process and equipment development
- Complete R&D project on schedule
- Design and install welder in F-Canyon
- Obtain NEPA coverage for storage in L Basin and dry spent fuel storage casks
- Obtain funding to qualify glass for the repository
- Fund operation of F Canyon systems required to support Am/Cm disposition.

Cost

- R&D, Project, Op/Maint costs (no D&D) to place canisters/carriers into racks. - \$80M
- Design and installation of welder. - \$1.3M
- Operational cost of F Canyon not included - Ongoing operation.
- Ship to L Basin -- \$150K - \$300K
- SNF canister -- \$0.5M - \$0.8M
- Dry Cask Storage -- \$2.5-3.4M
- Repository Shipment -- \$0.4M - \$0.5M
- Repository emplacement -- \$2.4 - 3.3M
- Glass Qualification for repository -- \$10M - \$50M

9.9.6.1. Function: Make Glass - Tank 17.1 Solution Disposition - Alternative Five

See Tank 17.1 Solution - Base Case Function 9.9.1.1

9.9.6.2. Function: Weld the glass canister(s) in the CWP-2 - Tank 17.1 Solution Disposition - Alternative Five

See Tank 17.1 Solution Alternative Three Function 9.9.4.2

9.9.6.3. Function: Store the CWP-2s in F-Canyon - Tank 17.1 Solution Disposition - Alternative Five

See Tank 17.1 Solution Alternative Three Function 9.9.4.3

Exception:

Schedule-

- Store until L Basin is ready to receive

9.9.6.4. Function: Ship to L Basin via F-Canyon - Tank 17.1 Solution Disposition - Alternative Five

See Tank 17.1 Solution Alternative Three Function 9.9.4.4

Exceptions:

Interfaces

- L Basin Schedule

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9.9.6.5. Function: Load CWP-2s into SNF Canister - Tank 17.1 Solution Disposition - Alternative Five

Sub-Functions

- Load CWP-2 into SNF canister
- Put lid on canister
- Dry canister
- Backfill canister with helium
- Seal canister
- Leak test canister
- Decontaminate canister

Requirements

- Loaded canister must meet criteria for dry storage.

Interfaces

- New SNF packaging function schedule
- New SNF packaging equipment

Issues

- Acceptability of SNF canister for Am/Cm glass storage, transportation, and emplacement in the MGDS.
- Acceptability of SNF glass
- Glass packaging in SNF canister has not been designed (needs spider)

Assumptions

- Three CWP-2s can be loaded per spent fuel canister -- e.g., 15 to twenty total canisters would be needed.

Schedule

- Earliest available date for starting to de-inventory glass from L Basin is after reduction of receipts, about 2010.
- Latest de-inventory of glass after SNF de-inventories from L Basin about 2013.

Cost

- Canister cost is approximately \$20K
- Operations cost is within envelope of new SNF packaging facility costs

9.9.6.6. Function: Store containers at L Reactor (Dry Storage) - Tank 17.1 Solution Disposition - Alternative Five

Sub-functions

- Load SNF canister into transfer cask
- Transfer cask from L Reactor to Storage Pad
- Load SNF canister into concrete storage cask

Requirements

- Canister must meet dry storage head and radiation (field) requirements
- Canister must meet transfer radiation requirements

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Interfaces

- SNF Transfer Cask
- SNF Storage Cask

Issues

- Radiation field from SNF canister
- Compatibility of SNF canister with Am/Cm glass with spent fuel canisters

Assumptions

- SNF canisters are loaded six to a cask
- Am/Cm glass canisters are compatible with SNF transfer cask
- Am/Cm glass canisters are compatible with SNF canisters when loaded in storage cask

Schedule

- Glass canisters will be loaded into storage canisters between 2006 and 2013.

Cost

- Concrete storage casks cost \$400K. Total -- \$2.5M - \$3.4M
- Movement costs are within the operational costs of the SNF packaging and storage activity.

9.9.6.7. **Function: Ship containers to Repository (MGDS) - Tank 17.1 Solution Disposition - Alternative Five**

Sub-functions

- Load SNF glass canisters in transport cask
- Rail ship transport cask to MGDS
- Unload canister at MGDS above ground facilities
- Place canister in co-disposal overpack in the MGDS

Requirements

- Fissile and radionuclide curie contents will need to be known for each canister

Interfaces

- MGDS EIS
- MGDS Waste Acceptance Criteria
- MGDS Transportation System
- Dry Spent Fuel Storage

Issues

- Acceptability of Glass in SNF canister for shipment and emplacement

Assumptions

- Shipment is at seven canisters per cask
- Glass in SNF canisters is loaded in the center of a co-disposal overpack

Schedule

- Glass will ship to MGDS after it opens estimated in about 2015

Cost

- Transportation cost is \$504K for a five car dedicated train, each cask containing seven SNF canisters -- \$400-500K
- MGDS Emplacement cost is \$580K for a co-disposal overpack containing 5 HLW canisters and one SNF canister -- \$2.4 - 3.3M

Appendix I

9.9.7. "Mark 18s" Disposition - Base Alternative

Flow chart: Mark 18 Disposition - Base Alternative

The base case for the Americium and Curium Target (Mk 18) disposition begins with Mk 18s stored in RBOF and finishes at ORNL. For the Purpose of this document, all alternate means of accomplishing the end state of use at ORNL emanate from this base case. From the point the material leaves SRS the functional description remains the same for all alternative cases.

Planning level estimated total life-cycle cost = \$17M
= \$0M (existing program) + \$17M (SRS) + \$0M (ORNL, covered by other program)

Premise: Mark 18 Disposition - Base Alternative

- All operations are performed in the RBOF basin.
- The Mk 18s provide primary containment for radionuclides.
- The shipping package is mechanically sealed with two Mk 18s per package
- A Helium atmosphere is provided internal to the package.
- Secondary waste stream impacts are minimal and not analyzed.
- Existing RBOF equipment is utilized to load the package into the On-site shipping cask.
- RBOF decontaminates a qualified Off-site shipping cask for transport to ORNL
- The off-site transport cask into which the package is placed is qualified as a secondary containment for shipment.
- ORNL receives the Off-site shipping cask, unloads and stores the package as a unit while returning the off-site shipping cask to SRS.

Primary functions - Mark 18 Disposition - Base Alternative

- 9.9.7.1 Cut ends off Mk 18s
- 9.9.7.2 Load Mk 18 Mk 18s in the package for shipment
- 9.9.7.3 Ship to ORNL via RBOF
- 9.9.7.4 Store material at ORNL

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Schedule

- Mk 18 Mk 18s to be removed from RBOF by year 2003.
- Packaging of Mk 18s to start 3/00 and be completed by 7/02.
- Round trip for off-site canisters to ORNL and back to RBOF $\approx$ 2 weeks
- ORNL to receive all shipments including Mark 18s by 2006

Rates

- 33 packages of two Mk 18s each produced between 3/00 and 7/02

Cost

- Design, equipment and packaging efforts in RBOF -- \$15M
- The qualification and approval, of a double containment cask (if necessary) for shipment of Am/Cm canisters to ORNL -- \$1.5M (Not included)
- The acquisition of a double containment cask (if necessary) for shipment of Am/Cm canisters to ORNL -- \$3.0M. (Not included)
- Shipment to ORNL - \$2M
- Operational cost of ORNL not included - Ongoing operation.
- Design and installation of storage space and equipment modifications at ORNL - \$3M

Issues

- Mark 18s may be brittle, they were irradiated for $\sim$ 10 years in a high flux atmosphere and have been stored under water for 10 years. If cut or handled they may break up.
- Shipment awaits storage availability from Mark 42 processing

Enabling Objectives

- Obtain funding for further process and equipment development
- Complete R&D project on schedule
- Install appropriate tanks and jumpers in F Canyon to support Mk 18 dissolution
- Design and install welder in F Canyon
- Design and licensing of a containment cask for shipment of Am/Cm to ORNL
- Add storage area to ORNL
- Fund operation of F Canyon systems required to support Am/Cm disposition.

9.9.7.1. Function: Cut ends of Mk 18s - Mark 18 Disposition - Base Alternative

Sub-Functions:

- Cut top off storage bundle
- Move Mk 18 to cutting station
- Determine cut locations base on gamma activity
- Cut off ends

Requirements:

- Cutting shall not fracture or deform the Mk 18
- Mk 18 shall be cut into 20" segments

Interfaces:

- RBOF equipment including new gamma measurement/positioning/cutting system
- Shipping can

Issues:

- Release of radio-nuclides to RBOF basin and air

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- Failure of target when shipped, causing material to concentrate and exceed allowable shipping dose rates
- Brittleness of Mk 18's
- USQD for Mk 18 cutting operations
- Technical maturity of cutting equipment (R&D)
- NEPA evaluation required

Assumptions

- Mk 18s can be cut without release or fracture/deformation problems

Schedule

- Operations start 3/00 and end 7/02.

Cost

- Design and packaging cost \$15M

9.9.7.2. Function: Load Mk 18s in the package for shipment - Mark 18 Disposition - Base Alternative

Sub-functions:

- Determine Mk 18 integrity
- Load can
- Blow out can; backfill with helium
- Seal Can
- Leak test can

Requirements:

- Fuel shall not be breached
- Cans shall meet leak rate requirements (TBD)

Interfaces:

- RBOF equipment including new integrity measuring and leak test equipment
- NLI 1/2 or NAC LWT casks

Issues:

- Disposition of breached fuel
- Technical maturity of integrity measurement equipment
- NEPA evaluation

Assumptions:

- None

Schedule:

- Operations start 3/00 and end 7/02.

Cost:

- Included in the function above

9.9.7.3. Function: Ship to ORNL via RBOF - Mark 18 Disposition - Base Alternative

See Tank 17.1 Solution Base Case Function 9.9.1.5

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9.9.7.4. Function: Store material at ORNL - Mark 18 Disposition - Base Alternative

See Tank 17.1 Solution Base Case Function 9.9.1.6 except:

Cost:

- Estimated cost of \$2M to modify storage for cut Mark 18s plus equipment modifications to handle longer tubes estimated at \$1M Total -- \$3M

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9.9.8. "Mark 18s" Disposition - Alternative One Review

Flow chart: Mark 18 Disposition - Alternative One

*Note: Glass functions not analyzed

Alternative one for Americium and Curium target (Mk 18) disposition begins with Mk 18s stored in RBOF and finishes at ORNL. For the Purpose of this document, all alternate means of accomplishing the end state of use at ORNL emanate from the base case glass production in Section 6.7.1 and may follow any of the base or alternatives shown. Additionally, as in previous glass cases, from the point the material SRS the functional description remains the same for all alternative cases.

Planning level estimated total life-cycle cost = \$7.6M

= \$0M (existing program) + \$7.1-8.1M (SRS) - \$1M (ORNL, reduced costs from not having waste stream associated with removal of AI)

Premise : Mark 18 Disposition - Alternative One

- All Mk 18s are brought to F Canyon for processing.
- All operations are remotely controlled
- The Mk 18s dissolved and stored in F Canyon
- The Am/Cm in solution (slurry) is immobilized by vitrification.
- The glass form is seal welded (for decontamination Purposes) into stainless steel canisters.
- The glass form (canisters) provides no containment function and must have a qualified primary and secondary containment for shipping.
- The "best" case for Tank 17.1 Solution will be used for Mk 18 glass packaging.
- *NOTE: The glass path from solution to ORNL should one of the alternative cases shown in Sections 6.7.1, 6.7.2, 6.7.3, 6.7.4 or 6.7.5.*

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- ORNL receives the Off-site shipping cask, unloads and stores the Mk 18 glass package as a unit while returning the off-site shipping cask to SRS.
- The off-site shipping cask into which the CWP-1s are placed is qualified as a secondary containment for shipment.

Primary functions - Mark 18 Disposition - Alternative One

- 9.9.8.1 Ship Mk 18s to F Canyon
- 9.9.8.2 Dissolve Mk 18s
- 9.9.8.3 Store Mk 18 slurry
- 9.9.8.4 Make glass *
- 9.9.8.5 Prepare glass to ship to ORNL**
- 9.9.8.6 Ship to ORNL**
- 9.9.8.7 Store material at ORNL

* Note: The "best" technique for preparing Tank 17.1 Solution for shipment will also be used for Mk 18 glass. ** Note: These sub-functions recapitulate the appropriate functions for preparing Am/Cm glass to ship to ORNL and shipping shown in the base case and alternatives.

Schedule

- Mk 18 glass production to start 1/02 to 3/02 and finish 7/02 to 9/02
- Round trip for off-site canisters to ORNL and back to RBOF $\approx$ 2 weeks
- ORNL to receive all shipments by 2006

Rates

- 65 Mk 18s shipped to F Canyon before dissolution. Estimated dissolution time is 6 months.
- 50 Mk 18 glass canisters in appropriate packaging will need shipping (7 shipments at 8 canisters/shipment).

Cost

The following would be covered by the "solution" to glass program

- R&D, Project, Op/Maint costs (no D&D) to place canisters/carriers into racks. - \$80M (existing program)
- Design and installation of welder. \$1.3M - \$1.7M
- Operational cost of F Canyon and RBOF not included - Ongoing operation
- The qualification and approval, of a double containment cask (if necessary) for shipment of Am/Cm canisters to ORNL -- \$1.5M
- The acquisition of a double containment cask (if necessary) for shipment of Am/Cm canisters to ORNL -- \$3.0M.
- Design and installation of storage space at ORNL -- \$7M
- Operational cost of ORNL not included - Ongoing operation.

The following would be increased costs from processing the Mk 18s @ SRS rather than ORNL

- Ship from RBOF to F Canyon -- \$200K
- Design installation and startup of 17.3D dissolver and tankage - \$3-6M
- Make Glass - \$1M to \$2M
- Shipment to ORNL, 50 canisters \$420K

Enabling Objectives

- Obtain funding for further process and equipment development
- Complete R&D project on schedule
- Install appropriate tanks and jumpers in F Canyon to support Mk 18 dissolution
- Design and install welder in F Canyon
- Add storage area to ORNL
- Funding for operation of F Canyon systems required to support Am/Cm disposition.

