6

10-8-96 Original

ENGINEERING CHANGE NOTICE

20

Page 1 of 2

1. ECN 634629**

Proj ECN

2. ECN Category (mark one) Supplemental ☐ Direct Revision ☒ Change ECN ☐ Temporary ☐ Standby ☐ Supersedure ☐ Cancel/Void ☐	3. Originator's Name, Organization, MSIN, and Telephone No. A. F. Manuel 74A20 H5-49 376-2279	4. USQ Required? ☐ Yes ☒ No	5. Date 8/19/96
	6. Project Title/No./Work Order No. Phase I High-Level Waste Pretreatment and Feed Staging Plan	7. Bldg./Sys./Fac. No. -- NA	8. Approval Designator NA
	9. Document Numbers Changed by this ECN (includes sheet no. and rev.) WHC-SD-WM-ES-370, Rev. 0	10. Related ECN No(s). --	11. Related PO No.

12a. Modification Work ☐ Yes (fill out Blk. 12b) ☒ No (NA Blks. 12b, 12c, 12d)	12b. Work Package No. -- NA	12c. Modification Work Complete -- NA Design Authority/Cog. Engineer Signature & Date	12d. Restored to Original Condition (Temp. or Standby ECN only) -- NA Design Authority/Cog. Engineer Signature & Date

13a. Description of Change

13b. Design Baseline Document? ☐ Yes ☒ No

This is an update of the Revision 0 (February 1996) version of this document.

**Original inadvertently lost in the plant mail. J. Bishop Sta. 37 10/8/96

14a. Justification (mark one)

Criteria Change	☐	Design Improvement	☐	Environmental	☐	Facility Deactivation	☐
As-Found	☒	Facilitate Const	☐	Const. Error/Omission	☐	Design Error/Omission	☐

14b. Justification Details

This is a scheduled update of the High-Level Waste Pretreatment and Feed Staging Plan to incorporate final Request for Proposals (RFP) requirements, new process data, and TWRS Program assumptions.

15. Distribution (include name, MSIN, and no. of copies)

see Distribution List

RELEASE STAMP

SEP 30 1996

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A-7900-013-2 (05/96) GEF095

A-7900-013-1

ENGINEERING CHANGE NOTICE	Page 2 of 2	1. ECN (use no. from pg. 1) 634629

16. Design Verification Required	17. Cost Impact						18. Schedule Impact (days)	
	ENGINEERING			CONSTRUCTION				
☐ Yes	Additional	☐	$	Additional	☐	$	Improvement	☐
☒ No	Savings	☐	$	Savings	☐	$	Delay	☐

19. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 13. Enter the affected document number in Block 20.

- SDD/DD ☐
- Functional Design Criteria ☐
- Operating Specification ☐
- Criticality Specification ☐
- Conceptual Design Report ☐
- Equipment Spec. ☐
- Const. Spec. ☐
- Procurement Spec. ☐
- Vendor Information ☐
- OM Manual ☐
- FSAR/SAR ☐
- Safety Equipment List ☐
- Radiation Work Permit ☐
- Environmental Impact Statement ☐
- Environmental Report ☐
- Environmental Permit ☐
- Seismic/Stress Analysis ☐
- Stress/Design Report ☐
- Interface Control Drawing ☐
- Calibration Procedure ☐
- Installation Procedure ☐
- Maintenance Procedure ☐
- Engineering Procedure ☐
- Operating Instruction ☐
- Operating Procedure ☐
- Operational Safety Requirement ☐
- IEFD Drawing ☐
- Cell Arrangement Drawing ☐
- Essential Material Specification ☐
- Fac. Proc. Samp. Schedule ☐
- Inspection Plan ☐
- Inventory Adjustment Request ☐
- Tank Calibration Manual ☐
- Health Physics Procedure ☐
- Spares Multiple Unit Listing ☐
- Test Procedures/Specification ☐
- Component Index ☐
- ASME Coded Item ☐
- Human Factor Consideration ☐
- Computer Software ☐
- Electric Circuit Schedule ☐
- ICRS Procedure ☐
- Process Control Manual/Plan ☐
- Process Flow Chart ☐
- Purchase Requisition ☐
- Tickler File ☐
- N/A ☒
- ☐

20. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision	Document Number/Revision	Document Number Revision
NA		

21. Approvals

	Signature	Date
Design Authority		
Cog. Eng. A. F. Manuel	a.f. Manuel	9-27-96
Cog. Mgr. D. J. Washenfelder	DJWashenfelder	9-27-96
QA		
Safety		
Environ.		
Other E. J. Kosiancic	EJKosiancic	9-27-96
G. A. Meyer		9-27-96
R. W. Powell	RWPowell	9/27/96
J. E. Truax	for JET	9/27/96

	Signature	Date
Design Agent		
PE		
QA		
Safety		
Design		
Environ.		
Other		
DEPARTMENT OF ENERGY Signature or a Control Number that tracks the Approval Signature		
ADDITIONAL		

Phase I High-Level Waste Pretreatment and Feed Staging Plan

A. F. Manuel, S. L. Lambert, and G. E. Stegen
Westinghouse Hanford Company, Richland, WA 99352
U.S. Department of Energy Contract DE-AC06-87RL10930

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Abstract: This document updates the planning basis for the U.S. Department of Energy (DOE) to provide a sufficient quantity of high-level waste (HLW) feed to the privatization contractor during Phase I. The DOE has sufficient HLW feed to satisfy the minimum order quantity and, with the transfer system upgrades recommended by Galbraith (1996), the means to provide the feed to the private contractor's facility during Phase I. Assuming the planned DST retrieval system (two 300-hp mixer pumps), the total sludge available as feed for Waste Envelope D is at least 130 percent of the minimum order quantity specified in the RFP, assuming dilute caustic washing. However, additional sources of feed will need to be identified to support the optional extension of HLW processing in Phase I. The maximum HLW sludge inventory available in the three DSTs identified for Phase I is less than the maximum order quantity (460 MT versus 465 MT). Assuming the anticipated efficiencies of the DST retrieval systems are achieved, the amount of waste available for feed would only be 70 to 80 percent of the maximum order quantity.

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WHC-SD-WM-ES-370

Page 1

(2) Title
Phase I High-Level Waste Pretreatment and Feed Staging Plan

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(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release	
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WHC-SD-WM-ES-370
Revision 1

PHASE I HIGH-LEVEL WASTE PRETREATMENT AND FEED STAGING PLAN

September 1996

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Prepared for:
U.S. Department of Energy
Richland, Washington

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CONTENTS

APPENDIXES

LIST OF FIGURES

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LIST OF TERMS

EA	Environmental assessment
CCC	Canister Centerline Cooled
CVS	Composition Variation Study
DOE	U.S. Department of Energy
DOE-HQ	U.S. Department of Energy-Headquarters
DOE-RL	U.S. Department of Energy-Richland Operations Office
ESP	Environmental Simulation Program
HLW	High-level waste
HWVP	Hanford Waste Vitrification Plant
IHLW	Immobilized high-level waste
LLW	Low-level waste
NCAW	Neutralized Current Acid Waste
OWVP	Operational Waste Volume Projection
PCT	Product Consistency Test
PFD	Process flow diagram
PHMC	Project Hanford Management Contractor
PNNL	Pacific Northwest National Laboratory
PPTB	Privatization Process Technical Baseline
PUREX	Plutonium-Uranium Extraction
RFP	Request for Proposals
ROM	Rough Order of Magnitude
SAR	Safety Analysis Report
SORWT	Sort on Radioactive Waste Type
TCR	Tank Characterization Report
TRU	Transuranic
TWRS	Tank Waste Remediation System
WHC	Westinghouse Hanford Company
WRSS	Waste Retrieval Sluicing System
WTD	Waste Transfer Day

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PHASE I HIGH-LEVEL WASTE PRETREATMENT AND FEED STAGING PLAN

1.0 OBJECTIVE

The objective of the *Phase I High-Level Waste Pretreatment and Feed Staging Plan* is to determine a strategy for pretreating and staging a high-level waste (HLW) feed to the Phase I private contractor selected to provide both low-activity waste (LAW) and HLW services. The HLW feed must meet certain requirements with regard to quantity, composition, physical properties, and schedule. Some of these requirements are specified in the U.S. Department of Energy (DOE) *Tank Waste Remediation System (TWRS) Privatization Request for Proposals (RFP)* (DOE 1996). A comparison of the estimated compositions of pretreated HLW with the feed composition requirements (Waste Envelope D) is included in Appendix B. Based on the RFP specifications, preliminary target schedules for pretreatment and feed staging have been developed.

This document summarizes the recommended transfer system architecture and transfer routing to be utilized for the delivery of batches of high-heat and aging waste sludge during Phase I. The basis is to pretreat the Phase I sludges and stage them sequentially from separate tanks to the private contractor's facility using existing transfer lines to the extent possible. Several waste transfer system routings, including new lines and upgrades, were evaluated to determine the preferred alternative for use in this study (Galbraith et al. 1996). A parametric study (Certa et al. 1996) was also used to evaluate the ability of each transfer system alternative to deliver feeds on time. The recommended transfer route for HLW presented here is based on the results of these two studies.

Revisions to this preliminary HLW pretreatment and feed staging plan will be conducted as program assumptions are verified or modified, and as any detail of private contractor proposals becomes available. This update to the *Phase I High-Level Waste Pretreatment and Feed Staging Plan* has been performed to satisfy U.S. Department of Energy-Richland Operations Office (DOE-RL) Milestones T33-96-235 and T33-96-335.

1.1 BACKGROUND AND SCOPE

As an option in Phase I of the TWRS Privatization strategy, one of the private contractors processing LAW may also be selected to provide HLW treatment services. If selected for this option, the private contractor will be required to receive batches of Waste Envelope D into a feed/receipt tank that he provides. The size, number, and frequency of the batches will be contractually agreed to between the DOE and the private contractor. The HLW/LAW private contractor will also be responsible for incorporating any of the ^{137}Cs, ^{99}Tc, and ^{90}Sr, and transuranics (TRU) resulting from their Phase I LAW services into the immobilized HLW product, but not from the second Phase I vendor. These intermediate waste streams shall not affect the HLW product volume. Entrained solids from LAW services will be returned to the DOE as an intermediate waste product.

It will be the responsibility of the private contractor to develop, finance, construct, own, operate, and deactivate the demonstration facilities as described in the RFP issued by the DOE in February 1996. It is stated in the RFP that:

> *The private contractor can recover the resources it has invested only through the delivery of acceptable services paid for by the DOE on a fixed-unit-price basis. ...The DOE will order a minimum quantity of waste treatment services and may provide additional orders up to a maximum quantity of waste treatment services* (DOE 1996).

Therefore, for each waste envelope, the minimum and maximum order quantities for HLW and LAW services are established in the RFP. The minimum order quantities must be completed by the private contractors between June 1, 2002, (hot startup) and June 1, 2007. The DOE also has the option to extend Phase I until June 1, 2011, for completion of the maximum order quantities. Phase II (full-scale processing) is scheduled to begin on June 1, 2011.

The candidate feeds for the Phase I HLW immobilization demonstration include the aging wastes stored in double-shell tanks (DSTs) 241-AZ-101 (101-AZ), 241-AZ-102 (102-AZ), and 241-AY-102 (102-AY), and the high-heat sludge retrieved from single-shell tank (SST) 241-C-106 (106-C) into 102-AY. Before the pretreatment and staging of the contents of 102-AY, between 75 and 99 percent of the 106-C solids will have been consolidated with the 102-AY waste, depending on the amount retrieved by the initial 106-C Waste Retrieval Sluicing System (WRSS) and the schedule and destination for the 106-C hard heel. This is the only sludge consolidation step planned to take place in Phase I. A minimum of 75 percent of the 106-C solids is assumed to be available for Phase I, consistent with the Project W-320 retrieval assumptions. The 99 percent retrieval of 106-C, which includes the hard heel removal, is to satisfy the *Hanford Federal Facility Agreement and Consent Order* (Ecology et al. 1994) (Tri-Party Agreement) milestone M-45-03-T01, "Complete SST Waste Retrieval Demonstration. Additional Phase I HLW feeds to provide up to the maximum order quantity have not been identified.

The *Phase I High-Level Waste Pretreatment and Feed Staging Plan* determines the processing necessary to prepare a HLW feed composed of high-heat and aging waste sludges, and summarizes the recommended transfer system alternative for delivering the feed to the private contractor feed tank(s). A preliminary time-phased, step-by-step plan for providing the Phase I HLW feed, and a sample feed batch delivery schedule are included. As program assumptions mature, cost estimates will be included in a future revision of this document.

This study is part of an integrated effort that includes the following documents:

- *Low-Level Waste Feed Staging Plan* (Certa et al. 1996)
- *Operational Waste Volume Projection* (Koreski and Strode 1996)
- *Initial Retrieval Sequence and Blending Strategy* (Penwell et al. 1996)
- *Neutralized Current Acid Waste Consolidation Management Plan* (Powell 1996)
- *Tank Waste Remediation System Phase I High-Level Waste Feed Processability Assessment Report* (Lambert and Stegen 1996)
- *Decision Document for Phase I Privatization Transfer System Needs* (Galbraith et al. 1996)
- *TWRS Privatization Process Technical Baseline* (Orme 1996).

Many of the issues addressed in these documents are related and, therefore, an effort has been made to ensure that the assumptions used are consistent.

1.2 PURPOSE AND NEED

The development and evaluation of the options associated with pretreating and staging the Phase I HLW sludge provides technical input to support Phase I Privatization. Sufficient processing of HLW for immobilization with the objective to minimize disposal costs is one crucial element of the TWRS involvement in Privatization. A demonstration of HLW pretreatment and immobilization technologies is necessary to identify the requirements, issues, and potential risks. To contribute to the success of this demonstration, a definition of the HLW sludge pretreatment requirements and feed staging plan must be prepared. The information contained in this document supports the decision process by establishing the HLW feed staging criteria that encompass estimates of feed inventory, pretreatment requirements, feed staging requirements, and project schedule.

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2.0 SUMMARY

The DOE has sufficient HLW feed to satisfy the minimum order quantity and, with the transfer system upgrades recommended by Galbraith (1996), the means to provide the feed to the private contractor's facility during Phase I. Assuming the planned DST retrieval system (two 300-hp mixer pumps), the total sludge available as feed for Waste Envelope D is at least 130 percent of the minimum order quantity specified in the RFP, assuming dilute caustic washing. However, additional sources of feed will need to be identified to support the optional extension of HLW processing in Phase I. The maximum HLW sludge inventory available in the three DSTs identified for Phase I is less than the maximum order quantity (460 MT versus 465 MT). Assuming the anticipated efficiencies of the DST retrieval systems are achieved, the amount of waste available for feed would only be 70 to 80 percent of the maximum order quantity.