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9.9.8.1. Function: Ship Mk 18s to F Canyon - Mark 18 Disposition - Alternative One - Appendix to Section 6.7.8

Sub-functions:

- Load CD cask
- Decontaminate CD Cask
- Transport CD Cask to F Canyon

Requirements:

- Casks shall be decontaminated to TBD surface levels beta/gamma/100 cm² and TBD surface level alpha/100 cm²
- TBD Mk 18s can be shipped per shipment

Interfaces:

- RBOF equipment
- CD casks
- F Canyon fuel handling equipment

Issues:

- NEPA evaluation

Assumptions:

- Mk 18s can be transferred to F Canyon for processing in a timely way
- Mk 18 processing will not interfere with other Canyon activities

Schedule:

- Shipments start no later than 1/02 to 3/02; shipments complete 5/01

Costs:

- Costs are within normal operations of RBOF and F Canyon

9.9.8.2. Function: Dissolve Mk 18 - Mark 18 Disposition - Alternative One

Sub-functions

- Unload CD Cask
- Transfer Mk 18s to 17.3 dissolver
- Remove Aluminum with NaOH
- Decant sodium aluminate solution
- Treat off-gas stream

Requirements

- Americium and Curium shall remain with insoluble lanthanide hydroxides
- Feed concentration of sodium shall be below TBD.
- Feed shall be capable of making a durable glass

Interfaces:

- F Canyon equipment

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Issues:

- Flowsheet has not been verified
- NEPA evaluation
- Compatibility of Mk 18 feed with the glass process
- The treatment of the added solution resulting from dissolving the Mark 18, and vitrification of additional Am/Cm materials will require that the operating life of pretreatment/vitrification equipment be extended.

Assumptions:

- Existing designs for Mk 18 dissolution system can be made compatible with present day requirements
- Tank 17.3D is still available

Schedule:

- Processing starts 1/02 to 3/02; processing complete 7/02 to 9/02

Cost:

- \$3-6M capital cost including tank modifications and jumpers
- Operating cost within cost of F canyon operations

9.9.8.3. **Function: Store Mk 18 Slurry - Mark 18 Disposition - Alternative One**

Sub-functions:

- Hold Mk 18 lanthanide-actinide hydroxides
- Allow solution adjustments as necessary

Requirements:

- See Function 9.9.8.2 above
- Hold TBD feed for glass process

Interfaces:

- MPPF glass process

Issues:

- See Function 9.9.8.2 above

Assumptions:

- See Function 9.9.8.2 above

Schedule:

- See Function 9.9.8.2 above

Cost:

- See Function 9.9.8.2 above

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9.9.8.4. Function: Make Glass - Mark 18 Disposition - Alternative One

Sub-Functions

- Pretreat Mk 18 slurry as necessary
- Transfer solution to feed tank in Multi-Purpose Processing Facility (MPPF)
- Feed solution to melter and combine with flow of glass frit
- Charge melter & Vitrify dissolved solids
- Treat off-gas stream
- Drain molten glass from bottom of melter into "canister"
- Seal "canister"
- Transfer sealed canister to "carrier"
- Transfer loaded carrier to "rack" and lag store
- Perform MC&A (calorimeter measurement)

Requirements:

- Glass product shall be nitric acid soluble {Only process available to ORNL}
 - Glass chemistry and canister size are to interface with ORNL. {ORNL equipment will be used to handle canisters}
 - Glass shall be capable of being "broken up" into chunks {Enables increased surface exposure to nitric acid, which decreases the dissolution time. ORNL proposed process: cut open canister, drill vertically into glass, break up within canister, dump out of canister and crush glass chunks to further decrease size}
 - Dissolution time goal: 2 days or less per canister {If greater then two days costs begin to become very prohibitive}
 - During dissolution, silica shall drop out of solution and remain behind in dissolution vessel {Silica creates problems if carried downstream in ORNL process}
 - Minimize potential RCRA issues, i.e. minimize lead content
 - Operations are to be performed remotely and shall be encompassed under each facility Authorization Basis {Minimize expected worker radiation exposure during operations}
- Note: Verification of product recovery is being performed by WSRC-SRTC sending glass samples to ORNL for testing.*

Interfaces

- MPPF equipment (manipulators, turntables, racks, crane, etc.) and new CWP-1 welder installation.
- ORNL chemical and equipment characteristics

Issues:

- Glass loading effects ability to vitrify
- Design and install canister seal/containment welder has not in the budget
- Method of sealing canister is TBD.
- F Canyon Authorization Basis does not deal with Mk 18 feed and may require USQD be performed to determine mitigating factors. Potential cost impact exists for mitigation factors.
- Making glass assumes an 80% reduction in Pu content. If less than 20cu may not stay that way. Short half life allows Pu 240 & 241 to creep back in from decay
- Technical Maturity of Americium/Curium vitrification process (R&D)

Assumptions:

- It is assumed that the plutonium content per shipment exceeds 20 Curies. The amount of plutonium per shipment depends on a number of factors, these are: (a) The amount of plutonium removed during pretreatment; (b) The total number of glass canisters produced; and (c) The number of glass canisters per shipment. When the plutonium content per shipment exceeds 20 Curies the shipping package will have to incorporate a primary and secondary containment

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- A off-site shipping cask may be designed/modified that will accept the desired number of canisters without exceeding the casks radiation shielding requirements.
- Both of the above assumptions must take into account the total number of canisters to be produced. Currently the number of canisters is thought to be in the 150 - 200 range.
- The allowable number of canisters per shipment based on Pu content is; a) 4.8 if 150 canisters are produced and b) 6.5 canisters if 200 canisters are produced. Refer to Appendix G.
- Project rebaseline being performed 1st Qtq FY99, will conclude 80M is correct and will not be exceeded.

Schedule

- Operations will start take about six months.

Cost:

Overall Cost - 80M

- Includes all R&D, Project, Op/Maint costs (no D&D) to place canisters/carriers into racks
- Design and installation of the welder will add another \$1.3M-\$1.7M

9.9.8.5. Function: Prepare glass to ship to ORNL - Mark 18 Disposition - Alternative One

See function descriptions for Tank 17.1 Solution preparation of glass for shipment. Once the glass canister is poured the base or any the alternative Tank 17.1 Solution cases my be utilized.

9.9.8.6. Function: Ship to ORNL- Mark 18 Disposition - Alternative One

See Functions 9.9.1.1 or 9.9.1.2 for Am/Cm glass shipment to ORNL. Once the glass canister is poured the base or any alternative Tank 17.1 Solution case my be utilized.

9.9.8.7. Function 7 - Store Material at ORNL - Mark 18 Disposition - Alternative One

See Tank 17.1 Solution Base Case Function 9.9.1.6

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9.9.9. "Slugs/Other" Disposition - Base Alternative

Flow chart: Slug/Other Disposition - Base Alternative

The base case for the Americium and Curium slug disposition begins with slugs/other stored in RBOF and finishes at ORNL.

Premise : Slug/Other Disposition - Base Alternative

- All operations are performed in the RBOF basin.
- The slugs/other provide primary containment for radionuclides.
- The shipping package is mechanically sealed with slugs/other per package
- A Helium atmosphere is provided internal to the package.
- Existing RBOF equipment is utilized to load the package into the On-site shipping cask.
- RBOF decontaminates a qualified Off-site shipping cask for transport to ORNL
- The off-site transport cask into which the package is placed is qualified as a secondary containment for shipment.
- ORNL receives the Off-site shipping cask, unloads and stores the package as a unit while returning the off-site shipping cask to SRS.

Primary functions - Slug/Other Disposition - Base Alternative

- 9.9.9.1 Load Am/Cm slugs/other in the package for shipment
- 9.9.9.2 Ship to ORNL via RBOF
- 9.9.9.3 Store material at ORNL

Schedule

- Am/Cm slugs/other to be removed from RBOF by year 2001.
- Packaging of Am/Cm slugs/other to start 5/99 and be completed by 1/00.
- Round trip for off-site canisters to ORNL and back to RBOF $\approx$ 2 weeks
- ORNL to receive all shipments including Mark 18s by 2006

Rates

- TBD packages of TBD Am/Cm slugs/other each produced between 6/00 and 9/00

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Cost

- Design and packaging efforts in RBOF -- \$1M
- Design and installation of storage space at ORNL - \$7M (Not included)
- The design and licensing of a double containment cask for shipment of Am/Cm to ORNL. - \$4M (Not included)
- Operational cost of ORNL not included - Ongoing operation.

Enabling Objectives

- Obtain funding for equipment development
- Add storage area to ORNL

9.9.9.1. **Function: Load Am/Cm slugs/other in the package for shipment - Slug/Other Disposition - Base Alternative**

Sub-functions:

- Load Am/Cm Slugs/other in the package
- Blowout, backfill with Helium and seal
- Leak test package

Requirements

- Cans shall meet leak rate requirements

Interfaces:

- RBOF equipment including new leak test equipment
- NLI 1/2 or NAC LWT casks

Issues:

- NEPA evaluation

Assumptions:

- The few Slugs/others that may not fit current storage configurations at ORNL will be able to be stored within ORNL cells.

Schedule:

- Start 5/99 complete 1/00

Cost:

- Package/load estimate (including shipping) is \$1M

9.9.9.2. **Function: Ship to ORNL - Slug/Other Disposition - Base Alternative**

See Tank 17.1 Solution Base Case Function 9.9.1.5

9.9.9.3. **Function: Store Material at ORNL- Slug/Other Disposition - Base Alternative**

See Tank 17.1 Solution Base Case Function 9.9.1.6

Appendix J

9.10. Appendix J: "National Asset" Recommendation

The NMI Project Team has requested materials be identified that comply with a proposal for establishing specific materials as "National Assets". The glass produced from Am/Cm in solution at SRS is a prime example of material that could be designated as a national asset.

9.10.1. Am/Cm Solution National Asset Recommendation, Chuck Alexander, ORNL

Ref: e-mail Per Chuck Alexander To William N. Jackson dated March 31, 1998
SRS Am/Cm Solution

- 1) Are there potential scientific or economic benefits from the future use of this material?
Absolutely yes! Some of the potential benefits are as follows:
 - Feedstock for the U.S. Heavy Element Program
 - Feedstock for foreign heavy element programs
 - Waste partitioning and transmutation research and development
 - Criticality studies
 - Defense programs
 - Research, development, and technology of the actinides and transactinides
 - basic studies of Am and Cm
 - target material for the production of the transactinide elements
- 2) Will U.S. or foreign production facilities for similar quantities exist in the future?
Most likely not. The scale of the reactors and the processing facilities required to produce multi-kilogram quantities of Am and Cm are very large and unique. All existing facilities are decades-old or are shut-down. Because of the down-turn in defense-related nuclear materials production it is doubtful that the U.S. will construct any facilities on this scale solely for the production of only Am and Cm. No foreign facilities of this scale exist that are capable of recovering Am and Cm. We have heard rumor that the Russians have recovered some Cm at Chelyabinsk but we do not know the amount or have been able to confirm the rumor. However, their facilities are on the same age as the U.S. facilities are. Commercial reprocessing plants are not built to recover Am and Cm. The Am in commercial spent fuel is also predominantly Am-241. Therefore, recovery in future commercial processing facilities does not address the production and supply of Am-243.
- 3) What would production cost today?
To build a production reactor and a processing facility of the scale and through-put of those currently existing at SRS would be in excess of 2 billion dollars. This is exclusive of the actual costs of procuring reactor feed-stock, fabrication of targets, reactor time, and process operating costs. These costs could be expected to be on the order of 50 million dollars a year. The lead time for the construction of these facilities could be expected to be on the order of 10-20 years.
- 4) What is the relative cost of safe disposal versus safe storage, including any pretreatment that may be required?
This is currently unknown because safe disposal of the SRS Am/Cm Solution has not been demonstrated on a reasonable scale.
- 5) If safe storage costs are significantly greater than current costs of disposal, do the potential benefits justify safe storage and for how long?
This is currently unknown because the costs of disposal have not been quantified.

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- 6) Does a safe disposal method exist today?
We do not believe one does exist. However, we believe safe disposal is feasible.
- 7) Does a safe long-term storage facility exist today?
No, one does not exist. Interim storage of the Am/Cm could be maintained at either the F-Canyon or RBOF(if proper precautions were taken).
- 8) Do criteria for safe disposal or storage exist?
Not explicitly. However, we feel that the criteria for safe storage are much more attainable.
- 9) Is pretreatment required to meet criteria?
Even though no explicit criteria exists, both safe disposal and storage will require some pretreatment or treatment due to the fact that the Am/Cm is in an acidic solution.

Chuck Alexander

9.10.2. Am/Cm Solution Value, Seaborg 1994

Letter to H. R. O'Leary (DOE Secretary of Energy) from G.T. Seaborg (Lawrence Berkeley Laboratory), expressing value of Am/Cm solution located at SRS, May 11, 1994

9.10.3. Am/Cm Solution Value, Seaborg 1992

Letter to Richard A. Claytor (DOE Assistant Secretary for Defense Programs) from G.T. Seaborg (Lawrence Berkeley Laboratory), expressing value of Am/Cm solution located at SRS, December 16, 1992

9.10.4. Am/Cm Solution Potential Uses, Seaborg 1992

Letter to Richard A. Claytor (DOE Assistant Secretary for Defense Programs) from G.T. Seaborg (Lawrence Berkeley Laboratory), expressing potential uses of Am/Cm solution located at SRS, December 16, 1992

Appendix K

9.11. Appendix K: Cost Analysis

Costs were based on the information that is available for a specific alternative. Costs were estimated as incremental increases over current operations. These alternative cost estimates are to be categorized as planning estimates. The DOE Cost Guide, Volume 6 states that planning estimates should have an accuracy range from -50 percent to +100 percent, which costs within this report are intended to reach

The functions Store Am/Cm Solution, Store Mk 18s, and Store Am/Cm slugs/other are currently funded and not considered in this analysis. The function Make Glass is common to all Am/Cm solution analyses and the Mk 18 Alternative One. The function "Make Glass" is currently part of an ongoing project to vitrify Am/Cm currently in solution within F-Canyon, with an \$80M total estimate including R&D, the project and glass operations. The function Store at ORNL is also a common function and not fully analyzed. ORNL estimates that upgrading Cell E of Bldg 7930 at a cost of \$15M would be required to accommodate Am/Cm glass storage. ORNL is currently also pursuing a role in Pu-238 production. If that mission is realized, it would allow cost sharing and reduce ORNL storage to about \$7M. The \$7M cost is used as a basis for this estimate.

Note: Functions are detailed in previous sections of this report. To obtain a better perspective on what a given cost covers the functions should be reviewed.