It is recommended at this time that pretreatment of the high-heat and aging waste sludges consist of between one and three washes with dilute caustic solution (0.1*M* NaOH) (i.e., inhibited water). These pretreatment steps represent an appropriate set of processes required to meet Waste Envelope D and produce a HLW product that is at least 25 wt% waste oxides excluding sodium and silicon. Caustic leaching is preserved as an option. The recommended pretreatment strategies are summarized in Chapter 4.0.

For the pretreatment of 102-AZ and 102-AY/106-C, dilute caustic washing the sludge to meet Waste Envelope D is also sufficient to maximize the projected waste oxide loadings. To estimate HLW product volumes in this analysis, the Composition Variation Study (CVS) glass limits (Hrma et al. 1994) are used. The CVS limits are an optimistic estimate of the minimum product volume (maximum waste oxide loading) achievable by the immobilization process, and may or may not be representative of the actual process proposed. Because of this uncertainty, the CVS limits are used in this analysis only to represent a bounding case, and as an enabling assumption in the optimization of the pretreatment strategy. The recommended conservative basis is the RFP minimum of 25 wt% waste oxides excluding sodium and silicon, which is the appropriate basis for calculating HLW product volume estimates and cost impacts.

In the case of 101-AZ, there is an incentive to perform one additional wash beyond what is required to meet Waste Envelope D. Based on the CVS glass limits, the additional wash repetition is estimated to reduce the volume of immobilized HLW by 24 percent, or approximately 40 0.62-m^3 canisters (versus two washes). This projection suggests that knowledge of the private contractor's immobilized HLW formulation will be a strong factor in developing the optimum pretreatment strategy.

However, if the private contractor does not agree to increase the waste oxide loading to the optimum predicted by CVS, or significantly above 25 wt%, caustic leaching should be considered. Caustic leaching of the 3 feeds further reduces the total mass of waste oxides to the private contractor by 70 to 83 MT excluding sodium and silicon. Most of this reduction is achieved for the 102-AY/106-C feed (36 to 49 MT). However, these extra washing steps create an additional 2.88 to 3.15 ML (760,000 to 832,000 gal) of wash solution (evaporated to 7*M* Na), which will require interim storage. The impact of this volume of caustic on the DST storage capability will require further evaluation in future revisions of this document.

Table 2-1 shows the estimated Phase I HLW feed compositions versus the minimum and maximum concentrations specified in the RFP for the major constituents of the three tanks, based on dilute caustic washing. This evaluation assumes that the wastes are staged to the private contractor sequentially from separate tanks as discussed in Bacon (1996).

Table 2-1. Acceptable Composition Ranges for Selected Phase I High-Level Waste Feed Components (DOE 1996). (Based on 31 g/L Non-Volatile Oxides)

Component	Minimum concentration (g/L)	Estimated concentration (g/L)			Maximum concentration (g/L)
		101-AZ	102-AZ	102-AY/106-C (75%)	
Aluminum	1.30 (0.33)	3.69	3.42	2.61	4.30 (5.30)
Chromium	0.00	0.06	0.09	0.07	0.21 (0.42)
Iron	2.60 (1.70)	7.59	8.35	3.47	8.90 (13.00)
Phosphorus	0.00	0.24	0.30	0.16	0.54
Silicon	0.00	0.43	0.27	4.42	5.80
Sodium[a]	2.30 (1.00)	2.02 (low)	3.47	5.90	6.00 (9.20)
Tellurium[b]	0.00	0.15 (high)	0.02	0.00	0.04
Thallium[b]	0.00	0.50 (high)	0.004	0.00	0.14
Zirconium	0.00	2.67	1.16	0.13	4.60
^{14}C[c]	0.00	5.12E-06 Ci/L (high)	2.98E-06 Ci/L (high)	2.16E-08 Ci/L	2.00E-06 Ci/L

[a] The low sodium value should be disregarded because the composition of the transfer solution can be altered to include some sodium (currently water only is assumed).

[b] The high Te and Tl values in the tank characterization reports and some TWRS databases results from high "less than detection limit" values being used as actual analyses. Actual values are likely to be much lower. See Appendix B for more information. Further refinement of the inventory assumptions for these tanks is in progress.

[c] The high value is the result of a high estimate for ^{14}C based on RADNUC 95 runs (see Appendix B). Actual ^{14}C values reported in core sample analyses are much lower and within the Waste Envelope D specifications. Refinement of the radionuclide inventories for these tanks is currently in progress.

Note: Values enclosed in parentheses are for the Expanded Design Basis for High-Level Waste Processing as defined in the RFP (DOE 1996).

Table 2-2 shows selected physical properties of the pretreated feed versus the Envelope D feed specification ranges. The requirements for physical properties of the washed solids (e.g., viscosity, yield stress, shear strength, heat capacity, etc.) are included in Appendix A. Much of the physical property data for the washed HLW feed are still not available. However, the pretreated HLW to be transferred to the private contractor facility will be conditioned to meet the transfer system requirements for physical properties, as defined in the *TWRS Functions and Requirements* (WHC 1995a).

Table 2-2. Acceptable Physical Property Ranges for Selected Phase I High-Level Waste Feed Components (DOE 1996).

Physical property	Minimum	Estimated		Maximum
		Water wash	Caustic wash	
Total mass of waste oxides excluding sodium and silicon	245 MT	325 to 379 MT	256 to 296 MT[a]	465 MT
Concentration of total equivalent non-volatile oxides	25 g/L	100 g/L[b]		100 g/L
Slurry Density	1.02 g/mL	1.04 g/mL		1.10 g/mL
pH	>10	13		NA

[a] The high and low values are dependent upon the amount of 106-C solids available for feed staging (75 to 99 percent).

[b] To minimize the number of HLW batch transfers and the amount of dilution water added, the maximum feed concentration of 100 g of non-volatile oxides/L is used in the recommended case. Based on Waste Envelope D, the feed concentration can actually range from 25 to 100 g/L.

For 101-AZ and 102-AZ, caustic leaching does not increase the maximum waste oxide loading in the glass product (assuming vitrification and CVS limits), but does reduce the quantity of feed oxides. Both tanks have a high iron content (relative to aluminum), which will limit the optimum waste oxide loading in the glass product regardless of how much aluminum is present in the feed. Thus, reducing the aluminum content by caustic leaching in 101-AZ and 102-AZ is primarily important to product volume reduction when the private contractor commits only to the 25 wt% waste oxide loading limit.

For the pretreatment of 102-AY/106-C, preliminary analyses suggest an incentive for reducing the amount of aluminum in the feed. Empirical glass property models have been developed by Pacific Northwest National Laboratory (PNNL) that estimate glass volumes are reduced by more than 30 percent by caustic leaching (Lambert and Stegen 1996) when allowing greater than 25 wt% loading. This information is considered preliminary, and may affect a future revision of this plan. As a base case assumption, and to be consistent with Bacon (1996), dilute caustic washing is used for 102-AY/106-C. Caustic leaching may allow more HLW to be treated during Phase I and is preserved as an option, but tank space may be a constraint. A preliminary assessment of caustic leaching is included in Section 3.2.4.7.

The conclusions reached in the pretreatment strategy analysis are waste form dependent. The decision of whether or not to caustic leach the sludge will be made based on overall system impacts. The private contractor is required to deliver immobilized HLW with a minimum of 25 wt% waste oxide loading excluding sodium and silicon. If the private contractor is not willing to increase the waste oxide loading to the levels predicted by the CVS limits or other reasonable models, then a large incentive will exist to caustic leach all of the sludge to reduce the quantity of waste oxides processed. The desirability to caustic leach will be evaluated during Phase I Part A. This evaluation will consider the effect of caustic leaching on the waste oxides delivered, the waste volume produced by the private contractor, the private contractor's capabilities and commitments, and tank space implications.

Another consideration is that an early demonstration of the technology of caustic leaching during Phase I may be important for later application in Phase II. The program goals for Phase I sludge pretreatment must be established. For example, the process information obtained from conducting a caustic leaching technology demonstration may be beneficial to mitigating program uncertainties/risks associated with Phase II processing of tank wastes. The program uncertainties and risks are discussed in the U.S. Department of Energy-Headquarters' (DOE-HQ) *TWRS Systems Requirements Review* (DOE 1995). For purposes of this study, the decision not to caustic leach is consistent with the recommendations of the *Final Neutralized Current Acid Waste Consolidation Recommendation* (Bacon 1996).

The flexibility of the current infrastructure within tank farms provides a variety of methods to transfer the feed to the private contractor's site. Examples of these methods are shown in the *Low-Level Waste Feed Staging Plan* (Certa et al. 1996). The primary issues involved in the selection of a transfer system design are as follows:

- Cost
- Hydraulic performance (i.e., head loss, pressure drop, and critical velocity)
- Schedule
- Flexibility
- Design limitations of the current transfer system and proposed upgrades
- Potential for conflicts (delays) in feed staging due to interactions with supernatant feed staging and other concurrent tank farm activities.

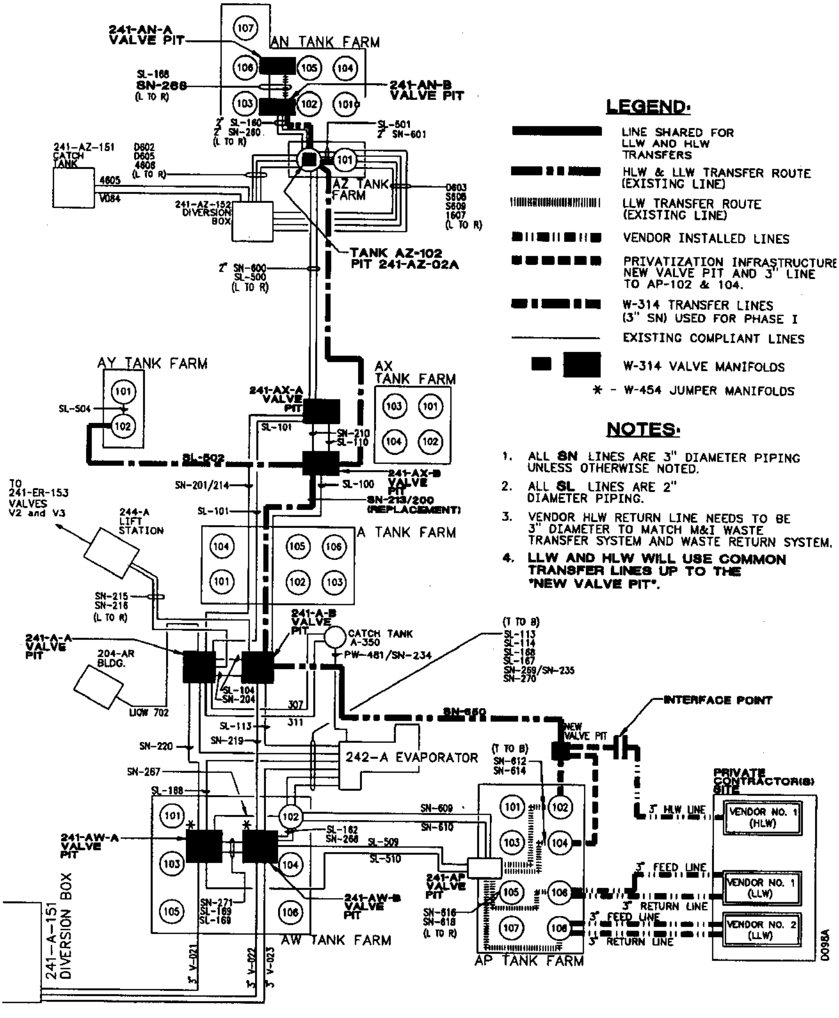
A separate study, *Decision Document for Phase I Privatization Transfer System Needs* (Galbraith et al. 1996) has been conducted to support the recommended transfer systems to be used in the HLW and LAW feed staging plans. Figure 2-1 (Preferred Alternative) is a schematic of the recommended feed transfer system from that study.

A preliminary transfer system architecture has been identified as a feasible path for delivering the Phase I HLW feed to the private contractor. The recommended transfer system alternative (Figure 2-1) uses existing 7.6-cm (3-in.) supernatant (SN) transfer lines in the *A Farm Complex Waste Transfer System*, installs a new 7.6-cm (3-in.) line in the northern quadrate from the 241-AZ Tank Farm to the 241-AX-B valve pit and modifies existing line SN-650 with a new SN-650 valve pit. A new 7.6-cm (3-in.) SN line would be installed by the private contractor from the new SN-650 valve pit to the contractor's processing facility. Line SN-650 will be used for both HLW and LAW feed staging.

For the transfer of sludges from 102-AZ and 102-AY/106-C, the recommended transfer system includes the upgrades of slurry (SL) lines SL-501 and SL-502 from 5.1-cm (2-in.) to 7.6-cm (3-in.) diameter pipe. If SL-502 is not upgraded to 7.6-cm (3-in.) line, the fallback strategy proposed in Galbraith et al. (1996) for 102-AY/106-C is to route the waste via 5.1-cm (2-in.) slurry lines back into tank 101-AZ after it has been emptied. (It is shown that the hydraulic performance of the transfer system is poor when the transfer route includes both 5.1-cm (2-in.) and 7.6-cm (3-in.) lines.) The 102-AY/106-C sludge would later be staged from 101-AZ to the private contractor. There is no fallback strategy in the case where the short line SL-501 between the AZ tanks is not upgraded to 7.6-cm (3-in.). These upgrades include integration with current plans for Project W-314, "Tank Farm Restoration and Safe Operations."

Interaction requirements with LAW feed staging operations and other operations of DSTs in the A Farm Complex are considered in this evaluation. In this analysis, interactions with LAW feed staging should have a minimal effect on the HLW feed slurry transfers in Phase I. A minimization of potential transfer conflicts between HLW and LAW is discussed in a nodal analysis included with the *Low-Level Waste Feed Staging Plan* (Certa et al. 1996). The analysis in Certa (1996) indicates that up to one HLW batch transfer per month is feasible with minimal schedule conflicts. The impacts on DST space will be discussed in the *Operational Waste Volume Projection* (Koreski and Strode 1996).