9.11.1. Tank 17.1 "Solution" Disposition - Base Alternative

Function -Weld CwP-1

Cost estimates for developing MPPF full penetration welding capability, including a weld head, training and qualification, range from about \$300K to \$700K. (Ref 3) Installing the welder in MPPF as a project during the current Am/Cm project is estimated to be \$1 M. Since this requires qualification to meet shipping requirements, the high end is chosen for a total cost of \$1.7M.

Function – Transport to RBOF

On-site transportation to RBOF from F-Canyon would require \$150K to \$300K.

The cost to transport a loaded CD cask from F-Canyon to RBOF is estimated at \$1.5K (3 workers @ \$65/hr , 1-8hr day). The cost to unload at RBOF is estimated at \$2K (\$10K/week operation costs, 1 day to turn around the CD cask). The cost to load at F-Canyon is estimated at \$4K. The total cost per CD shipment is therefore \$7.5 K. The total number of shipments is estimated at 20 to 40 (depending on the total number of canisters and number of canisters per CD cask), therefore the estimated transport cost is \$150 K to \$300 K.

Function – Store in RBOF

On-site storage at RBOF would increase the facilities incremental cost during placement into storage, which would be covered by the above transport costs. But, if RBOF was to remain open only for these materials a cost of ~ \$10K per week would be incurred to cover RBOF operations/maintenance costs. Based on current planning, the storage would not cause any delay in RBOF shutdown.

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Function – Ship to ORNL via RBOF

For 150 canisters shipping at 8 canisters per cask (therefore 19 shipments) at \$60 K/shipment (Ref 4) the cost would be \$1.2M. For 200 canisters shipping at 6 canisters per cask (therefore 34 shipments) at \$60 K/shipment (Ref 4) the cost would be \$2M. It would cost an additional \$1.5M to provide cask certification. If desired, procurement of a double containment cask would cost \$3.0M. Shipment costs assume cask rental at \$1.2-2.0M.

9.11.2. Tank 17.1 "Solution" Disposition - Alternative One

Function – Transport to RBOF

On-site transportation to RBOF from F-Canyon would require \$150K to \$300K.

Function – Weld Contamination Barrier (CwP-3)

Total estimated costs: \$3M

This operation is somewhere in cost between the cost of welding in MPPF and the cost of setting up underwater equipment for Mk 18 cutting, estimate: \$3M.

Function – Mechanical Seal msQSC

Total estimated cost: \$390K-\$430K

The cost for the container and sealing operation is considered to be within the Weld Contamination Barrier cost. The msQSC is a mechanical container which will have requirements similar to DWPF or SNF canisters. Estimate a cost of \$5K per msQSC or for 19-25 msQSCs \$90K-\$130K. Assume the msQSC design cost and associated tests would be \$300K.

Function – Ship to ORNL via RBOF

Total estimated costs: \$2.7M-\$3.5M

For 150 canisters shipping at 8 canisters per cask (therefore 19 shipments) at \$60 K/shipment (Ref 4) the cost would be \$1.2M. For 200 canisters shipping at 6 canisters per cask (therefore 34 shipments) at \$60 K/shipment (Ref 4) the cost would be \$2M. It would cost an additional \$1.5M to provide cask certification. If desired, procurement of a double containment cask would cost \$3.0M. Shipment costs assume cask rental at \$1.2-2.0M.

9.11.3. Tank 17.1 "Solution" Disposition - Alternative Two

Function -Weld CwP-1

Total estimated costs: \$1.7M

Cost estimates for developing MPPF full penetration welding capability including a weld head, training and qualification range from about \$300K to \$700K. (Ref 3) Installing the welder in MPPF as a project during the current Am/Cm project is estimated to be \$1 M. Since this requires qualification to meet shipping requirements, the high end was chosen for a total cost of \$1.7M.

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Function – Store in F-Canyon

Storage would not add any appreciable costs, unless F-Canyon had to remain open just due to the Am/Cm storage. Current planning is preliminary enough (including potential 94-1 mission assistance to Rocky Flats processing residues, fluorides etc.) that it is not expected that the canyon will have completed decommissioning activities prior to completing Am/Cm glass storage. Significant staff and facility support will also be required during the first three years of decommissioning activities.

Function – Ship to ORNL via F-Canyon

Total estimated cost: \$2.7M-3.5M

For 150 canisters shipping at 8 canisters per cask (therefore 19 shipments) at \$60 K/shipment (Ref 4) the cost would be \$1.2M. For 200 canisters shipping at 6 canisters per cask (therefore 34 shipments) at \$60 K/shipment (Ref 4) the cost would be \$2M. It would cost an additional \$1.5M to provide cask certification. If desired, procurement of a double containment cask would cost \$3.0M. Shipment costs assume cask rental at \$1.2-2.0M. If an additional decontamination shed is needed to prepare the Off-site cask for shipping, it is estimated to cost about \$300K for a Butler type building (this is not included in the estimate). It should be noted that this decontamination building could also be used to aid in D&D of the Canyon thus sharing that cost.

9.11.4. Tank 17.1 "Solution" Disposition - Alternative Three

Function -Weld Contamination Barrier (CwP-2)

Total estimated cost: \$1.3M

Cost estimates for developing MPPF full penetration welding capability including a weld head, training and qualification range from about \$300K to \$700K. (Ref 3) Installing the welder in MPPF as a project during the current Am/Cm project for a seal weld is estimated to be \$1.0M. It is assumed that welding a seal weld instead of a full penetration weld would require less qualification, thus slightly lower cost, so the low range is used as the estimate: \$1.3 M total.

Function – Store in F-Canyon

Storage would not add any appreciable costs, unless F-Canyon had to remain open just due to the Am/Cm storage. Current planning is preliminary enough (including potential 94-1 mission assistance to Rocky Flats processing residues, fluorides etc.) that it is not expected that the canyon will have completed decommissioning activities prior to completing Am/Cm glass storage. Significant staff and facility support will also be required during the first three years of decommissioning activities.

Function – Ship to ORNL via F-Canyon

Total estimated cost: \$2.7M-\$3.5M

For 150 canisters shipping at 8 canisters per cask (therefore 19 shipments) at \$60 K/shipment (Ref 4) the cost would be \$1.2M. For 200 canisters shipping at 6 canisters per cask (therefore 34 shipments) at \$60 K/shipment (Ref 4) the cost would be \$2M. It would cost an additional \$1.5M to provide cask certification. If desired, procurement of a double containment cask would cost \$3.0M. Shipment costs assume cask rental at \$1.2-2.0M. It should be noted that this assumes that the Am/Cm glass is successfully argued to provide primary containment of residual plutonium. If an additional decontamination shed is needed to prepare the Off-site cask for shipping, it is estimated to cost about

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\$300K for a Butler type building (Not included in the estimate0). It should be noted that this decontamination building could also be used to aid in D&D of the Canyon thus sharing that cost.

9.11.5. Tank 17.1 "Solution" Disposition - Alternative Four

Function -Weld Contamination Barrier (CwP-2)

Total estimated cost: \$1.3M

Cost estimates for developing MPPF full penetration welding capability including a weld head, training and qualification range from about \$300K to \$700K. (Ref 3) Installing the welder in MPPF as a project for a seal weld during the current Am/Cm project is estimated to be \$1.0M. It is assumed that welding a seal weld instead of a full penetration weld would require less qualification, thus slightly lower cost, so the low range is used as the estimate: \$1.3 M total.

Function – Store in F-Canyon

Storage would not add any appreciable costs, unless F-Canyon had to remain open just due to the Am/Cm storage. Current planning is preliminary enough (including potential 94-1 mission assistance to Rocky Flats processing residues, fluorides etc.) that it is not expected that the canyon will have completed decommissioning activities prior to completing Am/Cm glass storage. Significant staff and facility support will also be required during the first three years of decommissioning activities.

Function – Transport to L-Basin

On-site transportation to L-Basin from F-Canyon would require \$150K to \$300K.

Function -Load Glass Canister into msQSC

Total estimated cost: \$390K-\$430K

Canisters would be loaded into an msQSC either in L-Basin itself, or in the new Spent Fuel management facility (currently in planning) in the L-Reactor process area. Loading the msQSC is within normal operating costs. The msQSC is a mechanical container which will have requirements similar to DWPF or SNF canisters. Estimate a cost of \$5K per msQSC or for 19-25 msQSCs \$90-130K. Assume the msQSC design cost and associated tests would be \$300K.

Function - Store msQSC in Dry Storage Cask

The 19-25 msQSCs would be stored in horizontal dry storage casks. Assuming a cost of \$400K/cask and 6 msQSCs per cask this represents \$1.3M to \$1.7M.

Function - Ship to ORNL

Total estimated cost: \$2.7M-\$3.5M

For 150 canisters shipping at 8 canisters per cask (therefore 19 shipments) at \$60 K/shipment (Ref 4) the cost would be \$1.2M. For 200 canisters shipping at 6 canisters per cask (therefore 34 shipments) at \$60 K/shipment (Ref 4) the cost would be \$2M. It would cost an additional \$1.5M to provide cask certification. If desired, procurement of a double containment cask would cost \$3.0M. Shipment costs assume cask rental at \$1.2-2.0M.

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9.11.6. Tank 17.1 "Solution" Disposition - Alternative Five

Function -Weld Contamination Barrier (CwP-2)

Total estimated cost: \$1.3M

Cost estimates for developing MPPF full penetration welding capability including a weld head, training and qualification range from about \$300K to \$700K. (Ref 3) Installing the welder in MPPF as a project for a seal weld during the current Am/Cm project is estimated to be \$1.0M. It is assumed that welding a seal weld instead of a full penetration weld would require less qualification, thus slightly lower cost, so the low range is used as the estimate: \$1.3 M total.

Function – Store in F-Canyon

Storage would not add any appreciable costs, unless F-Canyon had to remain open just due to the Am/Cm storage. Current planning is preliminary enough (including potential 94-1 mission assistance to Rocky Flats processing residues, fluorides etc.) that it is not expected that the canyon will have completed decommissioning activities prior to completing Am/Cm glass storage. Significant staff and facility support will also be required during the first three years of decommissioning activities.

Function – Transport to L-Basin

On-site transportation to L-Basin from F-Canyon would require \$150K to \$300K.

Function – Load CwP-2 in SNF Canister

Assuming that three CwP-2s can be loaded into a 10' long SNF canister, 25-34 canisters would be needed. At an estimated cost of \$20K per canister this represents \$500K to \$700K. Loading operational costs are expected to be within normal operating costs for the new Spent Fuel facility (currently in planning) in the L-Reactor process area.

Function – Store containers at L Reactor (Dry Storage)

Spent Fuel canisters are stored 6 to a concrete storage cask at an estimated cost of \$400K/cask. Assuming that the glass canister filled SNF canisters are compatible with normal SNF canisters, this represents \$1.7M-\$2.3M.

Function – Ship containers to Repository (MGDS)

Total estimated cost: \$2.8M-\$3.8M

SNF canisters are planned to be shipped to the Repository (MGDS) at seven canisters per cask. Estimated cost for a shipment of a dedicated five car train is \$504K. For 25-34 canisters this represents \$360K-\$490K. Canisters are emplaced in the center of a co-disposal overpack at a total cost of \$580K/overpack. Emplacing 25-34 canisters represents a cost of \$2.4M-\$3.3M

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9.11.7. "Mark 18s" Disposition - Base Case

Function – Cut Mk 18 for Shipment to ORNL

Total estimated cost: \$15M

Equipment development and installation to cut and package Mk 18's was considered similar in complexity and cost to putting in a glove box line. Because of the unknown brittleness and condition of the Mark 18s it was assumed that an underwater dry-box operation would be needed. Based on previous experience it is estimated that putting in a robotized underwater dry box cutting and packaging system would cost about \$15M. A capability without an underwater drybox was estimated in 1993 to be \$3.6M (Ref.1). Escalated to 1998 dollars, this is approximately \$5M. The increase in cost is attributable to the increase in complexity and scope.

Function – Package for Shipment

Costs for packaging are included in the previous function estimate.

Function – Ship to ORNL from RBOF

Total estimated cost: \$2.0M

The cost for 33 shipments (two Mk 18s per shipment) at \$60K/shipment (Ref 4) is \$2M. It would cost an additional \$1.5M to provide cask certification. If desired, procurement of a double containment cask would cost \$3.0M. Since both certification would be driven by Am/Cm "solution" glass canisters, costs of certification are not included in this estimate. It is assumed the cask would be rented.

Function – Store at ORNL

Total estimated cost: \$3M

The cost of preparing storage for longer canisters at ORNL is estimated at \$2M. Handling equipment would require modifications and testing estimated at \$1M.

9.11.8. "Mark 18s" Disposition - Alternative One

(Note: this scenario assumes Am/Cm solution "alternative three" for a glass shipment basis)

Function Ship to F-Canyon

Total estimated costs: \$200K

Function Dissolve Mk 18s

Total estimated cost: \$5.5M

Based on previous projects to put dissolvers in F-Canyon section 17 the cost was estimated to be \$3-6M (Ref 2). The midpoint of the estimate is \$4.5M. The cost of operations to dissolve the Mk18's is estimated at \$1 M.

Function -Weld Secondary Contamination Barrier & Make Glass

Total estimated cost: \$1.5M

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At this point the costs would be for the additional operations to make the glass, fill the canisters, load the secondary canisters, and seal weld the secondary canisters. It is estimated this would be complete in 2 to 4 months and would cost \$1M to 2M.

Function – Store in F-Canyon

Storage would not add any appreciable costs, unless F-Canyon had to remain open just due to the Am/Cm storage. Current planning is preliminary enough (including potential 94-1 mission assistance to Rocky Flats processing residues, fluorides etc.) that it is not expected that the canyon will have completed decommissioning activities prior to completing Am/Cm glass storage. Significant staff and facility support will also be required during the first three years of decommissioning activities.

Function – Ship to ORNL via F-Canyon

Total estimated costs; \$420K

For approximately 50 canisters (based on Cm content) shipping at 8 canisters per cask at \$60K/shipment (Ref 4) the cost would be \$420K. Certification costs would be included in the Am/Cm glass certification. If an additional decontamination shed is needed it would have been added in the earlier shipments for "solution" made into glass and shipped to ORNL.

9.11.9. "Slugs/Other" Disposition - Base Case

Total estimated cost: \$1M

As these slugs/other represent a very small amount of material, it is expected that any costs will be covered (other than shipments) by Am/Cm solution and Mk 18 programs. Shipment is estimated at 1M.

Appendix 9.11, References:

1. Letter, R. Maher to C.C. Mason, "Evaluation of an Oak Ridge National Laboratory Proposal for the Canning and Shipment of Mark (Mk) -18 Target Rods to ORNL", NMP-VP-93212, dated November 18, 1993
2. W. H. Martin, personal communication March, 1998.
3. S. Nester, personal communication, March, 1998.
4. R. Rainisch, personal communication, March, 1998

Appendix L

9.12. Appendix L: Disposition Path Evaluations

9.12.1. Disposition Path Maturity Evaluations

Disposition Path Maturity's for the Am/Cm Tank 17.1 solution base case, its three alternatives and for the Mk 18 base case and its alternative were initially developed in a concentrated one-day effort by cognizant domain experts with the assistance of a Nuclear Materials Integration Systems Engineer and the Core Team. The analysis was performed according to the NMI handbook. However, this was the first time the methodology was used for multi-step process analysis. After documenting all of the DPM evaluations the Core Team reviewed the results for consistency, made recommended changes, contacted domain experts as needed for verification, and documented the logic for specific evaluations in Appendix M. This same process was used for additional alternatives identified. Summaries of these analyses are given below in sections 9.12.1.1 through 9.12.1.6.

The following discussion describes the NMI disposition path maturity analysis performed to support this study. It is extracted from the latest draft NMI Handbook. Disposition Path Maturity (DPM) is a measure of the time it will take needed to bring a process or technology to full production line operation. DPM is a component of Disposition Path Risk (Rdp) which is defined as:

$$Rdp = Pi * Cs ;$$

where Pi = Probability of Immaturity = $DPM/10$
and Cs = Schedule Consequence of Failure

Disposition Path Maturity (DPM) score for each function on the path is:

$$DPM = \text{SUM}(\text{category wt (CW)} * \text{category maturity level}) / \text{SUM(CW)}$$

Schedule consequence (Cs) is:

$$Cs = 1 - ((\text{Need date} - \text{evaluation date in yrs}) / 3.4 * \text{yrs})$$

*Note: 3.4 years is the estimated time to take a project to be installed within a facility (like a glovebox line melter) from concept ($DPM = 10$) to operation ($DPM = 0$).

Risk and Maturity evaluation requires collection of the following data, available from program plans, flowsheets, material balance sheets, and other site process descriptions:

- Function description
- Material category/type
- Material form (input/output)
- Material location
- Proposed technology
- Technology development site
- End-use site
- Evaluator(s)
- Evaluation date
- Operational need date.

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The following DPM **factors** must be evaluated for each function in disposition path. Scoring is accomplished by assessing scoring criteria for each of the following factors:

- Requirements maturity (RM)
- Process maturity
 - Processing and storage (PM) or
 - Transportation (TPM)
- Hardware/equipment maturity
- Processing and storage (EQ) or
- Transportation (TEQ)
- Facility readiness maturity (FAC)
- Operational safety maturity (SAFT)
- Personnel resource status (PER)
- Schedule maturity (SCH)
- NEPA readiness (NEPA)

Weighting for each factor are [category weights (CW)]:

Maturity category	CW	score
RM	medium (0.3)	
PM	high	(0.9)
EQ	high	(0.9)
FA	high	(0.9)
SAFT	medium	(0.3)
PER	low	(0.1)
SCH	medium	(0.3)
NEPA	high	(0.9)

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Requirements Maturity (RM) Scale

Level	Maturity Assessment Criteria
10	Mission objectives not quantified or baselined (<i>volatility in mission</i>)
8	System concept formulated, but flowsheet description (process inputs, outputs, volumes, and rates is incomplete and/or driving component performance parameters (e.g., storage duration, LOI) are not identified (<i>volatility in system concept</i>)
6	Flowsheet description complete and applicability of this component understood. Performance parameters are identified, but most parameter values are not quantified (<i>volatility in key requirements</i>)
4	Flowsheet description and impact on this component understood. Most driving performance parameter values for component have "first pass" values or the supporting analysis is incomplete (<i>volatility in minor requirements</i>)
3	All parameter values which drive the component selection have been resolved and supporting analysis is complete (<i>little to no change in requirements expected</i>)
2	Detailed design parameters and operational requirements are established. As necessary, requirement and parameter values have been validated by models of appropriate fidelity. Specification is under formal configuration control (<i>changes in requirements cause contract changes</i>)
1	Verification test procedures written to demonstrate that component satisfies requirements (<i>component test plan complete</i>)
0	Design procedures complete and results are acceptable (<i>requirements are verified</i>)

Processing & Storage Process Maturity (PM) Scale

Level	Maturity Assessment Criteria
10	No currently identified solutions that meets requirements
9	Design concept and/or technology application formulated.
8	Cold feasibility demonstrated
6	Hot feasibility demonstrated
5	End-to-end design (flowsheet) complete
4	Cold prototype demonstrated <u>at end-use site</u>
2	Hot prototype demonstrated <u>at end-use site</u>
0	Process integrated into operations

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Transportation Process Maturity (TPM) Scale

Level	Maturity Assessment Criteria
10	No currently identified solutions that meets requirements
9	Design concept and/or technology applications formulated.
7	Analogous system in operation that transports similar material.
5	End-to-end system design complete
4	Prototype system demonstrated using cold / surrogate material
2	Prototype system demonstrated using hot material (<i>1st hot shipment complete</i>)
0	Process integrated into operations (<i>several hot shipments completed</i>)

Transportation Hardware Equipment Maturity (TEQ) Scale

Level	Maturity Assessment Criteria
10	Equipment* requirements not yet defined
9	New design. Conceptual design completed.
7	Equipment certified.
5	Certified equipment available. Insufficient quantities available to meet need.
4	Plan complete to manufacture adequate quantities of equipment.
2	Sufficient equipment to begin operations.
0	Equipment in use and adequate quantities available to complete mission.

* This includes all equipment for the system. Use maximum score across all equipment in system.

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Processing & Storage Hardware Equipment Maturity (EQ) Scale

Level	Maturity Assessment Criteria
10	Equipment* requirements not yet defined
9	New design. Conceptual design completed.
8	Experimental system. Cold demonstrated.
7	Experimental system. Hot demonstrated.
6	Commercially equipment available. Requires modification.
4	Integrated end-to-end equipment designs completed.
3	Cold prototype demonstrated.
1	Hot prototype demonstrated.
0	Equipment in use processing the given material.

* This includes all equipment for the system. Use maximum score across all equipment in system.

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Facility Equipment Readiness (FAC) Scale

Level	Maturity Assessment Criteria
10	None available. New facility required
7	Facility available. Major modifications required (new glove boxes, seal in mode).
5	Facility available. Moderate modifications required (modify gloveboxes and equipment).
3	Facility available. Minor modifications required (existing gloveboxes and minor equipment modification).
0	Facility operating. No modifications required.

Operational Safety Readiness (SAFT) Scale

Level	Maturity Assessment Criteria
10	ORR required
8	RA required.
6	Contractor ORR complete.
4	Contractor RA complete.
2	DOE ORR complete (awaiting Secretary of Energy signature).
1	DOE RA complete (awaiting Site Manager signature).
0	Facility ATP issued or within authorization basis.

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Personnel Resource Status (PER) Scale

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Schedule Maturity (SCH) Scale

NEPA Readiness Scale

Level	
10	NEPA determination must be made (<i>i.e. EANS EIS; site or project specific</i>)
9	New site or project specific EIS required.
8	Notice of Intent issued for EIS
6	Draft of EIS issued for public comment
4	Final EIS issued with Record of Decision (ROD)
3	Supplement to existing EIS needed
2	Environmental Assessment (EA) required (assumes finding of No Significant Impact)
1	Categorical Exclusion (CX) required
0	Favorable environmental diagnosis issued (e.g. Environmental checklist); no additional documentation required.

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End-State skystem Interface Requirements Maturity Scale

Risk	Score	Maturity Assessment Criteria
High	10	Mission objectives not quantified or baselined
	8	System concept formulated but total system description (processes and interfaces is incomplete and/or impact of drivign performance parameters (e.g., duration of storage percent impurities, percent fissile material, level of containment) are not identified (volatility in system concept)
Medium	6	System description complete and applicability of this requirement understood. Performance parameters are identified, but most parameter values are not quantified (volatility in key requirements)
	4	System description complete and impact of this requirement on the design baseline understood. Most driving performance parameters have "first pass" values or supporting analysis is incomplete. (volatility in minor requirements).
Low	3	All parameter values which drive design baseline selection have been resolved and supporting analysis is complete (little or no change in requirements expected)
	2	Detailed design parameters and operational reuirements are established. As necessary requirement and paramenter values have been validated by models of appropriate fidelity. Design specifications are under formal configurartion control (changes in requirements cause contract changes)
	1	Verification test procedures written to demonstrate that design baseline satisfies requirements (system test plans complete)
	0	Design test procedure competed and results are acceptable (requirements are verified, system ready for use.)

9.12.1.1. Tank 17.1 "Solution" Disposition - Base Case"

Process / Function	Scoring Factors										
Base Case	RM	PM	EQ	FA	SAFT	PER	SCH	NEPA	ESI	FM1	FM2
weights	0.3	0.9	0.9	0.9	0.3	0.1	0.3	0.9	0.9	5.5	3.7
Weld Primary Shipping Container (PSC)	3	4	3	5	0	1	2	0	3	2.75	3.35
Transport to RBOF	1	2	2	0	0	0	1	0	1	0.93	1.14
Store in RBOF	6	2	1	0	2	0	2	0	4	1.69	1.54
Ship to ORNL	6	6	10	0	8	0	4	6	6	5.56	5.35
Store at ORNL	10	6	1	7	10	0	4	2	10	5.56	5.35
max of above:	10	6	10	7	10	1	4	6	10	7.71	5.35

Typical maturity period (years)

3.4

Need Date

5/1/99

Process will be mature in 3.9 years

Evaluation Date

3/19/98

Years till needed

1.12

Schedule Consequence

0.671

Schedule Risk

0.52

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9.12.1.2. Tank 17.1 "Solution" Disposition - Alternative One

Process / Function	Scoring Factors										
Alternative 1	RM	PM	EQ	FA	SAFT	PER	SCH	NEPA	ESI	FM1	FM2
weights	0.3	0.9	0.9	0.9	0.3	0.1	0.3	0.9	0.9	5.5	3.7
Transport to RBOF	1	2	2	0	0	0	0	0	1	0.87	1.05
Weld Contamination Can	8	9	10	7	10	3	6	0	8	6.93	8.35
Mechanical Seal	3	2	0	3	0	0	0	0	2	1.31	1.46
Store in RBOF	6	2	1	0	2	0	2	0	4	1.69	1.54
Ship to ORNL	6	6	10	0	8	0	4	6	6	5.56	5.35
Store at ORNL	10	6	1	7	10	0	4	2	10	5.56	5.35
max of above:	10	9	10	7	10	3	6	6	10	8.35	8.35

Typical maturity period (years)

3.4

Need Date

5/1/99

Process will be mature in 4.2 years

Evaluation Date

3/3/98

Years till needed

1.16

Schedule Consequence

0.66

Schedule Risk

0.5

9.12.1.3. Tank 17.1 "Solution" Disposition - Alternative Two

Process / Function	Scoring Factors										
Alternative 2	RM	PM	EQ	FA	SAFT	PER	SCH	NEPA	ESI	FM1	FM2
weights	0.3	0.9	0.9	0.9	0.3	0.1	0.3	0.9	0.9	5.5	3.7
Weld Primary Shipping Container (PSC)	3	4	3	5	0	1	2	0	3	2.75	3.35
Store in F Canyon	4	2	0	0	0	0	0	0	1	0.71	0.81
Ship to ORNL	8	9	10	5	10	1	6	6	6	7.22	7.81
Store at ORNL	10	6	1	7	10	0	4	2	10	5.56	5.35
max of above:	10	9	10	7	10	1	6	6	10	8.31	7.81

Typical maturity period (years)

3.4

Need Date

5/1/99

Process will be mature in 4.2 years

Evaluation Date

3/3/98

Years till needed

1.16

Schedule Consequence

0.7

Schedule Risk

0.55

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9.12.1.4. Tank 17.1 "Solution" Disposition - Alternative Three

Process / Function	Scoring Factors										
Alternative 3	RM	PM	EQ	FA	SAFT	PER	SCH	NEPA	ESI	FM1	FM2
weights	0.3	0.9	0.9	0.9	0.3	0.1	0.3	0.9	0.9	5.5	3.7
Weld Contamination Can	3	4	3	5	0	1	2	0	3	2.75	3.35
Store in F Canyon	4	2	0	0	0	0	0	0	1	0.71	0.81
Mechanical Seal in SSC	0	0	0	0	0	0	0	0	0	0.00	0.00
Ship to ORNL	8	9	10	5	10	1	6	6	6	7.22	7.81
Store at ORNL	10	6	1	7	10	0	4	2	10	5.56	5.35
max of above:	10	9	10	7	10	1	6	6	10	8.31	7.81

Typical maturity period (years)

3.4

Need Date

5/1/99

Process will be mature in 4.2 years

Evaluation Date

3/3/98

Years till needed

1.16

Schedule Consequence

0.7

Schedule Risk

0.55

9.12.1.5. Tank 17.1 "Solution" Disposition - Alternative Four

Process / Function	Scoring Factors										
Alternative 4	RM	PM	EQ	FA	SAFT	PER	SCH	NEPA	ESI	FM1	FM2
weights	0.3	0.9	0.9	0.9	0.3	0.1	0.3	0.9	0.9	5.5	3.7
Weld Contamination Can	3	4	3	5	0	1	2	0	3	2.75	3.35
Store in F Canyon	4	2	0	0	0	0	0	0	1	0.71	0.81
Ship to L Basin	1	3	2	0	0	0	1	0	1	1.09	1.38
Store in Dry Storage	4	6	6	10	10	1	4	10	6	7.22	6.84
Ship to ORNL	8	9	10	5	10	1	6	6	6	7.22	7.81
Store at ORNL	10	6	1	7	10	0	4	2	10	5.56	5.35
max of above:	10	9	10	10	10	1	6	10	10	9.45	7.81

Typical maturity period (years)

3.4

Need Date

5/1/99

Process will be mature in 4.7 years

Evaluation Date

3/3/98

Years till needed

1.16

Schedule Consequence

0.7

Schedule Risk

0.62

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9.12.1.6. Tank 17.1 "Solution" Disposition - Alternative Five