Figure 2-1. Proposed Phase I High-Level Waste Feed Transfer System.



LEGEND:

━━━	LINE SHARED FOR LLW AND HLW TRANSFERS
▬ ▪ ▪ ▬	HLW & LLW TRANSFER ROUTE (EXISTING LINE)
|||||||||	LLW TRANSFER ROUTE (EXISTING LINE)
▪||▪||▪	VENDOR INSTALLED LINES
▪ ▪ ▪ ▪	PRIVATIZATION INFRASTRUCTURE NEW VALVE PIT AND 3" LINE TO AP-102 & 104.
▬ ▪ ▬ ▪	W-314 TRANSFER LINES (3" SN) USED FOR PHASE I
──	EXISTING COMPLIANT LINES
■ ■	W-314 VALVE MANIFOLDS
*	W-454 JUMPER MANIFOLDS

NOTES:

1. ALL **SN** LINES ARE 3" DIAMETER PIPING UNLESS OTHERWISE NOTED.
2. ALL **SL** LINES ARE 2" DIAMETER PIPING.
3. VENDOR HLW RETURN LINE NEEDS TO BE 3" DIAMETER TO MATCH M&I WASTE TRANSFER SYSTEM AND WASTE RETURN SYSTEM.
4. **LLW AND HLW WILL USE COMMON TRANSFER LINES UP TO THE "NEW VALVE PIT".**

Alternative feed sources have yet to be identified to provide an additional amount of feed for Phase I HLW. Possible feed sources would be the SST solids retrieved during Phase I as identified in the *Initial Single-Shell Tank Retrieval System--Tank Selection* (Grenard 1996), and the sludge left behind in the source DSTs after staging the Phase I LAW feed. The acceptability of this feed will assume that we are not necessarily bound by the feed composition ranges and physical properties defined in Waste Envelope D. A knowledge of the flexibility in the design of the melter (or other HLW immobilization process) proposed by the HLW private contractor will help to determine the acceptability of these alternative feeds. Further analysis is required, which may entail the definition of a separate HLW feed envelope for the additional feed. Identification of additional HLW feeds and a recommendation for pretreating those feeds is planned for a future revision of this document.

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3.0 ASSUMPTIONS AND METHODS OF ANALYSIS

This chapter describes the enabling assumptions used in this evaluation. Best estimates of tank waste inventory, sludge retrieval, criteria for waste pretreatment, and HLW glass formulations are discussed. The value ranges are used to bound any uncertainties in the sludge pretreatment and feed staging parameters. As these parameters are validated, through ongoing analysis and/or negotiations between the DOE and the private contractor, the assumptions will be modified accordingly for future updates of this plan.

3.1 TANK WASTE INVENTORY

The candidate sludge feeds for Phase I HLW are Neutralized Current Acid Waste (NCAW) from 101-AZ and 102-AZ and high-heat sludge retrieved from 106-C into 102-AY. NCAW is the HLW generated from the first cycle solvent extraction process from the Plutonium-Uranium Extraction (PUREX) plant. The sludge from 106-C contains metal waste from the bismuth phosphate process, and PUREX supernatant and sludge washed waste from the 244-AR vault. 106-C received large amounts of strontium, resulting in a high heat load that requires water additions and ventilation for cooling. Currently, 106-C is on the High-Heat Load Watch List for critical monitor of temperature data. The 102-AY sludge contains large quantities of sodium, aluminum, iron, silicon, and uranium from B Plant and PUREX and from the deposition of concentrated evaporator wastes (WHC 1995b).

The tank waste inventories used in this analysis are compiled from the best analytical information available. For tanks 106-C, 101-AZ, and 102-AZ, the inventories and solubility data represent a change from the values reported in the *TWRS Process Flowsheet - Revision 1* (Orme 1995). The revised inventory assumptions presented here will be integrated into the next release of the flowsheet and into other relevant documents. The inventory assumed for tank 102-AY is the same as the *TWRS Process Flowsheet - Revision 1* (Orme 1995). Tables A-1 through A-4 of Appendix A contain the initial inventory assumptions for these tanks in terms of the mass of individual soluble and insoluble components.

The modifications to the tank inventory assumptions do not invalidate the TWRS flowsheet model. The flowsheet models all of the SSTs as one global inventory and allocates the global inventory to individual tanks using a calculated model (Agnew 1994a and 1994b). For purposes of the flowsheet, the global modeling does not alter the results when the SSTs are taken as a whole. However, for the processing of individual tanks, such as in this analysis for 106-C, it can have a significant impact on the outcome, and a better source for the inventory assumptions would be lab analyses (e.g., Weiss 1991). In the cases of 101-AZ and 102-AZ, the inventories are revised based upon a reevaluation of core sample data, Tank Characterization Reports (TCRs), lab analyses, and historical records. The TWRS flowsheet inventory for 102-AY is still considered valid, and therefore is not altered for purposes of this study.

3.2 PROCESS PARAMETERS FOR PHASE I SLUDGE PRETREATMENT

The following section details the sludge processing parameters that are considered in this analysis. To analyze the sensitivities and uncertainties to some of these parameters, a high- and a low- range value are evaluated. The HLW feed staging plan will interface with other tank farm activities: for example, sludge consolidation activities (i.e., DST retrieval and pretreatment), 106-C sluicing operations and hard heel removal, SST retrieval operations in Phase I, LAW feed staging plans, and other operations. Any changes in the planning bases may affect the outcome of this analysis.

3.2.1 Sludge Recovery Fractions

There is some uncertainty regarding the extent to which the sludge can be retrieved from the DSTs. The retrieval efficiencies will depend upon the operating constraints of the equipment in place and the physical characteristics of the sludge. These efficiencies are important because they impact the quantity of HLW feed available for the Phase I contractor and may reduce the ability to effectively wash the sludge in the tank. There are also impacts, not involved in HLW feed staging, that the remaining heel can have on subsequent waste storage and compatibility requirements in the DSTs after retrieval.

The initial DST sludge retrieval systems for Phase I Privatization are comprised of two or more mixer pumps, to be installed within the scope of Project W-151, "Tank 101-AZ Waste Retrieval System," and Project W-211, "Initial Waste Retrieval Systems." Two 300-hp mixer pumps in each tank are used as the current planning basis. For terminal cleanout of the DSTs, it may be possible to obtain more sludge from the tanks with the installation of additional retrieval equipment, although heel removal requirements for the DSTs have not been established. The DST heels are not currently planned for Envelope D feed, but could count toward the maximum RFP specified quantity, if retrieved.

The *Double-Shell Tank Retrieval Allowable Heel Trade Analysis* (Grams 1995) includes information on the amount of sludge that can be recovered from the DSTs. These calculations are based upon "worst case" sludge shear strength measurements and two 300-hp mixer pumps. As a basis, the largest values reported from shear strength measurements are used. Therefore, the calculated values represent the minimum amount of sludge that can be expected to be mobilized. The results of this study for the Phase I HLW tanks are shown in Table 3-1. The percent retrievable (recovery) values in Table 3-1 apply to the insoluble solids only; 95 percent of the combined supernatant and interstitial liquid is assumed to be available for recovery. The actual amount of liquid removed depends on the efficiency of the decant pump(s) (see Section 3.2.2). Most of the original supernatant and interstitial liquid can be diluted and decanted from the HLW feed.

Table 3-1. Base Case High-level Waste Sludge Recoveries for Phase I High-Level Waste (Percent of Tank Inventory).

Phase I high-level waste tank	101-AZ	102-AZ	102-AY	106-C	Total
Available mass of waste oxides excluding sodium and silicon (MT)	85.8	115	37.5	222	460
Estimated percent retrievable[a]	90[b]	60	36	75 to 99[c]	N/A
Retrieved mass of waste oxides excluding sodium and silicon (MT)	77.2	68.7	13.5	166 to 220	325 to 379

[a] These values represent the percent of insoluble solids retrievable, based on Grams (1995). The supernatant and interstitial liquid are assumed 95 percent available for recovery.

[b] The value reported in Grams (1995) is actually 97 percent mobilized (retrievable); however, a conservative value of 90 percent is used for the base case retrieval amount in this analysis.

[c] Because of schedule and destination uncertainties for the hard heel removal from 106-C, this analysis provides a case for both a 75 and 99 percent sluicing retrieval for 106-C into 102-AY.

The percent retrievable values in Table 3-1 are used for the base case calculations presented in the flowsheets, material balances, feed compositions, HLW feed batch volumes, feed oxide quantities, HLW product volumes, and other calculations used in this analysis. If 99 percent retrieval could be achieved in all four tanks, as much as 455 MT of waste oxides excluding sodium and silicon could be available for processing in Phase I.

The results of these assumptions are used to provide a range of sludge recoveries only. Early estimates based on sludge shear strength measurements of the AZ tanks indicate that the minimum heels left in each of the tanks, assuming sludge mobilization with two 300-hp mixer pumps, are 3 percent and 40 percent, for 101-AZ and 102-AZ, respectively (Grams 1995). If higher recovery fractions are desired, additional process equipment (e.g., sluicing systems) may be necessary, but are not in current Phase I sludge washing/retrieval plans.

More rigorous evaluation of mixer pump performance and specifications is necessary to validate the base case values. This analysis will draw upon the calculations presented in Grams (1995), and "...until greater experimental data are available, the shear strength data and resulting predictions in sludge mobilizations can not be considered to be precise." The results of mixer pump testing will help to establish these capabilities, and will be integrated into this analysis in a future revision. The base case values in Table 3-1 represent the best estimates available at this time.

3.2.2 Processing Equipment

To accomplish the required pretreatment steps necessary in Phase I to support the option for HLW Privatization, it is essential to initiate the design, construction, and testing of the processing equipment. Most significantly, the scheduled hot startup dates and the need to deliver the initial batch of Waste Envelope D must be considered. To meet the Privatization schedule, the projects must be properly managed and the pretreatment goals well understood. The primary processing equipment needed for Phase I are mixer pumps, decant pumps, and transfer pumps. In summary, the equipment that has been installed into 101-AZ (Project W-151) is also recommended for 102-AZ and 102-AY. Knowledge gained from the results of mixer pump testing in 101-AZ, currently being conducted, may modify these assumptions.

3.2.2.1 Mixer Pumps. Projects W-151 (101-AZ) and W-211 (102-AZ and 102-AY) will add two 300-hp mixer pumps into each of the tanks. These pumps are assumed to be capable of mobilizing the base case amounts of sludge in Table 3-1. The number of pumps ultimately installed will also depend on the performance of the 101-AZ mixer pumps. This evaluation assumes that two mixer pumps will be sufficient to meet the minimum feed order quantity. Testing in 101-AZ will help to more clearly define these equipment requirements, and may result in a modification to this plan.

3.2.2.2 Decant Pumps. Each Phase I HLW tank will be equipped with a floating suction decant pump. It is assumed that the supernatant can be pumped out of the tank down to 0.3 m (1 ft) above the settled sludge/liquid interface. This leaves approximately 125 m^3 (33,000 gal) of supernatant liquid in addition to the interstitial liquid within the settled sludge. The sludge washing simulation (Aspen Plus[1]) used in this evaluation treats all of the liquid as a single phase and will appear as such in the material balances.

3.2.2.3 Transfer Pumps. A transfer pump is outfitted into each tank for the slurry transfers of HLW batches to the private contractor feed tanks. This pump operates in conjunction with the mixer pumps to keep the solids in suspension.

3.2.2.4 Other Processing Equipment. Instrumentation and process control equipment has been designed for and installed into tank 101-AZ. If this is sufficient, a similar set of equipment is proposed for installation into tanks 102-AZ and 102-AY for Project W-211. Additional detail regarding the DST in-tank sludge processing equipment can be found in *In-Tank Processing of Hanford Wastes* (MacLean 1995). Figure 3-1 is a schematic of the recommended in-tank processing equipment.

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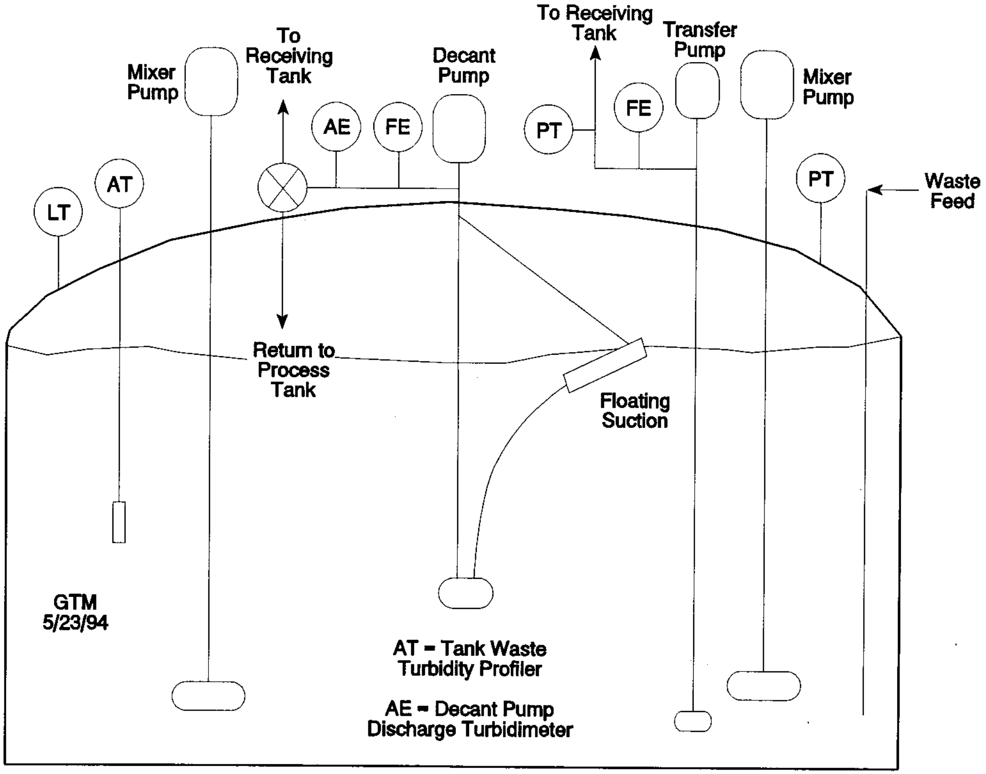
[1] Aspen Plus is a trademark of Aspen Technology, Inc., Cambridge, Ma.

Figure 3-1. In-Tank Processing Equipment and Instruments.