Process / Function	Scoring Factors										
Alternative 5	RM	PM	EQ	FA	SAFT	PER	SCH	NEPA	ESI	FM1	FM2
weights	0.3	0.9	0.9	0.9	0.3	0.1	0.3	0.9	0.9	5.5	3.7
Weld Contamination Can	3	4	3	5	0	1	2	0	3	2.75	3.35
Store in F Canyon	4	2	0	0	0	0	0	0	1	0.71	0.81
Ship to L Basin	1	3	2	0	0	0	1	0	1	1.09	1.38
Store in Dry Storage	4	6	6	10	10	1	4	10	6	7.22	6.84
Ship to MGDS	8	9	10	5	10	1	6	6	6	7.22	7.81
Store at MGDS	4	8	4	3	10	5	4	2	4	4.51	5.24
max of above:	8	9	10	10	10	5	6	10	6	8.76	7.81

Typical maturity period (years) **3.4**
 Need Date 5/1/99
 Evaluation Date 3/3/98
 Years till needed 1.16
 Process will be mature in **4.4** years
 Schedule Consequence **0.7**
 Schedule Risk **0.58**

9.12.1.7. Mark 18s Disposition - Base Alternative

Process / Function	Scoring Factors										
Base Case	RM	PM	EQ	FA	SAFT	PER	SCH	NEPA	ESI	FM1	FM2
weights	0.3	0.9	0.9	0.9	0.3	0.1	0.3	0.9	0.9	5.5	3.7
Unpack Mk 18	8	9	9	7	10	3	4	8	8	7.96	7.95
Cut Mk 18	8	9	9	7	10	3	4	8	8	7.96	7.95
Mech. Seal in canister	3	2	0	3	0	0	0	0	2	1.31	1.46
Ship to ORNL	6	6	10	0	8	0	4	10	6	6.22	5.35
Store at ORNL	10	6	1	7	10	0	4	10	10	6.87	5.35
max of above:	10	9	10	7	10	3	4	10	10	8.89	7.95

Typical maturity period (years) **3.4**
 Need Date 5/1/99
 Evaluation Date 3/3/98
 Years till needed 1.16
 Process will be mature in **4.4** years
 Schedule Consequence **0.66**
 Schedule Risk **0.59**

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9.12.1.8. Mark 18s Disposition - Base Alternative One

Process / Function	Scoring Factors										
Alternative 1	RM	PM	EQ	FA	SAFT	PER	SCH	NEPA	ESI	FM1	FM2
weights	0.3	0.9	0.9	0.9	0.3	0.1	0.3	0.9	0.9	5.5	3.7
Load in CD cask*	0	0	0	0	0	0	0	0	0	0.00	0.00
Ship to F-Canyon*	0	0	0	0	0	0	0	0	0	0.00	0.00
Unload CD cask*	0	0	0	0	0	0	0	0	0	0.00	0.00
Dissolve Mk 18s	4	6	6	5	8	0	2	8	4	5.51	5.27
Glass Feed Prep**	0	0	0	0	0	0	0	0	0	0.00	0.00
Make Glass**	0	0	0	0	0	0	0	0	0	0.00	0.00
Glass Canister functions**	0	0	0	0	0	0	0	0	0	0.00	0.00
Ship to ORNL	8	9	10	5	10	1	6	6	6	7.22	7.81
Store at ORNL	10	6	1	7	10	0	4	10	10	6.87	5.35
max of above:	10	9	10	7	10	1	6	10	10	8.96	7.81

Typical maturity period (years)

3.4

Need Date

5/1/99

Process will be mature in 4.5 years

Evaluation Date

3/3/98

Years till needed

1.16

Schedule Consequence

0.7

Schedule Risk

0.59

9.12.1.9. Tank 17.1 "Solution" Disposition - DPM Evaluation Summary

The Technical Maturity Analysis for the six Am/Cm "solution" alternatives is summarized in the below Table. DPM calculates a disposition path maturity including NEPA and ESI for an alternative. DPM calculates the maximum step TM excluding NEPA and ESI for each step. By inspection, it is quickly obvious that the Base Case has the lowest individual step maturity, since it is most like current operations. Alternatives two through five, which all employ welding in MPPF have similar maximum step technical maturity's driven by shipping out of either F canyon or a new Spend Fuel facility (with NEPA and ESI excluded because they should be essentially the same for the paths). Welding underwater in RBOF presents a significantly greater challenge. Note that there is almost no difference in schedule consequence (CS) and schedule risk (Risk) between the alternatives based on the NMI methodology.

Am/Cm Solution Technical Maturity Analysis

Alternative	DPM	DPM'	CS	Risk
Base Case	7.71	5.35	0.67	0.52
Alternative 1	8.35	8.35	0.66	0.55
Alternative 2	8.31	7.81	0.66	0.55
Alternative 3	8.31	7.81	0.66	0.55
Alternative 4	9.45	7.81	0.66	0.62
Alternative 5	8.76	7.81	0.66	0.58

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The table below shows the comparison between the two Mark 18 alternatives. The Disposition Path Maturity evaluated by the NMI methodology shows essentially no difference in Technical Maturity, schedule consequence or schedule risk. However, the maximum technical maturity for each step shows Alternative 1 as slightly higher in technical maturity (7.81 vs. 7.95) than the base case.

Mk-18 Technical Maturity Analysis

Alternative	DPM	DPM'	CS	Risk
Base Case	8.89	7.95	0.66	0.59
Alternative 1	8.96	7.81	0.66	7.81

The table below shows a comparison of five of the six solution technical maturities without ORNL storage included. Technical maturities increased slightly, but were not strongly driven by ORNL storage.

Am/Cm Solution Technical Maturity Analysis (Without ORNL Storage)

Alternative	DPM	DPM'	CS	Risk
Base Case	7.05	5.35	0.67	0.47
Alternative 1	8.56	8.35	0.66	0.56
Alternative 2	7.55	7.81	0.66	0.50
Alternative 3	7.55	7.81	0.66	0.50
Alternative 4	8.69	7.81	0.66	0.57

Similar behavior for the two Mark 18 alternatives is shown in the next table.

Mk-18 Technical Maturity Analysis (without ORNL Storage)

Alternative	DPM	DPM'	CS	Risk
Base Case	8.45	7.95	0.66	0.56
Alternative 1	7.55	7.81	0.66	0.59

9.12.2. Programmatic Risk Assessments

The Fall 1997, EM 2006 Plan required programmatic risk assessments for each Site's critical closure path. Table 8.0 in the EM 2006 Plan Guidance document describes the 3 Programmatic Risk Categories. These programmatic risk categories have been adopted for use by the NMI Project to help discriminate between alternative disposition paths. As part of this study, a programmatic risk assessment was performed for each baseline and alternative disposition path.

Criteria used for these assessments are summarized in the tables below:

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Programmatic Risk Categories	Technology	Work Scope Definition	Inter-Site Dependency
5 (high)*	<ul style="list-style-type: none"> I. No technology to accomplish the planned activity has been found to exist and no technology is under development. II. The identified STCG Need is listed in Table O.9.2. 	<ul style="list-style-type: none"> I. Project end state is not determined or supported by stakeholders or Tribal Nations II. Waste/material quantities and characteristics are unknown III. Process operations are not identified or supported by stakeholders or Tribal Nations IV. Final disposition location for waste/material has not been identified 	<ul style="list-style-type: none"> I. Activity involves multiple sites II. No concurrence has been reached between sites
4*	<ul style="list-style-type: none"> I. A potential technology has been identified to accomplish the planned activity, but development is only at the laboratory scale level or earlier, II. The identified STCG Need is listed in Table O.9.2. 	<ul style="list-style-type: none"> I. Project end state is determined but may be controversial to stakeholders or Tribal Nations II. Process operations are identified, but may be controversial to stakeholders or Tribal Nations III. Final disposition location for waste/material has not been identified and approved 	<ul style="list-style-type: none"> I. Activity involves multiple sites, site concurrence has been verbally reached II. The Waste Acceptance Criteria (WAC) has not been resolved III. No funding has been identified and no schedule for receipt or treatment of the waste/material exists
3*	<ul style="list-style-type: none"> I. A potential technology has been identified to accomplish the planned activity, and is being demonstrated at least at a pilot scale level. II. The identified STCG Need is listed in Table O.9.2. 	<ul style="list-style-type: none"> I. Project end state is determined and is expected to be acceptable to stakeholders or Tribal Nations II. Waste/material quantities and characteristics are broadly known III. Process operations are identified and are expected to be acceptable to stakeholders or Tribal Nations IV. Final disposition location for waste/material has been identified and EIS is being prepared 	<ul style="list-style-type: none"> I. Activity impacts another site, site concurrence has been verbally reached II. Receiving facility is reviewing characterization data to determine WAC acceptability III. Funding has been identified but no schedule for receipt or treatment of the waste/material exists
2*	<ul style="list-style-type: none"> I. The required technology has been fully developed and demonstrated at another site with a similar waste/material type 	<ul style="list-style-type: none"> I. Project end state is determined and supported by stakeholders or Tribal Nations II. Waste/material quantities and characteristics are well known III. Process operations are identified and are supported by stakeholders or Tribal Nations IV. Final disposition location for waste/material has been identified and EIS ROD is prepared 	<ul style="list-style-type: none"> V. Activity doesn't impact another site or Site concurrence has been documented if multiple sites are impacted VI. Receiving facility has verified WAC acceptability VII. Funding has been identified but no schedule for receipt or treatment of the waste/material exists
1 (low)*	<ul style="list-style-type: none"> I. Technology has been demonstrated at the site on some actual waste/materials and is operationally ready 	<ul style="list-style-type: none"> I. Project end state is determined and supported by stakeholders or Tribal Nations II. Waste/material quantities and characteristics are well known III. Process operations are identified and are supported by stakeholders or Tribal Nations IV. Final disposition location for waste/material has been identified and EIS ROD is pending 	<ul style="list-style-type: none"> I. Activity doesn't impact another site or Site concurrence has been documented if multiple sites involved II. Receiving facility has verified WAC acceptability III. Funding is identified in an approved PBS and facility is ready to receive the waste/material

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Analysis of Programmatic Risk for Am/Cm "Solution", Mk 18, and Am/Cm Slug Disposition Alternatives

The table (and accompanying notes) below indicate evaluated programmatic risk for Am/Cm "solution" (Tank 17.1), Mk-18 and slug/other alternatives. It should be noted that for a given material group, there is practically no difference in proposed programmatic risk scores. A large delta does exist when comparing installation of a dissolver in F Canyon vs. design/installation of an isolation chamber for RBOF.

Programmatic Risk

	Technology	Work Scope Definition	Inter-Site Dependency
Tank 17.1 Base Case	2	4	5
Tank 17.1 Alt. 1	2	4	5
Tank 17.1 Alt. 2	2	4	5
Tank 17.1 Alt. 3	2	4	5
Tank 17.1 Alt. 4	2	4	5
Tank 17.1 Alt. 5	2	4	5
Mk-18s Base Case	4	4	5
Mk-18s Alternative One	2	4	5
Slug/Other Base Case	2	4	5

Notes:

Technology

- Both remote and underwater welding have been demonstrated.
- Both Cs-137 positioning for cutting underwater and Mk-18 dissolution have been conceptualized but not demonstrated.

Work Scope Definition

- EISs or appropriate checklists have not been prepared.
- In the case of Mk 18s and slugs/Other the ROD is scheduled to be issued December 1998. At that time the selected alternatives would drop to a 1 or 2.

Inter-Site Dependency

- Because of funding and EIS issues, agreement on shipping Tank 17.1 vitrified materials to ORNL is in the very preliminary stages.
- Agreement has been verbally reached to ship "slugs/other and Mark 18s to ORNL, but the funding will not be available until after the EIS ROD.

9.12.3. Am/Cm ES&H Risk Assessments

This section provides background information, identifies the factors used as surrogate metrics for potential ES&H risk for this study.

The approach used in this study was developed to be consistent in format with the Disposition Path Maturity, Programmatic Risk, and Life-Cycle Cost assessments. Given the large number of paths to consider for each category of materials, and the need to address multiple functions per path, an attempt was made to use simple factors, for which information is likely to be readily available, as rough surrogate indicators of potential ES&H risk. Finally, the approach is based on the large amount of work

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on NM already conducted by DOE-EH in the preparation of ES&H vulnerability studies for spent fuel (published in 1993), plutonium (1994), and HEU (1996).

Vulnerability Categories and Risk Criteria Factors

Of the three categories of vulnerabilities identified in the DOE-EH ES&H NM studies (material/packaging, facility condition, and institutional/administrative), material/packaging vulnerability factors are used as screening criteria for the NMI project and this study. The facility condition vulnerability factors (e.g., facility structural integrity, safety systems status) and institutional vulnerability factors (e.g., authorization basis status, personnel training and qualification status) are addressed in the Disposition Path Maturity assessment screening process.

The Material Vulnerability Category includes five factors: material characterization; package integrity/condition; material form; mass of material; and material toxicity. For each factor, a description is provided of relatively lower risk and relatively higher risk conditions.

Worker ES&H risk is also expected to be influenced by the three factors described in the Handling Vulnerability Category. These include factors for: radiological hazard potential; non-radiological hazard potential; and material handling frequency.

In addition, public ES&H risk from the routine stabilization and disposition of NM is expected to be driven by transportation risks. The Transportation Vulnerability Category contains a single factor that considers whether off-site shipment of NM will occur. This factor is based on the potential physical trauma related to truck accidents, rather than on radiological exposure. On a national average basis, a physical trauma fatality resulting from a transportation accident is expected to occur every 2.5 million miles of truck travel, irrespective of the cargo shipped. This figure is very conservative, given the expected much lower incidence of shipping accidents for shipments of NM.

Material Vulnerability Category

1. Material Characterization Factor

- material well characterized; packages accurately labeled, including material limits and spacing requirements - 1
- material not well characterized; missing or inaccurate labels, unknown or uncharacterized material - 2

2. Package Integrity/Condition Factor

- no known deficiencies or degradation in packaging; packages intact and unlikely to be breached during handling accidents - 1
- condition of packaging is unknown; deficiency or degradation of package or container due to aging, corrosion, radiolytic damage, pressurization; package breach during handling accidents possible -

3. Material Form Factor

- material is a metal or solid with low leak, spill, dispersion potential - 1
- material is in a powder, oxide, or particulate form (e.g., ash) with intermediate leak, spill, dispersion potential - 2

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- material is a liquid or gas with high leak, spill, dispersion potential - 3

4. Mass of Material Factor

- amount of material ≤ 1 g - 1
- amount of material > 1 g < 1 metric ton - 2
- amount of material > 1 metric ton - 3

5. Material Toxicity Factor

Based on values for *exponents* of Derived Air Concentrations (DACs), as presented in Appendix A of 10 CFR 835 (attached). Find isotope of interest in Appendix A tables, and use *minimum* of available radioisotope-specific D, W, Y values presented (in units of $\mu\text{Ci/ml}$). For mixed isotopes, use isotope with lowest DAC value.