3.2.3 Washed Settled Sludge Volumes

Based on laboratory testing, when the sludge in the DSTs has been mobilized by the mixer pumps, the solids will not settle back to their original volume. The sludge volume is expected to expand by a factor of 2 to 2.5 based on laboratory analyses with samples from 101-AZ and 102-AZ. For this evaluation, after the 30 days allotted for settling, the solids are assumed to settle down to 20 wt%. The sludge is initially 40 wt% solids; solids are then mobilized by the mixer pumps and then settle back down to only approximately 20 wt%. This assumption is consistent with the *TWRS Process Flowsheet - Revision 1* (Orme 1995) and related studies. From this information, and assuming a liquid density of 1.25 g/mL, and a solids density of 1.6 g/mL, the total volume of washed settled sludge (insoluble solids and interstitial liquid) is calculated. This volume helps to determine the amount of space the washed solids will occupy following pretreatment and settling. Table 3-2 summarizes these calculations.

Table 3-2. Estimate of Washed Settled Sludge Volumes for Phase I High-Level Waste.

Phase I high-level waste tank	101-AZ	102-AZ	102-AY (36%)/ 106-C (75%)	102-AY (36%)/ 106-C (99%)
Insoluble solids mass (kg)	86,600	191,000	441,000	558,000
Interstitial liquid mass @ 20 wt% solids (kg)	346,000	763,000	1,760,000	2,230,000
Total washed sludge volume (L)	331,000	730,000	1,690,000	2,130,000
Volume expansion "fluff" factor	2.5	2.0	2.5	2.5

[a] A specific gravity of 1.6 is assumed for the insoluble phase.
[b] A specific gravity of 1.25 is assumed for the soluble phase.

The calculated washed sludge volumes in Table 3-2 indicate the volume that the sludge will occupy in the tank. These can be used to determine the maximum amount of wash solution that can be added without exceeding the tank capacity. A maximum tank capacity of 3,710,000 L (980,000 gal) is assumed.

The degree of settling may have an impact on the pretreatment performance. For example, if settling is much lower than 20 wt% solids, processing rates may have to be slowed down to prevent running out of tank space. A future revision of the HLW feed staging plan will examine the significance of these impacts.

3.2.4 Phase I High-Level Waste Pretreatment Criteria

The selected strategy for the Phase I HLW pretreatment plan is based upon the following criteria:

Contractual requirements (per the Privatization RFP)

- Schedule requirements
- Composition requirements (Envelope D specifications)
- Satisfaction of minimum feed quantity requirements
- Satisfaction of product loading requirements (i.e., based on the selected waste form, the PHMC must do sufficient sludge processing to allow the private contractor the opportunity to achieve the minimum product loading).

Cost minimization considerations

- Minimization of wash solutions (including the impacts of caustic leaching)
- Minimization of impacts to the HLW product volume
- Minimization of feed oxide quantities by caustic leaching.

These assumptions are outlined below, and the selected Phase I HLW pretreatment strategy is discussed in Chapter 4.0.

Contractually the TWRS Program is committed to achieving the first four requirements to provide pretreated feed to the private contractor. Future trade studies and cost/benefit analyses will determine the optimum combination of cost minimization considerations needed to achieve minimum life-cycle costs to the program. For example, additional sludge washing repetitions may significantly contribute to a reduction in immobilized HLW. Although a thorough evaluation of caustic leaching is deferred to the next revision of this document (see Section 3.2.4.7), caustic leaching may also have associated benefits, such as HLW product volume reduction. A thorough evaluation, including tank space limitations, is funded in FY 1997 and will be included in the next revision of this document. A formal decision analysis needs to be performed to support a caustic leaching decision. However, any additional processing must also be evaluated in the context of meeting the four contractual requirements.

The determination (optimization) of the pretreatment strategy in Section 4.4 considers all seven of these criteria. In one case (101-AZ) the recommendation goes beyond what is contractually required to meet Waste Envelope D by one additional wash repetition to reduce the estimated (CVS) glass volume by 24 percent. This issue is revisited in Appendix B, the "Phase I High-Level Waste Feed Envelope Assessment."

3.2.4.1 Sludge Pretreatment Schedule Requirements. As stated previously, the HLW sludge will be pretreated and staged sequentially from separate tanks to the private contractor. Based on current DST retrieval project schedules, the order of immobilization processing is assumed to be as follows:

1. 101-AZ
2. 102-AZ
3. 102-AY/106-C.

It follows from this assumption that the order of priority for pretreating these sludges should be the similar. More importantly, however, is that the tanks are pretreated well in advance of the date that they will be needed for feed. This will depend on the HLW private contractor's operating capacity. As an enabling assumption, this evaluation assumed that the sludges are pretreated in the same sequence as they are to be immobilized. No specific criteria were used to derive this sequencing of tanks. A set of criteria could be established (e.g., envelope fit, data certainty, schedule risks, etc.), but a thorough evaluation has not been performed. Should these criteria be important, this document will be revised. As an enabling assumption, the DST retrieval project schedules are used as the basis.

Before the pretreatment of the 102-AY/106-C sludge, 75 to 99 percent of 106-C is assumed to have been sluiced. Assuming no large differences in the composition of the 106-C heel and the initial 75 percent that is retrieved, retrieval of less than 99 percent of 106-C will have only a minimal impact on the pretreatment strategy. A reduction in the amount of 106-C sluiced into tank 102-AY before pretreatment in that tank begins will affect the available quantity of HLW feed. Table 3-1 shows the range of available feed oxides based on this uncertainty.

If HLW services are provided, the role of the PHMC is to prepare a HLW feed within the composition ranges defined for Waste Envelope D. These activities must be completed several months ahead of the Waste Transfer Day (WTD)--the date the private contractor requests that a specified quantity of feed be transferred to his facility. The "need for feed" dates will assume that the private contractor is operating at the minimum system capacity of 60 MT of waste oxides excluding sodium and silicon over a 12-month period. If the private contractor chooses to operate at a higher capacity, the need dates may need to be advanced. This capacity is currently an unknown, and the pretreatment and feed staging schedules will be adjusted accordingly when more information is available. A detailed schedule of these transfers is included in Chapter 6.0.

The minimum system capacity is a driver for the sludge pretreatment schedule to be conducted by the PHMC. Higher system capacities may place high demands on the pretreatment schedule. Since the HLW feed will be delivered in several batches, and the private contractor will have a limited lag storage capacity, there will exist certain critical dates when the private contractor may have to have feed available or else risk significant setbacks. Also, higher system capacities, without a corresponding increase in the size of the delivered batches, may adversely impact the ability of the feed delivery system to deliver feed on time. It will be the responsibility of the PHMC to ensure that the necessary equipment installations and projects are in place to meet the feed scheduling needs of the private contractor. This document attempts to identify some of these needs, based on available information, and future revisions based on the private contractor proposals will follow. Due to all of the uncertainties, the schedule will be updated in future revisions of this plan. The base case pretreatment schedule in this study is updated based upon the minimum system capacity for HLW processing.

3.2.4.2 Composition Requirements. The only requirement for the Phase I HLW feed established in the RFP is that it must be within Waste Envelope D. Waste Envelope D specifies the composition and physical property ranges for an acceptable HLW feed. The PHMC will prepare the feed to meet these requirements using in-tank sludge washing.

The sludge washing process will consist of a series of simple settle/decant operations with a dilute caustic solution. The process begins with an initial decant of the NCAW supernatant, and is followed by a series of washes to dilute the interstitial liquid. The initial decant is either followed by or preceded by a mixer pump test, depending upon the plans for the specific tank. Fluffing of the solids during the mixer pump tests is important because it affects the removal efficiency of the initial decant.

Meeting the Phase I HLW feed composition criteria depends upon the chemical and radionuclide inventory of the waste, and also to a large extent, the solubility effects of the HLW pretreatment process (in-tank sludge washing). For this study, the best estimates using recent lab testing combined with tank inventory estimates based on analytical data are used to model the chemical behavior of the Phase I sludges in the pretreatment process. More rigorous models, such as the Environmental Simulation Program (ESP[1]), are currently being developed which can be used to reconcile numerous inconsistencies in the analytical data (e.g., poor material balances).

3.2.4.3 Satisfaction of Product Loading Requirements. The product loading, also referred to as the waste oxide loading, is specified in Specification 1 of the RFP (DOE 1996):

1.2.2.2 Unique Requirements for Borosilicate Glass Waste Form:

> *1.2.2.2.1 Product Loading: Loading of non-volatile components shall be a minimum of 25 percent by weight in the product, on an equivalent oxide basis. No credit is given in the product loading for the Na_2O, SiO_2, and other materials that result from processing Low-Activity Waste. Product waste loading shall be calculated on an average basis for each batch transfer of Waste Envelope D.*

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[1] ESP is a trademark of OLI Systems, Inc.

1.2.2.3 *Unique Requirements for Waste Forms Other Than Borosilicate Glass:*

> *1.2.2.3.1* *Product Loading: Loading of non-volatile components shall be a minimum of 0.65 metric tons of waste oxides on an equivalent oxide basis for each 1.0* m^3 *of waste form produced. No credit is given in the product loading for the* Na_2O, SiO_2, *and other materials that result from processing Low-Activity Waste. Product waste loading shall be calculated on an average basis for each batch transfer of Waste Envelope D.*

The recommended pretreatment strategy verifies that the product loading can be greater than or equal to 25 wt% waste oxides excluding sodium and silicon, based on an assumed waste form (CVS limits). In-tank sludge washing will benefit the private contractor by reducing any potentially troublesome glass components that may make it difficult to achieve 25 wt% loading. Evaluation of this criterion will require knowledge of the HLW formulation, and will likely take place during Part A negotiations. The CVS limits are used as a preliminary basis. The flowsheets included in Appendix C represent the maximum allowable glass volume (at 25 wt% waste oxide loading), while the determination of the preferred pretreatment strategy is based on the single-component glass limit (>25 wt%). Going to the single-component glass limit facilitates the calculation of the optimum extent of pretreatment. That is, the feed will be prepared so that the private contractor will have the opportunity to increase the waste oxide loading to the optimum (assuming CVS glass limits). The CVS limits are used for preliminary evaluation purposes only; the maximum volume of glass (i.e., 25 wt% loading) should be used as the conservative basis.

3.2.4.4 Satisfaction of Minimum Feed Quantity Requirements. Because this analysis is based upon dilute caustic washing, no solids dissolution occurs during the sludge washing process. The only reduction in the feed oxide quantity is due to removal of soluble components by dilution. Since the reduction of specific soluble troublesome components will benefit the HLW product volume, removal by dilution is desirable. Caustic leaching is the only process in which this criterion is impacted. From dilute caustic washing, the results of this study show that the feed will be 150 percent of the minimum order quantity. Based on the leach efficiencies assumed in Orme (1995), caustic leaching will reduce this feed to between 104 and 121 percent of the minimum order quantity. By caustic leaching all three tanks, the available feed decreases to very close to the minimum feed order quantity. This may require identification of additional/alternative feeds, or caustic leaching should be applied to one tank only. (Caustic leaching 102-AY/106-C only still provides 120 to 130 percent of the minimum feed order quantity.)

3.2.4.5 Minimization of Wash Solutions. It is projected that there will be a limited amount of tank space available in the time period when sludge washing must take place. These impacts are analyzed in the *Operational Waste Volume Projection* (Koreski and Strode 1996). For the Phase I sludge pretreatment strategy, the wash solution demands are minimized by varying the number of wash repetitions and the volume of dilute caustic used in each repetition. This minimization is balanced against the first four criteria used in this evaluation for sludge pretreatment. The results of this optimization are presented in Chapter 4.0.

3.2.4.6 Minimization of Impacts to the HLW Product Volume. Another goal used in this analysis that has a significant benefit to the PHMC is to minimize the volume of HLW glass produced. Minimizing the HLW volume will minimize the cost for interim storage and geologic disposal. The method used to estimate the HLW product volume is discussed in Section 3.2.7.1. In actuality, the extent of pretreatment will need to be determined when the proposed waste form is known.

For HLW glass limited by aluminum, chromium, phosphorus, or sodium oxides, the amount of glass may be reduced by in-tank sludge washing with caustic. An added benefit is that a demonstration of the pretreatment process will provide better estimates of the effect of caustic leaching in the processing of the remaining tank waste. The issue of depleting tank storage space with large additions of wash solution requires further evaluation including an analysis of cost.

3.2.4.7 Minimization of Feed Oxide Quantities by Caustic Leaching. As discussed in Section 2.0, the mass of waste oxides delivered to the Phase I private contractor could be reduced by caustic leaching. The volume of immobilized HLW product would be reduced as a result of caustic leaching under two different circumstances:

1. If the private contractor agrees to increase the waste oxide loading above the 25 wt% minimum requirement of the RFP (excluding sodium and silicon), caustic leaching would remove glass limiting constituents such as aluminum, chromium, and/or phosphate leading to a volume reduction.
2. If the private contractor does not commit to increase the waste oxide loading above the 25 wt%, caustic leaching would reduce the feed oxide quantity, and consequently reduce the product volume.

In the first case, Lambert and Stegen (1996) estimate that no significant product volume reduction will be incurred by caustic leaching either of the AZ tanks. In the case of 102-AY/106-C, however, a product volume reduction in excess of 30 percent might be expected. This reduction translates into an overall glass volume reduction from the candidate Phase I sludge tanks of 18 to 20 percent.

In the second case, caustic leaching will result in a similar product volume reduction of about 22 percent. Table 3-3 summarizes the estimated feed oxide quantity reduction on an individual tank basis for this case.

Table 3-3. Reduction in Feed Oxides by Caustic Leaching.

Phase I high-level waste tank	Total feed oxides (MT excluding sodium and silicon)		Feed oxide reduction (MT)	Percent reduction
	Water washing	Caustic washing		
101-AZ (90 percent retrieved)	77.2	59.6	17.6	23
102-AZ (60 percent retrieved)	68.7	52.8	15.9	23
102-AY/106-C (36/75 percent retrieved)	180	144	36.0	20
102-AY/106-C (36/99 percent retrieved)	233	184	49.0	21
Total	325 to 379	256[a] to 296	70 to 83	22

[a] This value approaches the minimum feed order quantity of 245 MT. Unless additional/alternative feeds are identified, the ability to deliver the minimum may be compromised if all 3 tanks are caustic leached.