- DAC exponent range 10^{-1} to 10^{-4} - 1
- DAC exponent range 10^{-5} to 10^{-9} - 2
- DAC exponent range 10^{-10} to 10^{-13} - 3

Handling Vulnerability Category

6. Radiological Hazard Potential Factor

- mainly manual or contact-handled processing - 1
- mainly remote-handled processing - 2

7. Non-radiological Hazard Potential Factor

- non-energetic process; no hazardous chemicals - 1
- energetic process (e.g., high pressure, temperature; explosive potential); hazardous chemicals (e.g., nitric acid, beryllium) - 2

8. Material Handling Frequency Factor

- single step/pass processing - 1
- multiple step/pass processing - 2

Transportation Vulnerability Category

9. Material Shipment Factor

- no off-site transfer of material - 1
- total number of truck shipments x number of round-trip miles per shipment < 2.5 million miles (e.g., multiple local or regional shipments) - 2
- total number of truck shipments x number of round-trip miles per shipment ≥ 2.5 million miles (e.g., multiple cross-country shipments) - 3

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Guidance Provided for Conducting ES&H Risk Screening

For the NMI Project, ES&H screening will be conducted to: (1) estimate the potential ES&H vulnerability of the material in its current state; and (2) to compare baseline disposition pathways and alternative pathways.

Material Current State ES&H Vulnerability Screen

Material Current State Vulnerability is *qualitatively* characterized as High, Medium, or Low based on the scores for Factors 1 through 5, as follows:

- Factors 1-5 Material Current State Vulnerability is Low if:
 - Scores for Factors 1-3 are 1 (irrespective of scores for Factors 4 and 5)
- Factors 1-5 Material Current State Vulnerability is High if:
 - Scores for Factors 1 and 2 are 2 and Factor 3 are 2 or 3 **AND**
- Factors 1-5 Material Current State Vulnerability is Medium:
 - for all other combinations of Factor scores

Disposition Pathway ES&H Vulnerability Screen

For comparison of baseline and alternative disposition pathways, ES&H vulnerability metrics are:

Handling Vulnerability = sum of scores of Factors 6, 7 & 8

Transportation Vulnerability = score of Factor 9

ES&H vulnerability scores are estimated for the each disposition pathway. Material Evaluation Teams should consider the entire disposition pathway in developing scores for Handling Vulnerability Factors 6 through 8 and Transportation Vulnerability Factor 9. The overall pathway Handling Vulnerability score is the sum of the scores for Factors 6-9. The pathway Transportation Vulnerability score is the score for Factor 9. These scores will be used to compare baseline disposition pathways with alternative pathways.

Samples of the ES&H Material Current State Vulnerability Screening Worksheet and the Disposition Pathway Vulnerability Screening Worksheet are attached.

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ES&H MATERIAL CURRENT STATE VULNERABILITY
SCREENING WORKSHEET

Material Stream ID: Material Stream Name: Function:	Factor Score	Category Score
1. Material Characterization Factor <ul style="list-style-type: none"> material well characterized; packages accurately labeled, including material limits and spacing requirements - 1 Material not well characterized; missing or inaccurate labels, unknown or uncharacterized material or packaging - 2 	1 or 2	
2. Package Integrity/Condition Factor <ul style="list-style-type: none"> Packages intact and unlikely to be breached during handling accidents - 1 Deficiency or degradation of package or container due to aging, corrosion, radiolytic damage, pressurization; package breach during handling accidents likely - 2 	1 or 2	
3. Material Form Factor <ul style="list-style-type: none"> Material is a metal or solid with low leak, spill, dispersion potential - 1 Material is in a powder, oxide, or particulate form (e.g., ash) with intermediate leak, spill, dispersion potential - 2 Material is a liquid or gas with high leak, spill, dispersion potential - 3 	1, 2 or 3	
4. Mass of Material Factor <ul style="list-style-type: none"> Amount of material ≤ 1 g - 1 Amount of material >1 g < 1 metric ton - 2 Amount of material >1 metric ton - 3 	1, 2, or 3	
5. Material Toxicity Factor <ul style="list-style-type: none"> Radioisotope-specific DAC exponent range 10^{-1} to 10^{-4} - 1 Radioisotope-specific DAC exponent range 10^{-5} to 10^{-9} - 2 Radioisotope-specific DAC exponent range 10^{-10} to 10^{-13} - 3 	1, 2 or 3	H, M, or L

Factors 1 - 5: If scores for Factors 1-3 are 1 (irrespective of scores for Factors 4 and 5),
Material Current State Risk is Low

Factors 1 - 5: If: (a) scores for Factor 1 & 2 are 2 and scores for Factor 3 are 2 or 3; **AND**
(b) scores for Factor 4 are 2 or 3 **OR** score for Factor 5 is 3,
Material Current State Risk is High

Factors 1 - 5: Material Current State Risk for all other combinations of scores is Medium

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ES&H DISPOSITION PATHWAY VULNERABILITY
SCREENING WORKSHEET

Material Stream ID: Material Stream Name: Function:	Factor Score	Category Score
Material Handling Vulnerability Category		
6. Radiological Hazard Potential Factor • contact-handled processing - 1 • remote-handled processing - 2	1 or 2	
7. Non-radiological Hazard Potential Factor • non-energetic process; no hazardous chemicals - 1 • energetic process; hazardous chemicals - 2	1 or 2	
8. Material Handling Frequency Factor • single step/pass processing - 1 • multiple step/pass processing - 2	1 or 2	Sum
Transportation Vulnerability Category		
9. Material Shipment Factor • no off-site transfer of material - 1 • Total number of truck shipments x number of round-trip miles per shipment < 2.5 million miles - 2 • Total number of truck shipments x number of round-trip miles per shipment ≥ 2.5 million miles - 3	1	1,2, or 3

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Am/Cm ES&H Risk Evaluation

The table below indicates the proposed scores for the Am/Cm "solution, Mark-18 and Am/Cm slug alternatives. It should be noted that there is no expected difference in scores for a base case and alternatives for a given material.

	Material Vulnerability Category					Handling Vulnerability			Transportation Vulnerability
	Material Characterization	Package Integrity	Material Form	Material Mass	Material Toxicity	Rad. Hazard Potential	Non-Rad. Hazard Potential	Material Handling Frequency	Material Shipment
Tank 17.1 Base Case	1	1	1	2	TBD	2	1	2	2
Tank 17.1 Alt. 1	1	1	1	2	TBD	2	1	2	2
Tank 17.1 Alt. 2	1	1	1	2	TBD	2	1	2	2
Tank 17.1 Alt. 3	1	1	1	2	TBD	2	1	2	2
Tank 17.1 Alt. 4	1	1	1	2	TBD	2	1	2	2
Tank 17.1 Alt. 5	1	1	1	2	TBD	2	1	2	2
Mk-18s Base Case	1	1	1	1	TBD	2	1	2	2
Mk-18s Alternative One	1	1	1	1	TBD	2	1	2	2
Slug/Other Base Case	1	1	1	1	TBD	2	1	2	2

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9.12.4. Disposition Path Evaluation Summary

Alternative Cost Evaluation

Costs were evaluated for the six Am/Cm solution alternatives and the two Mk 18 alternatives for preparing the material for shipment and shipping it to ORNL. Since the estimated \$80M cost for the Am/Cm glass project and the \$7M ORNL storage project were common costs, they were not included. These costs are summarized in the table below:

Case	Prepare to ship	Ship	Total	Avg.
Tank 17.1 Solution	1.9-2.0	2.7-3.5	4.6-5.5	5
Tank 17.1 Sol. Alt 1	3.2-3.4	2.7-3.5	5.9-6.9	6.4
Tank 17.1 Sol. Alt 2	1.7	2.7-3.5	4.4-5.2	4.8
Tank 17.1 Sol. Alt 3	1.3	2.7-3.5	4-4.8	4.4
Tank 17.1 Sol. Alt 4	2.8-3.4	2.7-3.5	5.5-6.9	6.2
Tank 17.1 Sol. Alt 5	14.5-55.8	1.9-2.0	16.3-57.8	37.1
Mk-18 Base	15	2	17	17
Mk-18 Alt 1	6.7-7.7	0.4	7.1-8.1	7.6
Slugs & Other	1	0	1	1

Since these are planning level costs, i.e. -50%/+100% there is no large difference between alternatives, with the exception of disposition as waste, Tank 17.1 Alternative 5

Decision Analysis

Since there was no difference between alternatives for Programmatic Risk and ES&H risk, for this type of analysis it is customary to eliminate these two factors from further consideration. Without any additional information decision analysis would consider cost and technical maturity equal. If we calculate a cost and DPM' ratio where:

$$\text{Cost Ratio} = \text{Alternative Cost} / \text{sum(Alternative Costs)}$$

and

$$\text{DPM Ratio} = \text{DPM(Alternative)} / \text{sum(DPM(Alternatives))}$$

Then we can define a Score that yields a higher score for more attractive alternatives:

$$\text{Score} = 1 - (\text{Cost Ratio} + \text{DPM Ratio}) * 0.5$$

The table below gives the calculated scores for the six Am/Cm solution alternatives and two Mk 18 alternatives:

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Am/Cm Solution			
Alternative	Cost Ratio	DPM Ratio	Score
Base Case	0.078	0.152	0.885
Alternative 1	0.100	0.164	0.868
Alternative 2	0.075	0.163	0.881
Alternative 3	0.069	0.163	0.884
Alternative 4	0.097	0.186	0.859
Alternative 5	0.580	0.172	0.624
Mk-18			
Base Case	0.725	0.501	0.387
Alternative 1	0.275	0.499	0.613

In addition to this analysis the following pros and cons were developed to look at the alternatives:

Am/Cm "Solution" Base Case

- + No Pu curie content limit for system (no waivers required)
- + Off-site casks shipped from RBOF (no "decon shed" required)
- Increases shipping from RBOF -- not in current schedule
- Increases CwP-1 handling
- Full penetration weld qualification required

Am/Cm "Solution" Alternative One

- + "Contamination Barrier" seal weld does not require qualification
- + Off-site casks shipped from RBOF (no "decon shed" required)
- Increases shipping from RBOF -- not in current schedule
- Increases handling (more steps)
- Potential contamination of RBOF
- Requires underwater weld rig (bell jar)

Am/Cm "Solution" Alternative Two

- + No Pu curie content limit for system (no waivers required)
- + Minimizes CwP-1 handling
- + No impact on RBOF shipping
- Full penetration weld qualification required
- Requires new F-Canyon procedures for commercial cask

Am/Cm "Solution" Alternative Three

- + Minimizes CwP-2 handling
- + No impact on RBOF shipping
- Requires waivers for shipping
- Potential CwP-2 decontamination difficulties
- Requires new F-Canyon procedures for commercial cask/decon shed

Am/Cm "Solution" Alternative Four

- + Does not require ORNL storage addition
- + No impact on RBOF shipping
- + Requires no waiver for shipping
- Requires new facilities in L Reactor area
- Requires transport machine to load cask storage

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Am/Cm "Solution" Alternative Five

- +
 - +
 - +
 -
 -
 -
 -
- Does not require ORNL storage addition
 - No impact on RBOF shipping
 - Requires no waiver for shipping
 - Requires new facilities in L Reactor area
 - Requires transport machine to load cask storage
 - Requires sampling, qualification and analysis of the glass
 - Some risk of making material that is not acceptable to the repository

Mk 18 Base Case

- +
 -
 -
 -
 -
 -
 -
- No Aqueous processing/canyon modifications required
 - Untested equipment required to reduce Mk 18 size
 - Potential significant RBOF airborne and water contamination
 - Larger number of shipments (33)
 - Larger impact on ORNL storage
 - Different material from Am/Cm Solution to be handled at ORNL
 - Requires Mk 42 processing completion to make space available

Mk 18 Alternative One

- +
 - +
 - +
 - +
 - +
 -
- Produces glass form like "Solution"
 - Some preliminary design available
 - Minimizes number of shipments (8-10)
 - Minimizes impact on ORNL Storage
 - Minimum impact on RBOF operations
 - Requires canyon Modifications and aqueous processing
 - NOTE: May be able to use existing F Canyon facilities, equipment and personnel, this would have a significant impact on decreasing costs, schedules and risks.

Slugs Base Case

- +
 - +
 -
- Minimal RBOF impact
 - Requires no canyon processing
 - Requires shipping package analysis

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9.13. Appendix M – Disposition Path Maturity Evaluation Score Basis

9.13.1. Tank 17.1 "Solution" – Base Alternative

MPPF Primary, RBOF Secondary Containment, Shipped from RBOF to ORNL

9.13.1.1. Function 1: Make Glass

The function "Make Glass" was not evaluated based on the assumption that the current program will meet the scope, cost, and schedules provided in this report.

9.13.1.2 Function 1: Weld CwP-1

Tank 17.1 Solution – Base Alternative – Glass Date: 3/19/98		FUNCTION: Weld CwP-1 in MPPF/F-Canyon			
Scale		Weight	Score	Final	Rationalization
Requirements Maturity	RM	0.3	3	.9	Remote welding has been done. Not a new technology. Little change in requirements expected
Processing & Storage Maturity	PM	0.9	4	3.6	Process has been done cold at PNL.
Transportation Process Maturity	TPM				
Process & Storage Hardware Equipment Maturity	EQ	0.9	3	2.7	Prototype has been done on site
Transportation Hardware Equipment Maturity	TEQ				
Facility Equipment Readiness	FAC	0.9	5	4.5	Requires moderate modifications will be required
Operational Safety Readiness	SAFT	0.3	0	0	Making glass and welding canisters within the facility authorization basis.
Personal Resource Status	PER	0.1	1	.1	Time is available, training is relatively simple and operators are currently trained in remote operations
Schedule Maturity	SCH	0.3	2	.6	Welding glass canisters within MPPF/F-Canyon is conceptual. Input is from experienced personnel using engineering judgment to extrapolate.
NEPA Readiness	NEPA	0.9	0	0	ROD presently covers welding in F-Canyon
End State System Interface Requirements	ESI	0.9	3	2.7	ORNL has bounded the design. Detail design remains to be done.