As shown in Table 3-3, caustic leaching of the Phase I feeds has important benefits to product volume reduction. The reduction in feed oxides could result in cost savings of greater than $100M during production, interim storage, and disposal of HLW. Based on a total mass reduction in the feed oxide quantity of 70 to 83 MT of waste oxides excluding sodium and silicon, rough order of magnitude (ROM) cost savings are estimated in Table 3-4.

In addition to the cost savings, the value of obtaining process information from a caustic leaching demonstration should also be considered. This information will be important for application in Phase II, and will allow for a more accurate picture of the sludge and product volume reduction effects associated with the full-scale implementation of caustic leaching.

Table 3-4. Potential Cost Savings by Caustic Leaching.

Phase I high-level waste tank	Feed oxide reduction (MT)	Reduced number of canisters (0.62-m^3 capacity)[a]	Estimated incremental cost savings		
			Production cost[b]	Interim storage cost[c]	Disposal cost[d]
101-AZ (90 percent retrieved)	17.6	43	$1.5M ($10.8M)	$2.8M	$13.6M
102-AZ (60 percent retrieved)	15.9	39	$1.4M ($9.8M)	$2.5M	$12.3M
102-AY/106-C (36/75 percent retrieved)	36.0	88	$3.1M ($22.0M)	$5.7M	$27.8M
102-AY/106-C (36/99 percent retrieved)	49.0	119	$4.2M ($29.8M)	$7.7M	$37.7M
Total	70 to 83	170 to 201	$6.0M to $7.1M ($42.6M to $50.4M)	$11.0M to $13.0M	$53.7M to $63.6M
Grand Total			$70.7M to $83.7M ($107M to $127M)		

[a] At 25 wt% waste oxides excluding sodium and silicon.

[b] ROM estimate, based on a $35,000 incremental cost savings per canister (Defense Waste Processing Facility [DWPF] estimate). The numbers in parenthesis account for a reduction in the operating duration of the facility, based on a $320,000 incremental cost savings per canister.

[c] ROM estimate, based on a $65,000 incremental cost savings per canister, based on 20 years of on-site storage (calculated from *Solidified High-Level Waste Interim Storage Alternative Analysis and Path Forward Recommendation* (WHC-SD-WM-SP-011) and *TWRS FY 97 Multi-Year Work Plan* (WHC-SP-1011).

[d] ROM estimate, based on a $250,000 incremental cost savings per canister (calculated from Milner, R. A., 1996, *Repository Disposal Fee Estimates for the Hanford TWRS-EIS*, letter to J. E. Kinzer, (July 1), Office of Civilian Radioactive Waste Management.

These cost savings must be carefully weighed against several other factors, including the feasibility of storing additional volumes of wash solution. The volume of caustic solution can not be reduced as much as dilute caustic through evaporation, due to the higher sodium concentration. In addition to this, several water washes will be required after the caustic leach in order to dilute the caustic solution left in the sludge. Table 3-5 summarizes these effects.

Table 3-5. Volume of Wash Solutions from Phase I Pretreatment.

Phase I high-level waste tank	Total volume of wash solution at 7*M* Na (L)	
	Water wash	Caustic wash
101-AZ (90 percent retrieved)[a]	295,000	1,030,000
102-AZ (60 percent retrieved)[b]	242,000	1,250,000
102-AY/106-C (36/75 percent retrieved)[c]	45,400	1,450,000
102-AY/106-C (36/99 percent retrieved)[d]	45,400	1,180,000
Total	582,000	3,460,000 to 3,730,000

[a] Requires 3 water washes OR 1 caustic wash followed by 2 water washes. The dilution ratio is 3:1.

[b] Requires 3 water washes OR 1 caustic wash followed by 2 water washes. The dilution ratio is 2:1.

[c] Requires 1 water wash OR 1 caustic wash followed by 6 water washes. The dilution ratio is 0.3:1 for the caustic leach or the 1 water wash and 1.2:1 (fill tank) for the successive water washes.

[d] Requires 1 water wash OR 1 caustic wash followed by 8 water washes. The dilution ratio is 0.3:1 for the caustic leach or the 1 water wash and 0.7:1 (fill tank) for the successive water washes.

The effectiveness of caustic leaching needs to be better quantified in further laboratory scale testing, and the benefits from lower aluminum, chromium, and phosphate levels also must be better understood. These factors also need to be carefully weighed against the overall cost impacts, and possible operational constraints, such as DST space depletion and Phase I LLW operations. Caustic leaching is therefore preserved as an option until further information is known regarding private contractor capabilities and commitments. As shown in Table 3-5, caustic leaching requires the ability to store as much as 3,150,000 L (832,000 gal) of wash solution at 7*M* Na. Depletion of DST space is expected to be a major concern during Phase I. The feasibility of storing this much wash solution from a logistics standpoint will need to be addressed by Koreski and Strode (1996).

3.2.5 Water Wash Solubility Factors

Appendix A contains the revised soluble and insoluble component masses for each tank based on the analytical data explained below. The water wash factors are based on laboratory testing.

The results obtained from water washing of the core composites are used to determine the solubility of each component for the Phase I HLW source tanks. For each component, the amount removed from the sludge is assumed to be equal to the amount found in the wash solution(s) divided by the sum of the soluble mass and the amount left in the washed solids. For the majority of the components, the mass balances are not in total agreement. However, for all of the major components, including aluminum, chromium, iron, and sodium, the mass balances are within 15 percent. The water wash factors (or efficiencies) for NCAW are taken from tank characterization reports for 101-AZ and 102-AZ (Gray et al. 1993a, Gray et al. 1993b, and Peterson et al. 1989). These estimates will continue to improve as greater knowledge is gained with regard to tank inventories and chemical behavior.

Water solubility factors for 106-C are based upon data presented by Colton (1995). Where wash data are unavailable, the flowsheet assumptions for SST waste components are used. There is some concern that characterization data are limited for 106-C, and that the inventory assumptions may not be totally representative of the tank's contents. Therefore, as better data become available for 106-C, the assumptions in this plan will be modified accordingly.

3.2.6 Caustic Wash Solubility Factors

The impacts of caustic leaching are presented here as a sensitivity case in this evaluation. The caustic leach efficiencies (percent removal from the solid phase into the soluble phase) assumed for this study are shown in Table 3-6, and are consistent with the *TWRS Process Flowsheet - Revision 1* (Orme 1995).

Table 3-6. Enhanced Sludge Washing--Caustic Leach Efficiencies.

High-heat tank	Aluminum	Chromium	Phosphate
101-AZ	85%	75%	70%
102-AZ	85%	75%	70%
106-C[a,b]	43.5%	11.0%	43.3%

[a] Based on 241-C-103 (103-C) caustic leach efficiencies.

[b] Because 106-C will be blended with 102-AY waste, the caustic leach efficiencies for 106-C are assumed for the entire blend.

No analytical data are currently available for the caustic washing of 106-C. Therefore, in the absence of these data, the caustic leach efficiencies for 106-C are assumed to be the same as those determined from testing 241-C-103 (103-C) samples. Single-shell tank 106-C is assumed to contain similar waste as 103-C (Brevick 1994). Tanks 101-C through 106-C all received metal waste from the bismuth phosphate process. Tanks C-103 and C-106 both received strontium leached sludge and are grouped under the same category (Group XIX) in the Sort on Radioactive Waste Type (SORWT) model (Hill et al. 1995). Therefore, the caustic leach factors obtained from experimental data for 103-C (Rapko et al. 1995) are assumed to be applicable to 106-C for this study.

The caustic leach factors assumed for 101-AZ and 102-AZ are the same as the global average DST caustic leach factors assumed in the *TWRS Process Flowsheet - Revision 1* (Orme 1995). The percentages leached from the sludge are assumed to be 85 percent, 75 percent, and 70 percent for aluminum, chromium, and phosphate, respectively. Preliminary data suggest lower leach efficiencies (Herting 1995). The validity of the experimental data are currently being evaluated and the factors assumed here may be revised in a future release of this document.

3.2.7 High-Level Waste Product Criteria

The reference immobilized HLW form is a vitrified borosilicate glass. The private contractor has the option to specify an alternative waste form, the requirements for which are specified in the RFP (DOE 1996):

> *The [private] Contractor may provide an alternate, non-borosilicate glass waste form as the IHLW product, but shall provide evidence of a testing, evaluation, and data collection program that: (1) verifies conformance with waste acceptance criteria; (2) verifies performance characteristics meet or exceed those of the vitrified borosilicate glass waste form; and (3) provides adequate documentation to meet the licensing requirements of the proposed repository.*

It is shown that the amount and type of pretreatment (sludge washing) necessary for the Phase I processing can be tailored to support the pretreatment demonstration goals without having a significant impact on the HLW product volume (i.e., either inhibited water or caustic leaching can be used). However, the effect of pretreatment on HLW product volume reduction will depend on the selected immobilization process and waste loading achieved. This is important from a disposal cost standpoint. Some knowledge of the waste form is necessary to recommend the optimum pretreatment strategy. For example, it helps to determine the extent to which certain troublesome components must be removed from the feed. A vitrified waste form using the single-component CVS glass limits (Hrma et al. 1994) is assumed, to provide a preliminary estimate of what might be achievable in terms of product volume reduction. The PHMC will work with the private contractor during Part A of Privatization Phase I to establish higher waste loadings. Waste minimization incentives will also be negotiated during Part A.

3.2.7.1 Example Glass Formulations. The HLW glass formulation (for a borosilicate glass) depends on the type of melter selected, the composition of the waste, and other parameters. It also affects the maximum waste oxide loading and the total volume of glass produced. Two reference glass formulations for low-temperature (1150 °C) melters are currently available (see Appendix D). The low-temperature glass formulations for HLW glass reported in the *Composition Variation Study (CVS)* (Hrma et al. 1994) and the *HWVP Project Technical Data Package* (Kalia 1994) are shown.

Other alternative glass formulations for high-temperature melters (>1350 °C) may have higher limits for major glass constituents, such as Al_2O_3, Na_2O, or Fe_2O_3, and permit a higher waste oxide loading for the Phase I HLW sludges. The high-temperature glass formulation represents a bounding case and may results in a much lower cost for disposal. High-temperature glass formulations are currently being reviewed, and will be included in a future update to this document, if available. However, compared with low-temperature vitrification, high-temperature vitrification technology is less mature and is associated with a greater uncertainty range. These formulations are not available at this time.

Additional testing with simulated sludges and computer models is being conducted to determine alternative glass formulations based on the glass properties. The low-temperature glass formulations (compositions) presented in Appendix D do not necessarily guarantee a glass of good quality, and the property models must be applied to verify the compositions. Currently the CVS glass composition limits are used for the reference cases. The applicability of new formulations that consider glass properties is currently under review, and the preliminary results are presented in Appendix D.

3.2.8 Phase I High-Level Waste Pretreatment Flowsheets

The base case sludge pretreatment flowsheets (Process Flow Diagrams (PFDs) and material balances) for tanks 101-AZ, 102-AZ, and 102-AY/106-C are included in Appendix C. Each PFD represents a series of washing steps in a single tank. The feed streams (#1) contain only the masses of the mobilized amount of sludge assumed in Table 3-1. The pretreatment strategies are determined by the criteria described above, and each of the processes are detailed in Chapter 4.0.

3.3 PREFERRED PHASE I HIGH-LEVEL WASTE TRANSFER SYSTEM

The preferred HLW transfer system (HLW Option 3) has been determined by a formal decision process (Galbraith et al. 1996). Work is in progress to support the detailed design of the waste transfer system to determine whether it can handle the entire range of physical properties defined in Waste Envelope D. It is assumed for this report that the operating range can span the entire range of Waste Envelope D, until this range is narrowed by further hydraulic analysis.

3.4 TANK SAFETY ISSUES

The Safety Analysis Report (SAR) for the Hanford Site DSTs is currently being finalized. The sludge consolidation and pretreatment actions described in this plan will need to be evaluated to determine compliance with the finalized DST SAR, when available. Modifications to the safety basis and/or the sludge pretreatment and consolidation actions may be necessary to accomplish the goals of Phase I sludge pretreatment.

The TWRS Program is continuing to evaluate the conditions of tank wastes to ensure that proper controls are in place for safe storage. Evaluations of tanks 101-AZ and 102-AZ may lead to the addition of controls that could affect this plan. (Tank 102-AY has been separately evaluated for the receipt and storage of tank 106-C sludges). If this results, revision of this plan will be necessary.

The major potential control in HLW pretreatment and feed staging is a limit to the sludge height allowed in a tank, due to flammable gas issues. Such controls could affect 102-AY/106-C, and the concern would be to require more movement of sludges around the tank farm, or to reduce the amount of retrieval of 106-C into 102-AY for Phase I HLW. These issues are discussed in greater detail in Powell (1996).

A complete evaluation of compliance of the actions in this plan with the requirements set forth in the draft DST SAR and safety basis documents has not been performed. An evaluation of compliance with the requirements in these documents is deferred until the issuance of the final safety basis documents because the final safety basis may be substantially different. The goal of the Phase I HLW pretreatment and feed staging operations is to minimize failure risk by performing this evaluation prior to actual operations. It is expected that an evaluation using the finalized safety basis will occur in time to support the scheduled transfers.

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4.0 PHASE I HIGH-LEVEL WASTE PRETREATMENT STRATEGY

Based on the criteria used for Phase I sludge pretreatment discussed in Section 3.2.5, the following pretreatment strategy has been developed. This section summarizes the base case pretreatment flowsheets, and discusses how the results of the sensitivity studies are employed. Based on the decisions made in Powell (1996), caustic leaching is omitted from the options.

4.1 SUMMARY OF TANK 241-AZ-101 SLUDGE PRETREATMENT

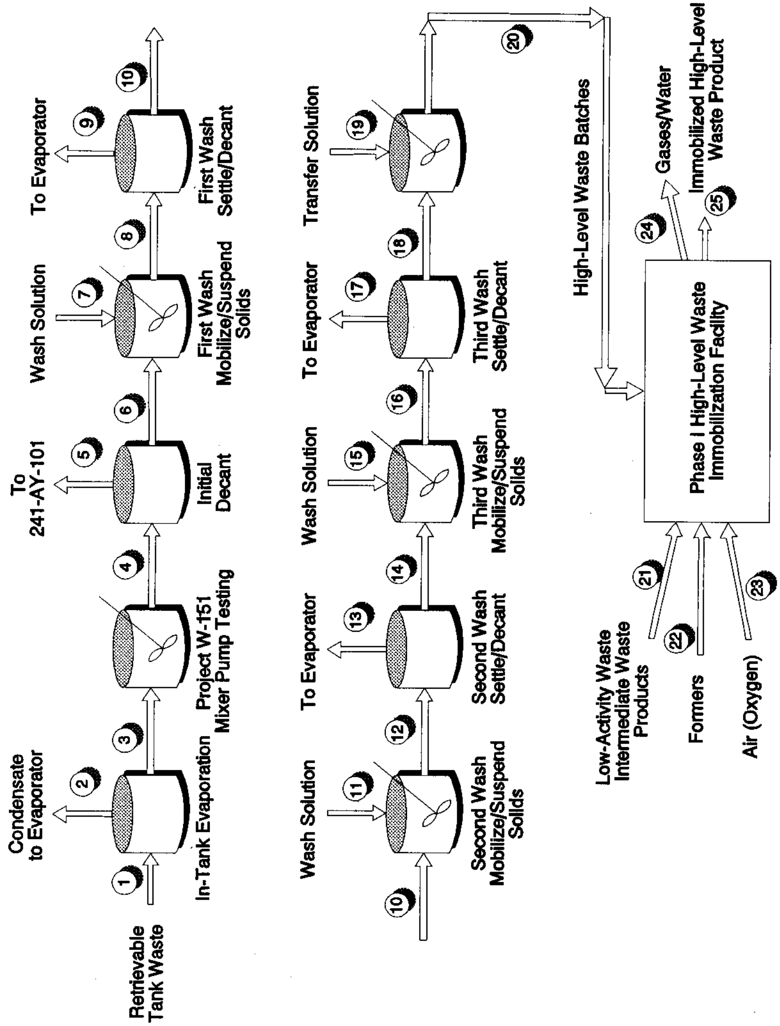
It is assumed that the supernatant in 101-AZ is in-tank concentrated to the 5*M* sodium limit. This is followed by the mobilization of the sludge as part of the Project W-151 mixer pump testing. Mobilization of the sludge results in a 20 wt% solids layer, after 30 days of settling. The supernatant is then decanted down to 0.3 m (1 ft) above the sludge layer, and routed into tank 241-AY-101 (101-AY). The sludge is subsequently washed three times with dilute caustic solution (0.1*M* NaOH and 0.01*M* $NaNO_2$). The wash solutions are added in a 3:1 dilution ratio with the settled solids volume.

The decanted wash solutions are sent to the evaporator. In the final step, enough transfer solution is added to the tank to dilute the solids to the maximum RFP slurry concentration of 100 g/L waste oxides. The slurry is transferred to the HLW immobilization facility in two 439,000-L (116,000-gal) batches. This volume is based on the 587,000-L (155,000-gal) private contractor feed/receipt capacity developed in Chapter 5.0. A schematic of this process is shown in Figure 4-1. The contents of each of the streams is included in Appendix C. The streams depicted in between each tank illustration represent the composition of the sludge after each operation in the process.

4.2 SUMMARY OF TANK 241-AZ-102 SLUDGE PRETREATMENT

For 102-AZ, it is also assumed that the supernatant is in-tank concentrated to the 5*M* sodium limit. However, instead of the evaporation step being followed by sludge mobilization (mixer pump testing), the supernatant is decanted first to 0.3 m (1 ft) above the sludge, and the tank is refilled with wash solution. The solution from the initial decant is split between tank 102-AY and an available tank in AP Farm. Approximately two-thirds of the initial decant volume (1,260,000 L [133,000 gal]), can be stored in the remaining space available in 102-AY. The results of the Operational Waste Volume Projection (Koreski and Strode 1996) will verify the destination of this supernatant liquid.

Figure 4-1. In-Tank Sludge Washing of Double-Shell Tank 241-AZ-101.



The mixer pump test can actually function as part of the first wash cycle. The sludge is washed three times with dilute caustic solution in a 2:1 dilution ratio with the settled solids volume. Transfer solution is added to achieve a 100 g of waste oxides/L slurry, and the slurry is transferred to the HLW immobilization facility in two 416,000-L (110,000-gal) batches. A schematic of this process is shown in Figure 4-2, and the contents of each of the streams are presented in Table C-2 of Appendix C.

4.3 SUMMARY OF TANKS 241-AY-102/241-C-106 SLUDGE PRETREATMENT

Two cases are run for the consolidated 102-AY/106-C sludge, assuming 75 percent and 99 percent retrieval of 106-C into 102-AY. The process flow diagram is shown in Figure 4-3. After the retrieval of 106-C, the supernatant is decanted down to 0.3 m (1 ft) above the settled solids layer. In both cases, the wash solution is 0.3 times the settled solids volume and requires one wash.

The wash solutions resulting from these pretreatment steps, including the initial decant, are routed to an available tank in AP Farm, or to the evaporator. Transfer solution is added to dilute the waste to 100 g of waste oxides per liter slurry. The transfer solution may have to be added in-line due to a limited tank capacity. The slurry is delivered in five initial 521,000-L (138,000-gal) batches to reach the minimum order quantity specified for Waste Envelope D (245 MT of waste oxides excluding sodium and silicon). If Phase I HLW processing is extended, the remaining slurry is delivered in either 3 or 5 additional batches of the same volume, depending on the percent retrieval from 106-C. The material balances are presented in Appendix C.

Figure 4-2. In-Tank Sludge Washing of Double-Shell Tank 241-AZ-102.

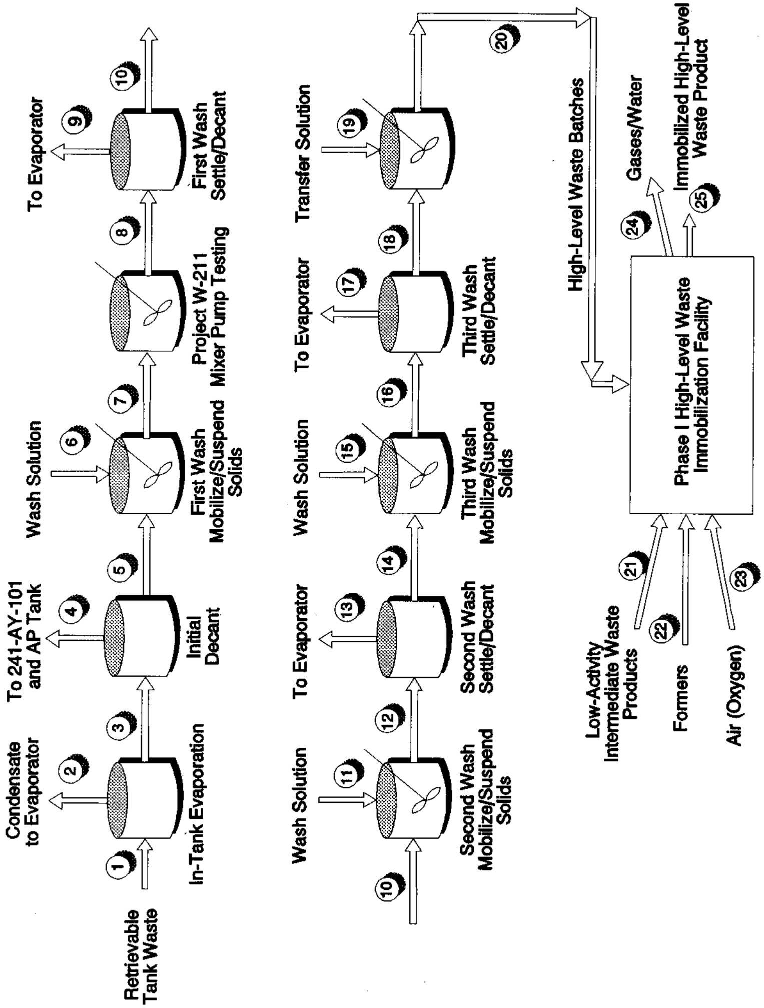
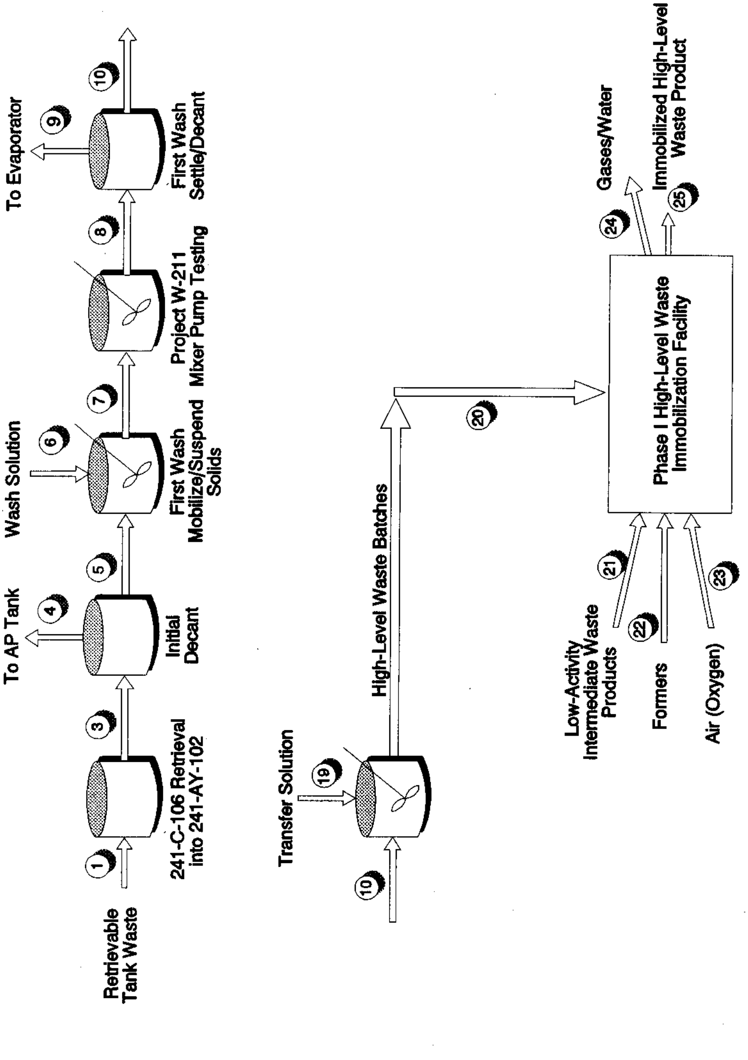


Figure 4-3. In-Tank Sludge Washing of Double-Shell Tank 241-AY-102/241-C-106.



4.4 DETERMINATION OF THE BASE CASE PRETREATMENT STRATEGY

The following section discusses how the pretreatment strategy was determined, and the methods used to calculate glass product volumes. This methodology was used for the in-tank processing summaries in Sections 4.1 to 4.3. The base case is dilute caustic washing. Caustic washing is evaluated separately in Section 3.2.4.7.

4.4.1 Glass Canister Predictions

The single-component CVS glass limits are used as an enabling assumption in the optimization of the pretreatment strategy. However, there is more than one method for estimating the amount of glass, depending upon the type of analysis. Three documents, the *Tank Waste Remediation System Phase I High-Level Waste Feed Processability Assessment Report* (Lambert and Stegen 1996), the *TWRS Privatization Process Technical Baseline* (PPTB) (Orme 1996), and the HLW feed staging plan, include estimates of Defense Waste Production Facility-sized glass canisters for the Phase I HLW product. These results are summarized in Table 4-1 below.

Table 4-1. Phase I High-Level Waste Glass Canister Count (Based on a 0.62-m^3 Capacity).

Phase I high-level waste tank	Request for Proposal limit[a]	CVS limits[b]	Glass property models[c]
101-AZ (90 percent retrieved)	190	120	140
102-AZ (60 percent retrieved)	160	130	130
102-AY (36 percent retrieved) 106-C (75 percent retrieved)	440	340	390
102-AY (36 percent retrieved) 106-C (99 percent retrieved)	560	440	510
Total Canisters	790 to 910	590 to 690	660 to 780

CVS = Composition Variation Study

[a] Based on 25 wt% non-volatile waste oxides excluding sodium and silicon (DOE 1996), and consistent with Orme (1996) and Appendix D of the HLW feed staging plan.

[b] Based on the single-component limits reported in Hrma et al. (1994), and consistent with the pretreatment optimization section (Section 4.4.2) of the HLW feed staging plan.

[c] Based on empirical glass property models from Lambert and Stegen (1996), and washed solids compositions from the HLW feed staging plan.

The PPTB (Orme 1996) assumes that glass formers are added to reach 25 wt% non-volatile oxides excluding sodium and silicon. The number of canisters produced represents a conservatively high estimate of the amount of glass. This estimate can also be used as an upper limit for the number of canisters, since it is based on the minimum waste oxide loading specified in the RFP. These values are shown in the first data column of Table 4-1. This estimate should be used for planning purposes.

As stated above, the single-component CVS limits are used only for purposes of the pretreatment optimization study discussed in the next section. The material balances in Appendix C and Tables D-2 through D-4 of Appendix D contain the HLW product masses, based on the recommended pretreatment strategy, but are taken to the 25 wt% limit, to be consistent with the PPTB. The canister numbers based on the CVS limits are shown in the second data column of Table 4-1.

For comparison, the empirical glass property models used in Lambert and Stegen (1996) are used to estimate the number of canisters produced from the washed sludge feed compositions predicted in this document. These values are shown in the third data column of Table 4-1. A discussion is also included in Appendix D. The glass estimates use recently developed glass property models developed by PNNL as the basis for predicting glass volumes and compositions, which also provide information on the multi-component (especially aluminum and iron) interactions in the glass. These models predict glass properties important to the processing of glass such as liquidus temperature, electrical conductivity, and viscosity. The amount and composition of frit added to the waste is adjusted until a balance of desirable physical properties is obtained. Because the work supporting these models was completed recently, and has not yet been published, it was not available for direct implementation into the pretreatment optimization for the HLW feed staging plan. The preliminary results shown in Table 4-1 (compare data columns 2 and 3) indicate that the CVS limits may slightly, but not significantly, underpredict the amount of glass produced.

There is a difference in the 101-AZ and 102-AZ aluminum and iron inventories between the *Phase I High-Level Waste Pretreatment and Feed Staging Plan* (this report) and the feed processability assessment (Lambert and Stegen 1996). The HLW feed staging plan uses an NCAW inventory developed from tank characterization data from Gray et al. (1993a and 1993b). The feed processability assessment uses an NCAW inventory developed from the previous reports and additional tank characterization from Hodgson (1995) and Ryan (1995). This difference resulted from a change in the tank characterization reports that was not communicated in time to be included in the feed staging plan work. Use of this inventory, assuming 100 percent retrieval, using the glass property models, and other differences in the approach in the draft processability assessment yielded canister estimates of 183, 305, and 514 for AZ-101, AZ-102, and C-106, respectively. Accounting for the partial retrieval would yield canister estimates of 160, 180, and 420, respectively.