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9.13.1.2. Transport to RBOF

Tank 17.1 Solution – Base Alternative – Glass Date: 3/19/98		FUNCTION: Transport to RBOF			
Scale		Weight	Score	Final	Rationalization
Requirements Maturity	RM	0.3	1	.3	Tasks utilizes on-site cask and will follow existing WSRC 19Q requirements. Calculation is incomplete for contents of cask.
Processing & Storage Maturity	PM				
Transportation Process Maturity	TPM	0.9	2	1.8	Tasks has been performed but not recently.
Process & Storage Hardware Equipment Maturity	EQ				
Transportation Hardware Equipment Maturity	TEQ	0.9	2	1.8	Tasks has been performed but not with this material (N) or basket. Shipping Mk 18 was done under old requirements. Calculation has to be done. Equipment is available.
Facility Equipment Readiness	FAC	0.9	0	0	Facility is on a continued operating basis.
Operational Safety Readiness	SAFT	0.3	0	0	USQ required but obtainable within one year.
Personal Resource Status	PER	0.1	0	0	Personnel available and transfers in progress.
Schedule Maturity	SCH	0.3	2	0.6	CwP-1 concept only; schedule from experienced professionals
NEPA Readiness	NEPA	0.9	0	0	Requires NEPA Checklist.
End State System Interface Requirements	ESI	0.9	1	.9	Tool to handle insert has not been built

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9.13.1.3. Store in RBOF

Tank 17.1 Solution – Base Alternative – Glass Date: 3/19/98		FUNCTION: Store In RBOF			
Scale		Weight	Score	Final	Rationalization
Requirements Maturity	RM	0.3	6	1.8	Glass project has not determined how many canisters will be generate but does know a range.
Processing & Storage Maturity:	PM	0.9	2	1.8	CwP-1 is a slightly different in form.
Transportation Process Maturity	TPM				
Process & Storage Hardware Equipment Maturity	EQ	0.9	1	.9	New tools may be required
Transportation Hardware Equipment Maturity	TEQ				
Facility Equipment Readiness	FAC	0.9	0	0	Facility is presently storing radioactive material
Operational Safety Readiness	SAFT	0.3	2	.6	Bounded in Authorization Basis pending analysis.
Personal Resource Status	PER	0.1	0	0	Personnel available and operations in progress.
Schedule Maturity	SCH	0.3	2	.6	Number of containers to be stored has a range but is not yet detailed
NEPA Readiness	NEPA	0.9	0	0	ROD presently covers RBOF operation
End State System Interface Requirements	ESI	0.9	4	3.6	Need to know criticality number dose rates, sizes.

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9.13.1.4. Ship to ORNL via RBOF

Tank 17.1 Solution – Base Alternative – Glass Date: 3/19/98		FUNCTION: Ship to ORNL via RBOF			
Scale		Weight	Score	Final	Rationalization
Requirements Maturity	RM	0.3	6	1.8	Requirements for licensed glass shipping container are not mature.
Processing & Storage Maturity	PM				
Transportation Process Maturity	TPM	0.9	6	3.6	Neutron shielding issue. ORNL has no prior experience with receiving this particular source and unknown loading.
Process & Storage Hardware Equipment Maturity	EQ				
Transportation Hardware Equipment Maturity	TEQ	0.9	10	9	Neutron shielding requirement is an unknown at this time
Facility Equipment Readiness	FAC	0.9	0	0	RBOF facility for shipping is presently in operation
Operational Safety Readiness	SAFT	0.3	8	2.4	License agreement requires about 3-6 months. Mk 42 knowledge helps but does not go far enough for this material.
Personal Resource Status	PER	0.1	0	0	Personnel available and operations in progress.
Schedule Maturity	SCH	0.3	4	1.2	Conceptual design only or less. Inputs is from experienced personnel based on analogous experience
NEPA Readiness	NEPA	0.9	6	5.4	An Environmental Assessment may be needed.
End State System Interface Requirements	ESI	0.9	6	5.4	Shielding for this neutron source has been defined.

* Note: Assumes NLI Cask

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9.13.1.5. Store at ORNL

Tank 17.1 Solution – Base Alternative – Glass Date: 3/19/98		FUNCTION: Store at ORNL			
Scale		Weight	Score	Final	Rationalization
Requirements Maturity	RM	0.3	10	3	Mission has volatility in that it is not approved and adds storage to ORNL
Processing & Storage Maturity:	PM	0.9	6	5.4	Design is conceptual. Storage of highly radioactive material is feasible. Cooling may be an issue.
Transportation Process Maturity	TPM				
Process & Storage Hardware Equipment Maturity	EQ	0.9	1	.9	Heat load design is only conceptual. Modifications must be made. Cooling design and build in 2-3 years
Transportation Hardware Equipment Maturity	TEQ				
Facility Equipment Readiness	FAC	0.9	7	6.3	Little room available without additional modification.
Operational Safety Readiness	SAFT	0.3	10	3	Modification required and hazard classification will change.
Personal Resource Status	PER	0.1	0	0	Personnel available in ongoing operations.
Schedule Maturity	SCH	0.3	4	1.2	Conceptual design only or less. Inputs is from experienced personnel based on analogous experience
NEPA Readiness	NEPA	0.9	2	1.8	ORNL handles Am/Cm feedstocks; EA or less required
End State System Interface Requirements	ESI	0.9	10	9	ORNL needs to look at EIS and talk to internal personnel.

9.13.1.6. ORNL Operations

The "Make Products", "Use Products", "Recycle Products" and "Dispose of Products" are ORNL Operations and are outside the scope of this study.

Appendix M

9.13.2. Tank 17.1 "Solution" – Alternative #1

MPPF Contamination Control Can, RBOF Primary & Secondary Containment, Shipped from RBOF to ORNL

9.13.2.1. Make Glass (Refer to Section 9.13.1.1)

9.13.2.2. Transport to RBOF (Refer to Section 9.13.1.3)

9.13.2.3. Weld CwP-3 in RBOF

Tank 17.1 Solution – Alternative #1 – Glass Date 3/19/98		FUNCTION: Weld CwP-3 RBOF			
Scale		Weight	Score	Final	Rationalization
Requirement Maturity	RM	0.3	8	2.4	Remote welding has not been done in RBOF.
Processing & Storage Maturity	PM	0.9	9	8.1	Design is conceptual at best, but underwater welding has been done.
Transportation Process Maturity	TPM				
Process & Storage Hardware Equipment Maturity	EQ	0.9	10	9	All equipment requirements are not yet defined
Transportation Hardware Equipment Maturity	TEQ				
Facility Equipment Readiness	FAC	0.9	7	6.3	Impact to NIMs due OT power surges. Welder has to be seismically qualified. New equipment will be placed into system.
Operational Safety Readiness	SAFT	0.3	10	3.0	ORR required. Will be a major modification
Personal Resource Status	PER	0.1	3	0.3	Significant training required, not on critical path.
Schedule Maturity	SCH	0.3	6	1.8	Design is conceptual or less. Experienced personnel using Engineering judgment to extrapolate.
NEPA Readiness	NEPA	0.9	0	0	Would have to do a NEPA Checklist to prove we are bounded. Expectation is that it is covered
End State System Interface Requirements	ESI	0.9	8	7.2	Other than a mission exists, nothing else is known.

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9.13.2.4. Mechanically Seal msQSC

Tank 17.1 Solution – Alternative #1 – Glass Date 3/19/98		FUNCTION: Mechanically Seal msQSC			
Scale		Weight	Score	Final	Rationalization
Requirement Maturity	RM	0.3	3	0.9	Operation is similar to cask closure which is a normal RBOF function
Processing & Storage Maturity	PM	0.9	2	1.8	Similar operations have been performed.
Transportation Process Maturity	TPM			0.0	
Process & Storage Hardware Equipment Maturity	EQ	0.9	0	0.0	Equipment has been used for comparable operations.
Transportation Hardware Equipment Maturity	TEQ			0.0	
Facility Equipment Readiness	FAC	0.9	3	2.7	Minor modifications will be required.
Operational Safety Readiness	SAFT	0.3	0	0.0	Task should be within Authorization Basis.
Personal Resource Status	PER	0.1	0	0.0	Personnel are available in ongoing production. Only minor training required.
Schedule Maturity	SCH	0.3	0	0.0	Function falls within scope of normal operational capability. Schedule inputs are from experienced personnel on analogous experience
NEPA Readiness	NEPA	0.9	0	0.0	Falls under an existing EIS.
End State System Interface Requirements	ESI	0.9	2	1.8	Verification testing will have to be performed.

9.13.2.5. Store in RBOF (Refer to Section 9.13.1.4

9.13.2.6. Ship to ORNL via RBOF (Refer to Section 9.13.1.5)

9.13.2.7. Store at ORNL (Refer to Section 9.13.1.6)

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9.13.3. Tank 17.1 "Solution" – Alternative #2

MPPF Primary - Cask Secondary Containment, Shipped for F-Canyon to ORNL

9.13.3.1. Make Glass (Refer to Section 9.13.1.1)

9.13.3.2. Weld CwP-1 in MPPF/F-Canyon (Refer to Section 9.13.1.2)

9.13.3.3. Store in F-Canyon

Tank 17.1 Solution – Alternative #2 Date 3/19/98		FUNCTION: Store in F-Canyon*			
Scale		Weight	Score	Final	Rationalization
Requirement Maturity	RM	0.3	4	1.2	Moving material out of tank is not fully analyzed in terms of exposure and distribution.
Processing & Storage Maturity	PM	0.9	2	1.8	Hot storage in MPPF has been done
Transportation Process Maturity	TPM				
Process & Storage Hardware Equipment Maturity	EQ	0.9	0	0.0	No new equipment required.
Transportation Hardware Equipment Maturity	TEQ			0.0	
Facility Equipment Readiness	FAC	0.9	0	0.0	No further modifications required assuming project has completed rack modifications.
Operational Safety Readiness	SAFT	0.3	0	0.0	Storage of radioactive material is within Authorization Basis
Personal Resource Status	PER	0.1	0	0.0	Personnel are trained and operations are ongoing.
Schedule Maturity	SCH	0.3	0	0.0	Racks and slag buckets are designed
NEPA Readiness	NEPA	0.9	0	0.0	Task is within existing facility operations
End State System Interface Requirements	ESI	0.9	1	.9	Detailed design parameters & operational procedures are defined (Current project is clarifying)

*Assume MPPF

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9.13.3.4. Ship to ORNL via F-Canyon

Tank 17.1 Solution – Alternative #2 Date 3/19/98		FUNCTION: Ship to ORNL via F-Canyon*			
Scale		Weight	Score	Final	Rationalization
Requirements Maturity	RM	0.3	8	2.4	Direct shipping from F-Canyon to ORNL for this application has never been done (off-site shipping cask has not been brought into railroad tunnel). Requirements for licensed glass shipping container are not mature.
Processing & Storage Maturity:	PM				
Transportation Process Maturity	TPM	0.9	9	8.1	Neutron shielding issue. ORNL has no prior experience with receiving this particular source and unknown loading. Design concept and technology application formulated.
Process & Storage Hardware Equipment Maturity	EQ				
Transportation Hardware Equipment Maturity	TEQ	0.9	10	9	Commercially made but requires modification. Neutron shielding is an issue.
Facility Equipment Readiness	FAC	0.9	5		F-Canyon facility is available but needs contamination control building for cask decontamination and storage.
Operational Safety Readiness	SAFT	0.3	10		ORR is required. Mk 42 knowledge helps but does not go far enough for this material.
Personal Resource Status	PER	0.1	1		Personnel available and operations in progress. Minor training would be required.
Schedule Maturity	SCH	0.3	6		Conceptual design only or less. Inputs is from experienced personnel using engineering experience to extrapolate.
NEPA Readiness	NEPA	0.9	6		An EA is believed to be needed.
End State System Interface Requirements	ESI	0.9	6		System description is complete and applicability of the requirement is understood.

- Note: Assumes NLI Cask

9.13.3.5. Store at ORNL (Refer to 9.13.1.6)

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9.13.4. Tank 17.1 "Solution" – Alternative #3

MPPF Contamination Can - Shipping Cask Primary Containment, Ship From F-Canyon to ORNL

9.13.4.1. Make Glass (Refer to Section 9.13.1.1)

9.13.4.2. Weld CwP-2 in MPPF/F-Canyon (Refer to Section 9.13.2.3)

9.13.4.3. Store in F-Canyon (Refer to Section 9.13.3.3)

9.13.4.4. Ship to ORNL via F-Canyon (Refer to Section 9.13.3.4)

9.13.4.5. Store at ORNL (Refer to Section 9.13.1.6) (refer to Section 9.13.1.6)

9.13.5. Tank 17.1 "Solution" – Alternative #4

Interim SRS Glass Storage, Transfer to ORNL as Needed

9.13.5.1. Make Glass (refer to Section 9.13.1.1)

9.13.5.2. Weld Cwp-2 in MPPF/F Canyon (Refer to Section 9.13.1.2)

9.13.5.3. Store in F Canyon (Refer to Section 9.13.3.2)

9.13.5.4. Ship to L Basin (Refer to Section 9.13.1.3; Transport to RBOF)

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9.13.5.5. Store in Dry Storage

Tank 17.1 Solution – Alternative #4 - Interim Store at SRS Date: 4/21/98		FUNCTION: Store Containers at L Reactor Dry Storage			
Scale		Weight	Score	Final	Rationalization
Requirements Maturity	RM	0.3	4	1.2	Flowsheet impact understood. Most driving performance parameters have "first pass" values
Processing & Storage Maturity:	PM	0.9	6	5.4	Hot feasibility demonstrated on similar materials (SNF)
Transportation Process Maturity	TPM				
Process & Storage Hardware Equipment Maturity	EQ	0.9	6	5.4	Commercially designed units in use for SNF. Modifications may be required.
Transportation Hardware Equipment Maturity	TEQ				
Facility Equipment Readiness	FAC	0.9	10	9	No facility available (Concrete cask pad cask storage)
Operational Safety Readiness	SAFT	0.3	10	3	ORR Required
Personal Resource Status	PER	0.1	1	0.1	Sufficient trained personnel available, but not trained in this activity
Schedule Maturity	SCH	0.3	4	1.2	Design is conceptual; schedule based on analogous experience with experienced personnel.
NEPA Readiness	NEPA	0.9	2	1.8	Requires EA
End State System Interface Requirements	ESI	0.9	6	5.4	System description is complete and applicability understood; most parameter values are unquantified.