Until a standard basis for calculating glass volumes has been determined, it is recommended that the glass estimates used for planning purposes be based upon the 25 wt% limit (data column 1). Subsequent updates to this feed staging plan will consider the models used in Lambert and Stegen (1996), and will adjust the pretreatment optimization section accordingly.

4.4.2 Optimization of the Pretreatment Strategy

To determine the preferred pretreatment strategy, several sensitivity cases were run using the Aspen Plus[1] software to simulate the sludge washing process. In each of the alternative cases, the number of wash repetitions and the volume of wash solution added were varied, as shown in Tables 4-1 through 4-4. For each case, the number of 0.62-m^3 HLW canisters and the total volume of decanted wash solution are listed, based on the results of the flowsheet model runs.

Based on the results of these sensitivity cases, a judgement is made to determine the preferred sludge washing alternative. The number of wash repetitions must be sufficient to meet Waste Envelope D, minimize the estimated volume of HLW glass, and minimize the volume of decanted wash solution. The number of wash repetitions must not be unreasonably high either, so that the pretreatment schedule is not compromised. The limited life expectancy specified for the mixer pumps is another incentive to minimize the number of wash repetitions.

The results from all of the sensitivity cases are shown in Tables 4-1 through 4-4. The recommended number of wash repetition and dilution ratios are shaded. The flowsheets for the preferred alternatives are included in Appendix C. The immobilized HLW product streams in the flowsheets are based on 25 wt% waste oxides excluding sodium and silicon. This represents the maximum glass volume allowed. Tables D-2 through D-5 in Appendix D present example glass product compositions also based on the 25 wt% limit.

4.5 WASTE ENVELOPE D COMPARISON

The estimated feed compositions are compared to the Waste Envelope D specifications. These results are presented in Appendix B, and summarized in Table 2-1. All of the components, with the exception of tellurium and thallium in 101-AZ, and ^{14}C in 101-AZ and 102-AZ, are within the feed composition ranges. The estimates for these components are believed to be high due to high "less than detection limit" values being used as actual analyses in current TWRS inventory databases. The tank inventories are currently being "standardized," and these minor discrepancies will be resolved in future updates.

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[1] Aspen Plus is a trademark of Aspen Technology, Inc., Cambridge, MA.

Table 4-2. In-Tank Sludge Washing Sensitivity Runs--Dilute Caustic Washing of 241-AZ-101 (90 percent Retrieval).

Dilution Basis: Fluffy Settled Solids Volume = 331,000 L (87,500 gal)

Number of washes	Number of 0.62-m^3 high-level waste canisters						
	1:1 Dilution	2:1 dilution	3:1 dilution	4:1 dilution	5:1 dilution	6:1 dilution	Fill tank (10.2:1)
0 (decant only)	810	810	810	810	810	810	810
1	500	380	310	270	240	220	150
2	320	210	160	140	130	120	120
3	220	140	120	120	120	120	120
4	170	120	120	120	120	120	120
5	170	120	120	120	120	120	120
6	140	120	120	120	120	120	120
7	120	120	120	120	120	120	120
8	120	120	120	120	120	120	120

b.

	1:1 Dilution	2:1 Dilution	3:1 Dilution	4:1 Dilution	5:1 Dilution	6:1 Dilution	Fill Tank (10.2:1)
Volume evaporated (L)	243,000	243,000	243,000	243,000	243,000	243,000	243,000
Initial decant volume (L)	2,510,000	2,510,000	2,510,000	2,510,000	2,510,000	2,510,000	2,510,000
Na molarity (mol/L)	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Decanted wash solution volume (L)	1,890,000	2,590,000	2,920,000	3,910,000	4,900,000	3,910,000	6,690,000
Na molarity (mol/L)	0.4	0.8	0.7	0.5	0.5	0.6	0.4

Assumptions:

1. Assumes a 1.22-m (4-ft) minimum head for acceptable mixer pump performance at full speed.
2. Dilution ratios are defined as: Volume of Wash Solution Added per Volume of 20 wt% Settled Solids
3. The recommended dilution ratio and number of wash repetitions are shaded.
4. Each decant step leaves a 0.3-m (1-ft) supernatant layer above the settled solids.
5. Canister numbers are computed assuming no contribution from the final transfer liquid.

Table 4-3. In-Tank Sludge Washing Sensitivity Runs--Dilute Caustic Washing of 241-AZ-102 (60 percent Retrieval).

Dilution Basis: Fluffy Settled Solids Volume = 730,000 L (193,000 gal)

Number of washes	Number of 0.62-m^3 high-level waste canisters				
	1:1 dilution	2:1 dilution	3:1 dilution	4:1 dilution	Fill tank (4.1:1)
0 (decant only)	1110	1110	1110	1110	1110
1	660	420	330	270	270
2	340	180	140	130	130
3	200	130	130	130	130
4	140	130	130	130	130
5	130	130	130	130	130
6	130	130	130	130	130
7	130	130	130	130	130
8	130	130	130	130	130

b.

	1:1 Dilution	2:1 Dilution	3:1 Dilution	4:1 Dilution	Fill Tank (4.1:1)
Volume evaporated (L)	1,980,000	1,980,000	1,980,000	1,980,000	1,980,000
Initial decant volume (L)	1,260,000	1,260,000	1,260,000	1,260,000	1,260,000
Na molarity (mol/L)	5.0	5.0	5.0	5.0	5.0
Decanted wash solution volume (L)	2,800,000	4,070,000	6,250,000	5,520,000	5,670,000
Na molarity (mol/L)	0.5	0.4	0.3	0.3	0.3

Assumptions:

1. Assumes a 1.22-m (4-ft) minimum head for acceptable mixer pump performance at full speed.
2. Dilution ratios are defined as: Volume of Wash Solution Added per Volume of 20 wt% Settled Solids
3. The recommended dilution ratio and number of wash repetitions are shaded.
4. Each decant step leaves a 0.3-m (1-ft) supernatant layer above the settled solids.
5. Canister numbers are computed assuming no contribution from the final transfer liquid.

Table 4-4. In-Tank Sludge Washing Sensitivity Runs--Dilute Caustic Washing of 241-AY-102/241-C-106 (36 percent/75 percent Retrieval).

Dilution Basis: Fluffy Settled Solids Volume = 1,690,000 L (446,000 gal)

Number of washes	Number of 0.62-m^3 high-level waste canisters						
	0.1:1 dilution	0.2:1 dilution	0.3:1 dilution	0.4:1 dilution	0.5:1 dilution	0.6:1 dilution	Fill tank (1.2:1)
0 (decant only)	357	357	357	357	357	357	357
1	349	343	340	338	336	335	329
2	341	336	332	330	327	325	319
3	337	331	327	324	321	319	314
4	333	326	322	319	317	315	311

b.

Initial decant volume (L)	2,540,000	2,540,000	2,540,000	2,540,000	2,540,000	2,540,000	2,540,000
Na molarity (mol/L)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Decanted wash solution volume (L)	340,000	680,000	510,000	670,000	840,000	1,010,000	2,020,000
Na molarity (mol/L)	0.6	0.5	0.5	0.5	0.4	0.4	0.3

Assumptions:

1. Assumes a 1.22-m (4-ft) minimum head for acceptable mixer pump performance at full speed.
2. Dilution ratios are defined as: Volume of Wash Solution Added per Volume of 20 wt% Settled Solids.
3. The recommended dilution ratio and number of wash repetitions are shaded.
4. Each decant step leaves a 0.3-m (1-ft) supernatant layer above the settled solids.
5. Canister numbers are computed assuming no contribution from the final transfer liquid.

Table 4-5. In-Tank Sludge Washing Sensitivity Runs--Dilute Caustic Washing of 241-AY-102/241-C-106 (36 percent/99 percent Retrieval).

Dilution Basis: Fluffy Settled Solids Volume = 2,130,000 L (564,000 gal)

Number of washes	Number of 0.62-m^3 high-level waste canisters						
	0.1:1 dilution	0.2:1 dilution	0.3:1 dilution	0.4:1 dilution	0.5:1 dilution	0.6:1 dilution	Fill tank (0.7:1)
0 (decant only)	470	470	470	470	470	470	470
1	460	450	440	440	440	440	430
2	450	440	430	430	430	420	420
3	440	430	430	420	420	420	410
4	430	420	420	420	410	410	410

b.

	0.1:1 Dilution	0.2:1 Dilution	0.3:1 Dilution	0.4:1 Dilution	0.5:1 Dilution	0.6:1 Dilution	Fill Tank (0.7:1)
Initial decant volume (L)	2,080,000	2,080,000	2,080,000	2,080,000	2,080,000	2,080,000	2,080,000
Na molarity (mol/L)	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Decanted wash solution volume (L)	650,000	860,000	640,000	850,000	1,060,000	1,280,000	1,490,000
Na molarity (mol/L)	0.5	0.5	0.5	0.5	0.4	0.4	0.4

Assumptions:

1. Assumes a 1.22-m (4-ft) minimum head for acceptable mixer pump performance at full speed.
2. Dilution ratios are defined as: Volume of Wash Solution Added per Volume of 20 wt% Settled Solids
3. The recommended dilution ratio and number of wash repetitions are shaded.
4. Each decant step leaves a 0.3-m (1-ft) supernatant layer above the settled solids.
5. Canister numbers are computed assuming no contribution from the final transfer liquid.

5.0 HIGH-LEVEL WASTE BATCH TRANSFER VOLUME STUDY

The volume of each HLW batch transferred to the vendor is a function of the waste composition, the slurry concentration, and the feed batch size (i.e., the mass of waste oxides excluding sodium and silicon). The waste composition is defined by Waste Envelope D, and the best estimates for the individual tank compositions is included in Appendix A. Based on the RFP, the slurry concentration can range between 25 and 100 g waste oxides/L. The initial feed batch size specified in the RFP is 5 MT. It is assumed that subsequent feed batches will be 5 MT or larger. The actual batch size will be in quantities agreed to between the PHMC and the private contractor.

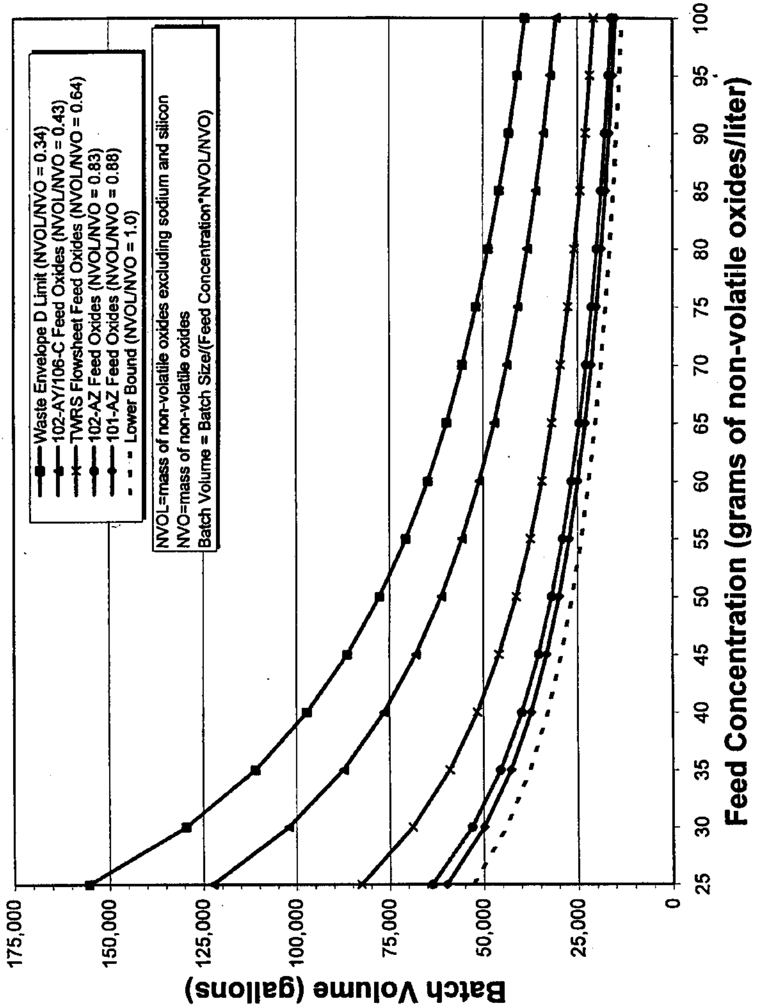
Each of these parameters will determine how many transfers will have to be made to reach the minimum and maximum feed order quantities, 245 and 465 MT excluding sodium and silicon, respectively. It also affects how often the transfers will have to occur and how large the private contractor's feed receiving capacity will have to be. Because these parameters are also uncertainties, the following section describes the enabling assumptions used to derive the HLW batch transfer volumes and base case feed staging schedule presented in Chapter 6.0.

5.1 MINIMUM BATCH VOLUME

Figure 5-1 illustrates the effects of waste composition, slurry concentration, and feed batch size on the batch volume. The calculations of the batch volumes are based on a 5 MT feed batch size, and will increase proportionally to the actual requested feed batch size. For example, a 10 MT batch of 102-AY/106-C waste (the top curve) transferred at 25 g waste oxides/L slurry, will require twice the volume (10 MT/5 MT = 2 times) shown on the figure, or 931,000 L (246,000 gal). If this is beyond the private contractor's feed receipt capacity, the private contractor will likely request or negotiate for a smaller feed batch size.

The RFP specified range of 25 to 100 g/L waste oxides is interpreted as a design requirement. Under this assumption, the private contractor's facility must be designed to receive a feed batch at the lowest permissible concentration, and the lowest ratio of non-volatile oxides excluding sodium and silicon to non-volatile oxides, as defined by Waste Envelope D (NVOL/NVO = 0.34, calculated by Stegen). According to these estimates, it follows that the highest volume that the private contractor will be required to accept, based on a 5-MT batch size, will be approximately 587,000 L (155,000 gal), as shown in Figure 5-1.

Figure 5-1. High-Level Waste Batch Transfer Volumes (5 MT Feed Batch Size).