9.13.5.6. Ship to ORNL (Refer to Section 9.13.1.5)

9.13.5.7. Store at ORNL (Refer to Section 9.13.1.6)

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9.13.6. Tank 17.1 "Solution" – Alternative #5:

Treat Glass to Waste

9.13.6.1. Make Glass (refer to Section 9.13.1.1)

9.13.6.2. Prepare for Disposition (refer to Section 9.13.3.2; Weld CwP-2 in MPPF/f Canyon)

9.13.6.3. Ship to L Basin (refer to Section 9.13.1.3; Transport to RBOF)

9.13.6.4. Load Glass CwP-2 in SNF Canister

Tank 17.1 Solution – Alternative #5 - Treat to Waste Date: 4/17/98		FUNCTION: Load CwP-2 in SNF Canister			
Scale		Weight	Score	Final	Rationalization
Requirements Maturity	RM	0.3	8	2.4	System concept only
Processing & Storage Maturity:	PM	0.9	6	5.4	Flow sheet description and applicability of this component understood
Transportation Process Maturity	TPM				
Process & Storage Hardware Equipment Maturity	EQ	0.9	9	8.1	New design, conceptualized
Transportation Hardware Equipment Maturity	TEQ				
Facility Equipment Readiness	FAC	0.9	7	6.3	L Reactor process area is available and under consideration for SNF packaging activities
Operational Safety Readiness	SAFT	0.3	10	3.0	ORR Required
Personal Resource Status	PER	0.1	1	.1	Sufficient trained personnel but not involved in this specific activity
Schedule Maturity	SCH	0.3	6	1.8	Conceptual design; schedule extrapolated by experienced personnel
NEPA Readiness	NEPA	0.9	0	0	NEPA checklist required
End State System Interface Requirements	ESI	0.9	8	7.2	System concept formulated only

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9.13.6.5. Ship to Repository

Tank 17.1 Solution – Alternative #5 - Treat to Waste Date: 4/17/98					
FUNCTION: Ship Containers to MGDS					
Scale		Weight	Score	Final	Rationalization
Requirements Maturity	RM	0.3	6	1.8	Requirements for licensed glass shipping container are not mature.
Processing & Storage Maturity	PM				
Transportation Process Maturity	TPM	0.9	7	5.6	Neutron shielding issue. MGDS has no prior experience with receiving this particular source and loading.
Process & Storage Hardware Equipment Maturity	EQ				
Transportation Hardware Equipment Maturity	TEQ	0.9	10	9	Neutron shielding requirement is unknown at this time.
Facility Equipment Readiness	FAC	0.9	10	9	Shipping capability to be provided by SNF transfer facility (in L Reactor)
Operational Safety Readiness	SAFT	0.3	8	2.4	License agreement requires about 3-6 months. Mk-42 knowledge helps but does not go far enough with this material
Personal Resource Status	PER	0.1	1	.1	Personnel available, but no operations currently
Schedule Maturity	SCH	0.3	4	1.2	Conceptual design only or less; input is from experienced personnel based on analogous experience.
NEPA Readiness	NEPA	0.9	10	9	Not covered in existing EIS
End State System Interface Requirements	ESI	0.9	6	5.4	Shielding for this neutron source has not been defined

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9.13.6.6. Store at Repository

Tank 17.1 Solution – Alternative #5 - Treat to Waste Date: 4/17/98		FUNCTION: Store Containers at MGDS			
Scale		Weight	Score	Final	Rationalization
Requirements Maturity	RM	0.3	4	1.2	Repository requirements currently in draft form. Repository basis awaits NRC acceptance
Processing & Storage Maturity:	PM	0.9	8	7.2	Repository cold testing demonstrated (for heat removal)
Transportation Process Maturity	TPM				
Process & Storage Hardware Equipment Maturity	EQ	0.9	4	3.6	Cold testing essentially complete at MGDS
Transportation Hardware Equipment Maturity	TEQ				
Facility Equipment Readiness	FAC	0.9	3	2.7	Heat load may effect repository spacing; Neutron dose may effect surface handling.
Operational Safety Readiness	SAFT	0.3	10	3	ORR required for Repository
Personal Resource Status	PER	0.1	5	0.5	Repository is not staffed
Schedule Maturity	SCH	0.3	4	1.2	Conceptual design only or less. Input is from experience personnel based on analogous experience.
NEPA Readiness	NEPA	0.9	2	2	MGDS handles SNF; EA or less required
End State System Interface Requirements	ESI	0.9	4	3.6	Most Repository design factors analyzed. Specific analysis would be required for long term release

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9.13.7. "Mark 18s" – Base Alternative

Cut Mk 18's in RBOF Basin and Ship to ORNL

9.13.7.1. Unpack Mk 18 Package for CD Cask in RBOF

Mk 18 Disposition - Base Alternative Date: 3/19/98		FUNCTION: Unpack Mk 18 Package for CD Cask in RBOF			
Scale		Weight	Score	Final	Rationalization
Requirements Maturity	RM	0.3	8	2.4	Task has not been performed in recent years and under current regulatory requirements. (Have not cut in recent years in RBOF either).
Processing & Storage Maturity:	PM	0.9	9	8.1	Task has not been performed in recent years and under current regulatory requirements. (Have not cut in recent years in RBOF either).
Transportation Process Maturity	TPM				
Process & Storage Hardware Equipment Maturity	EQ	0.9	9	8.1	Many fuels have been unpacked but not in an isolation chamber.
Transportation Hardware Equipment Maturity	TEQ				
Facility Equipment Readiness	FAC	0.9	3	2.7	Major modifications required to design/test isolation chamber.
Operational Safety Readiness	SAFT	0.3	10	3.0	ORR required. Risk of fuel failure and resulting contamination. Very little containment in RBOF once out of water.
Personal Resource Status	PER	0.1	3	.1	Several people will require major training.
Schedule Maturity	SCH	0.3	4	1.2	Basic equipment exists but new design for modification is very conceptual. Schedule inputs are from experienced personnel based on experience with cutting in current RBOF configuration (not in isolation chamber).
NEPA Readiness	NEPA	0.9	8	7.2	Nuclear Spent Fuel EIS has not been released for public hearing
End State System Interface Requirements	ESI	0.9	8	7.2	Design requirements for interface with basin are known. New concept. Needs complete analysis

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9.13.7.2. Cut Mk 18 for Shipment or ORNL

Mk 18 Disposition - Base Alternative Date: 3/19/98	FUNCTION: Cut Mk 18 in RBOF for Shipment to ORNL				
Scale		Weight	Score	Final	Rationalization
Requirements Maturity	RM	0.3	8	2.4	Task has not been performed in recent years and under current regulatory requirements. (Have not cut in recent years in RBOF either
Processing & Storage Maturity:	PM	0.9	9	8.1	Fuels have been irradiated for >10 years and material may be brittle so task will be performed in an isolation chamber.
Transportation Process Maturity	TPM				
Process & Storage Hardware Equipment Maturity	EQ	0.9	9	8.1	Mk 18s have been cropped in past but not analogous to what exists now. Existing equipment may not now cut without potential contamination releases. (Use of isolation chamber)
Transportation Hardware Equipment Maturity	TEQ				
Facility Equipment Readiness	FAC	0.9	7.	6.3	Modifications for under water cutting and contamination control would be required. (Use isolation chamber)
Operational Safety Readiness	SAFT	0.3	10	3.0	ORR required. Risk of fuel failure and resulting contamination. Very little containment in RBOF once out of water.
Personal Resource Status	PER	0.1	3	.3	Several people will require major training.
Schedule Maturity	SCH	0.3	4	1.2	Basic equipment exists but new design for modification is very conceptual. Schedule inputs are from experienced personnel based on experience with cutting in current RBOF configuration (not in isolation chamber).
NEPA Readiness	NEPA	0.9	8	7.2	Nuclear Spent Fuel EIS has not been released for public hearing
End State System Interface Requirements	ESI	0.9	8	7.2	Design requirements for interface with basin are known. New concept. Needs complete analysis

9.13.7.3. Package for Shipment (Refer to Section 9.13.1.4 and 9.13.2.4)

9.13.7.4. Ship to ORNL (Refer to Section 9.13.1.5)

9.13.7.5. Store at ORNL (Refer to Section 9.13.1.6)

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9.13.8. "Mark 18s" – Alternative #1

Transfer to F-Canyon and Dissolve for Vitrification, Ship to ORNL

9.13.8.1. Ship to F-Canyon

Mk 18 Disposition Alternative #1 Date: 3/19/98	FUNCTION: Ship to F-Canyon				
Scale		Weight	Score	Final	Rationalization
Requirements Maturity	RM	0.3	0	0	Function falls within scope of normal operational capability of the facility.
Processing & Storage Maturity:	PM	0.9	0	0	SA
Transportation Process Maturity	TPM		0		NA
Process & Storage Hardware Equipment Maturity	EQ	0.9	0	0	SA
Transportation Hardware Equipment Maturity	TEQ		0	0	NA
Facility Equipment Readiness	FAC	0.9	0	0	SA
Operational Safety Readiness	SAFT	0.3	0	0	SA
Personal Resource Status	PER	0.1	0	0	SA
Schedule Maturity	SCH	0.3	0	0	SA
NEPA Readiness	NEPA	0.9	8	7.2	Only need environmental checklist.
End State System Interface Requirements	ESI	0.9	0	0	

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9.13.8.2. Dissolve Mk 18's

Mk 18 Disposition - Alternative #1. Date: 3/19/98	FUNCTION: Dissolve Mk 18s				
Scale		Weight	Score	Final	Rationalization
Requirements Maturity	RM	0.3	4	1.2	Flow sheets for a previous Californium project exists.
Processing & Storage Maturity:	PM	0.9	6	5.4	Have processed Mk 18s previously during MPPF californium program.
Transportation Process Maturity	TPM				
Process & Storage Hardware Equipment Maturity	EQ	0.9	6	5.4	This is not an experimental process. Dissolution in canyon has been done
Transportation Hardware Equipment Maturity	TEQ				
Facility Equipment Readiness	FAC	0.9	5	4.5	Canyon has a dissolver and jumpers. Some modifications will have to be made to the existing equipment.
Operational Safety Readiness	SAFT	0.3	8	2.4	ORR probably required
Personal Resource Status	PER	0.1	0	0	Dissolution process is normal operation for canyon personnel
Schedule Maturity	SCH	0.3	2	.6	Preliminary design exists. Inputs is from experienced personnel based on analogous experience
NEPA Readiness	NEPA	0.9	8	7.20	Will include in site-specific EIS.
End State System Interface Requirements	ESI	0.9	4	3.6	Similar process design exist. There is some minor volatility in minor requirements.

9.13.8.3. Store Am/Cm Solution

9.13.8.4. Make Glass (Refer to Section 9.13.1.1)

9.13.8.5. Package for Shipment (Refer to Section 9.13.1.4 and 9.13.2.4)

9.13.8.6. Store at ORNL (Refer to Section 9.13.1.6)

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9.13.9. Slugs/Other – Base Alternative

Package Slugs in RBOF and Ship to ORNL

9.13.9.1. Package Slugs for Shipment in RBOF (Refer to Section 9.13.1.4)

9.13.9.2. Ship to ORNL (Refer to Section 9.13.1.5)

9.13.9.3. Store at ORNL (Refer to Section 9.13.1.6)

Appendix N

9.14. Appendix N: Mark 18s Background

This appendix seeks to set forth the current physical dimensions of the Mark 18 targets. It is intended to be an overview and is written such that no classified information will be included. Refer to DPSOP 134, Revision 6, July 1982, pages 2204-5 for more detail. A figure at the end of this appendix is provided. For more detailed drawings, consult the following:

ST-MDX5-7797 Rev. 13, Mark 18 fuel dimensions
ST-MDX5-8256, Mark 18 Assemblies
ST-MDX4-8142, Outer Target Tube Machining
ST-MDX5-8141, Outer Target Housing Weldment

The original length of the Mark 18 targets was 252 in. Both ends have been cropped (past history). The current length of the targets is now approx. 92 in. long, with a 4.22 in. diameter. Of that length, the length of the core ("active element") is in the approximate center and is ~ 48 in. +/- 6 in.

Each Mark 18 target is housed in RBOF in an aluminum can, larger than the target, capped with a crimped fit lid with a j-tube for expelling gas. Each canned target is housed in another aluminum can with dimensions of 5.56 in. diameter by 14 feet length. This outermost can is also capped with a crimped fit lid and j-tube. RBOF/ Fuel Handling Engineering advises to ship this entire package to F-Canyon or ORNL without opening either of the two cans. The primary issue being the expected condition of the Mk18s, resulting in a high potential for contamination release if the Mk18s are repackaged in RBOF.

Historical records show that when the inner targets were first shipped to RBOF, it took approximately 20 trips with about 5 targets transported at a time using the existing on-site cask. However the original insert in the cask may not be able to accommodate the extra width due to the double aluminum cans surrounding the target, i.e. 4.22 in. vs 5.56 in. dia. The length is not a problem for the insert.

References for the fuel cask inserts that were used originally to ship the Mark 18 assemblies from Reactors to RBOF are unavailable. Based on knowledge of site shipping experts pertaining to other cask insert sizes that are designed to carry bare fuel, it has been surmised that the originally designed Mark 18 cask insert would not dimensionally accept canned Mark 18 targets. Original drawings of the inserts could confirm this.

Cask inserts are also referred to as fuel bundle frames. Approximately one year ago, Spent Fuel Storage Division designed a new fuel bundle frame for use with Research Reactor Fuel (RRF). The working width of this cask insert is 5.75 inches. Since the canned Mark 18 OD is 5.563 inches, the RRF insert may work for handling/transporting the canned Mark 18 targets. A calculation has been done, T-CLC-L-00015, in which a more detailed description of the RRF cask insert can be found. This insert is designed to transport three rows of RRF.

Use of the RRF insert for shipping the canned Mark 18 targets will have to be evaluated. Typically this includes the type of calculation that was performed for the RRF fuel along with a criticality analysis. Presently there is an On-site Safety Assessment being performed for the 70-Ton site transfer cask(s). This assessment will identify the types of contents to be shipped in the cask. The most recent information from on-site shipping experts is that the canned Mark 18s will fit the 70-Ton cask RRF insert.

Appendix N

Figure of Canned Mark 18 Target

Appendix N

Figure of Canned Mark 18 Target