This study assumes that the PHMC will elect to concentrate the slurry feed to the maximum concentration (100 g waste oxides/L), and in the largest batch volume that the private contractor can accommodate. Issues concerning the waste transfer system capabilities are addressed in Chapter 7.0. Therefore, under this enabling assumption, Table 5-1 shows the batch sizes that can be accommodated, assuming 587,000 L (155,000 gal) of capacity.

Table 5-1. Base Case Phase I High-Level Waste Batch Sizes and Batch Volumes.

Phase I sludge feed	Maximum batch size in 587,000 L (155,000 gal)	Total waste oxides excluding sodium and silicon	Preferred batch size	Batch volume	Number of batches
101-AZ (90 percent retrieved)	52 MT	77 MT	38.5 MT	439,000 L	2
102-AZ (60 percent retrieved)	48 MT	69 MT	34.5 MT	416,000 L	2
102-AY/106-C (36 percent retrieved/75 percent retrieved)	25 MT	180 MT	22.5 MT	521,000 L	8
102-AY/106-C (36 percent retrieved/99 percent retrieved)	25 MT	233 MT	23.3 MT	521,000 L	10
Total	N/A	325 to 379 MT	N/A	N/A	12 to 14

The base case schedule for feed staging included in Chapter 6.0 is based on the assumptions derived from Table 5-1. The values in Table 5-1 may vary depending on private contractor proposals. Any necessary modifications to the base case assumptions used here will be incorporated into the next revision of this document.

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6.0 PRELIMINARY HIGH-LEVEL WASTE PRETREATMENT AND FEED STAGING SCHEDULES

Based on the feed batch sizes and volumes calculated in Chapter 5.0, a base case feed delivery schedule has been prepared. The dates reflect a HLW immobilization facility operating at the minimum capacity specified in the RFP. Pretreatment project requirements and detailed scheduling of activities are currently being evaluated. Much of the data acquired from the Project W-151 mixer pump test, will help to identify these requirements. For purposes of this study, it assumed that a minimum of two years before the feed delivery dates is allowed for pretreatment of each of the Phase I HLW sludges. This section identifies some of these requirements.

6.1 PRETREATMENT SCHEDULE

The duration of sludge pretreatment processing will impact the installation dates for the processing equipment described in Section 3.2.2. Each of the operations will have the following estimated durations (Table 6-1), and the total time required will vary depending upon the number of wash repetitions. These durations are taken from *In-Tank Processing of Hanford Wastes* (MacLean 1995).

Table 6-1. Pretreatment Processing Durations.

Operation	Duration	Repetitions		
		101-AZ	102-AZ	102-AY/106-C
Decant Supernatant/Wash Solution	7 days	4	4	2
Add Dilute Caustic Solution	7 days	3	3	1
Mix Waste with Mixer Pumps	7 days	3	3	1
Allow Waste to Settle	30 days	3	3	1
Add Water for Slurry Transfer	5 days	1	1	1
Transfer HLW Batch to Private Contractor	1 day	1	1	1
Total Sludge Processing Time		166 days	166 days	64 days

The total sludge processing times in Table 6-1 do not include the time that will be needed for waste composition certification, waste form qualification, characterization (performed by the private contractor), and other activities that must also occur after the sludge has been washed. The previous Hanford Waste Vitrification Plant (HWVP) basis of 18 months is currently allocated for these activities, but this duration may be shortened as process knowledge is gained and as schedules are finalized.

For the installation of processing equipment, one must work backwards from the feed delivery date discussed in Section 6.2. It is concluded that a minimum of two years is required from the time that the processing equipment is installed and operational to the date that the feed is needed. The equipment is needed before the following dates:

- The 101-AZ processing equipment must be installed and operational before June 1, 2000. The assumed date will be September 1, 1997. Mixer pump(s) will be installed in 101-AZ by September 1997 as part of the W-151 Project's goal to demonstrate mixer pump effectiveness.

- The 102-AZ processing equipment must be installed and operational before September 12, 2001. The assumed date will be September 1, 2000.

- The 102-AY/106-C processing equipment must be installed and operational before November 5, 2002. The assumed date will be September 1, 2001.

These dates are based on a processing capacity of 60 MT of waste oxides excluding sodium and silicon per year. The schedule must be accelerated if the private contractor proposes a higher operating capacity.

Tables 6-2 through 6-4 show preliminary schedules for the sludge pretreatment, equipment installation, and transfer of the HLW feeds to the private contractor at 100 g waste oxides/L. To be conservative, one month is assumed for each pretreatment step. These preliminary schedules identify the need to conduct engineering analyses of the proposed HLW pretreatment and feed transfer systems, including design, fabrication, and installation of jumpers, mixer pump testing, and sampling of the washed sludges in preparation for supplying feed to the privatization contractor. The equipment installation dates are consistent with the requirements above, and are taken from the *TWRS Disposal Program Assumptions for Operational Waste Volume Projection* (Washenfelder 1996).

Table 6-2. Sludge Pretreatment Schedule for Tank 241-AZ-101.

Activity	Start	Finish	Volume (ML)
Project W-151 In-Tank Processing Equipment Operational	9/1/97		
Transfer Supernatant to 101-AY	10/1/97	11/1/97	2.5
Add Dilute Caustic Solution (3:1) and Mix Waste (1st Wash)	11/1/97	12/1/97	1.0
Allow Waste to Settle	12/1/97	1/1/98	
Sample/Decant Supernatant to AN, AW, or AP Tank	1/1/98	2/1/98	1.0
Add Dilute Caustic Solution (3:1) and Mix Waste (2nd Wash)	2/1/98	3/1/98	1.0
Allow Waste to Settle	3/1/98	4/1/98	
Sample/Decant Supernatant to AN, AW, or AP Tank	4/1/98	5/1/98	1.0
Add Dilute Caustic Solution (3:1) and Mix Waste (3rd Wash)	5/1/98	6/1/98	1.0
Allow Waste to Settle	6/1/98	7/1/98	
Sample/Decant Supernatant to AN, AW, or AP Tank	7/1/98	8/1/98	1.0
Sample Washed Solids	8/1/98	9/1/98	
Add Water for Slurry Transfer	9/1/98	9/5/98	0.4
Mix Waste with Mixer Pumps Certify/Characterize Waste	9/5/98		
Qualify Waste Form[a]		WTD[b]	
Transfer Feed Batches to Private Contractor[c]	6/1/02	9/11/03	

[a] This activity is the responsibility of DOE-RL/private contractor. It is not the responsibility of the PHMC.

[b] WTD = Waste Transfer Day. Periodically, the sludge is mobilized with the mixer pumps to limit the amount of solids settling.

[c] Batches of Waste Envelope D are transferred to the private contractor in quantities agreed to between the PHMC and the private contractor. This is the latest date that the private contractor will request feed, based on the minimum system capacity.

Table 6-3. Sludge Pretreatment Schedule for Tank 241-AZ-102.

Activity	Start	Finish	Volume (ML)
Project W-211 In-Tank Processing Equipment Operational	9/1/00		
Transfer Supernatant to 101-AY and AP Tank	10/1/00	11/1/00	1.3
Add Dilute Caustic Solution (2:1) and Mix Waste (1st Wash)	11/1/00	12/1/00	1.5
Allow Waste to Settle	12/1/00	1/1/01	
Sample/Decant Supernatant to AN, AW, or AP Tank	1/1/01	2/1/01	1.2
Add Dilute Caustic Solution (2:1) and Mix Waste (2nd Wash)	2/1/01	3/1/01	1.5
Allow Waste to Settle	3/1/01	4/1/01	
Sample/Decant Supernatant to AN, AW, or AP Tank	4/1/01	5/1/01	1.5
Add Dilute Caustic Solution (2:1) and Mix Waste (3rd Wash)	5/1/01	6/1/01	1.5
Allow Waste to Settle	6/1/01	7/1/01	
Sample/Decant Supernatant to AN, AW, or AP Tank	7/1/01	8/1/01	1.5
Sample Washed Solids	8/1/01	9/1/01	
Add Water for Slurry Transfer	9/1/01	9/5/01	0.3
Mix Waste with Mixer Pumps Certify/Characterize Waste	9/5/01		
Qualify Waste Form[a]		WTD[b]	
Transfer Feed Batches to Private Contractor[c]	9/12/03	11/4/04	

[a] This activity is the responsibility of DOE-RL/private contractor. It is not hte responsibility of the PHMC.

[b] WTD = Waste Transfer Day. Periodically, the sludge is mobilized with the mixer pumps to limit the amount of solids settling.

[c] Batches of Waste Envelope D are transferred to the private contractor in quantities agreed to between the PHMC and the private contractor. This is the latest date that the private contractor will request feed, based on the minimum system capacity.

Table 6-4. Sludge Pretreatment Schedule for Tanks 241-AY-102/241-C-106.

Activity	Start	Finish	Volume (ML)[a]
Project W-211 In-Tank Processing Equipment Operational	9/1/01		
Transfer Supernatant to AP Tank	10/1/01	11/1/01	2.5/2.1
Add Dilute Caustic Solution (0.4:1/0.3:1) and Mix Waste (1st Wash)	11/1/01	12/1/01	0.7/0.6
Allow Waste to Settle	12/1/01	1/1/02	
Sample/Decant Supernatant to AN, AW, or AP Tank	1/1/02	2/1/02	0.7/0.6
Sample Washed Solids	2/1/02	3/1/02	
Add Water for Slurry Transfer	3/1/02	3/5/02	2.5/3.3[b]
Mix Waste with Mixer Pumps Certify/Characterize Waste	3/5/02		
Qualify Waste Form[c]		WTD[d]	
Transfer Feed Batches to Private Contractor[e]	11/5/04	9/16/08	

[a] The two values for volume shown are for 75 percent 106-C and 99 percent 106-C retrieval, respectively.

[b] In the case of 102-AY/106-C, a portion of the slurry transfer water may have to be added in-line, due to limitations in the tank capacity.

[c] This activity is the responsibility of DOE-RL/private contractor. It is not hte responsibility of the PHMC.

[d] WTD = Waste Transfer Day. Periodically, the sludge is mobilized with the mixer pumps to limit the amount of solids settling.

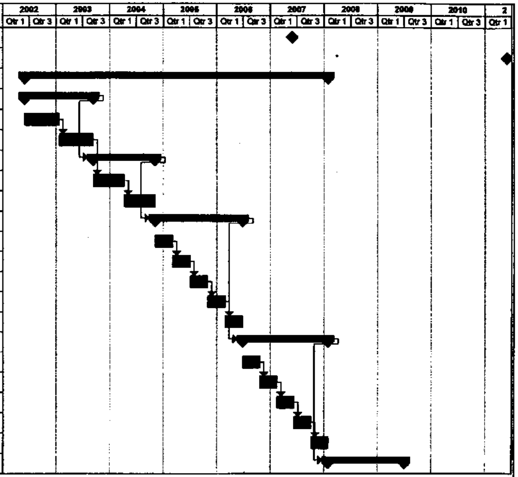
[e] Batches of Waste Envelope D are transferred to the private contractor in quantities agreed to between the PHMC and the private contractor. This is the latest date that the private contractor will request feed, based on the minimum system capacity.

6.2 BASE CASE FEED BATCH DELIVERY SCHEDULE

Section 5.0 presented the results of the HLW batch transfer analysis. Based on these calculations, the durations for processing each individual feed batch were calculated, and compiled into a base case feed delivery schedule. Figure 6-1 presents the start and finish dates for HLW services. Pretreatment, delivery, and other waste form certification activities must be completed before each start date.

Figure 6-1. Base Case Feed Batch Delivery Schedule.

ID	Activity	Duration	Start	Finish	Volume (L)	Oxides (MT)
1	Complete Minimum Order Quantity	0d	6/1/07	6/1/07	4,315,000	245
2	Complete Maximum Order Quantity	0d	6/1/11	6/1/11	4,315,000 + ?	465
3	Immobilize Phase I HLW Sludge Feeds	2068d	6/1/02	1/28/08	6,920,000	379
4	Immobilize 101-AZ Sludge	468d	6/1/02	9/11/03	878,000	77
5	Immobilize HLW Batch #1	234d	6/1/02	1/20/03	439,000	38.5
6	Immobilize HLW Batch #2	234d	1/21/03	9/11/03	439,000	38.5
7	Immobilize 102-AZ Sludge	420d	9/12/03	11/4/04	832,000	69
8	Immobilize HLW Batch #3	210d	9/12/03	4/8/04	416,000	34.5
9	Immobilize HLW Batch #4	210d	4/9/04	11/4/04	416,000	34.5
10	Immobilize Minimum 102-AY/106-C Sludge	600d	11/5/04	6/27/06	2,606,000	112.5
11	Immobilize HLW Batch #5	120d	11/5/04	3/4/05	521,000	22.5
12	Immobilize HLW Batch #6	120d	3/5/05	7/2/05	521,000	22.5
13	Immobilize HLW Batch #7	120d	7/3/05	10/30/05	521,000	22.5
14	Immobilize HLW Batch #8	120d	10/31/05	2/27/06	521,000	22.5
15	Immobilize HLW Batch #9	120d	2/28/06	6/27/06	521,000	22.5
16	Immobilize Remaining 102-AY/106-C Sludge	580d	6/28/06	1/28/08	2,605,000	114.1
17	Immobilize HLW Batch #10	116d	6/28/06	10/21/06	521,000	22.5
18	Immobilize HLW Batch #11	116d	10/22/06	2/14/07	521,000	22.5
19	Immobilize HLW Batch #12	116d	2/15/07	6/10/07	521,000	22.5
20	Immobilize HLW Batch #13 (if available)	116d	6/11/07	10/4/07	521,000	23.3
21	Immobilize HLW Batch #14 (if available)	116d	10/5/07	1/28/08	521,000	23.3
22	Immobilize Alternative Feeds (if available)	522d	1/29/08	7/3/09	?	92.4



Project: Phase I HLW Feed Staging
Date: 9/24/96

Task ▬	Milestone ◆	Rolled Up Task ▬	Rolled Up Progress ▬
Progress ▬	Summary ▬	Rolled Up Milestone ◇	

Page 1

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7.0 ACTIONS AND ISSUES

This chapter describes the actions and issues identified in this evaluation. Resolution of the issues addressed in this plan may be useful for evaluating the HLW private contractor proposals. The actions and issues addressed in this chapter will fall under one or more of the following categories:

1. Projects that need to be implemented to allow Phase I HLW feed staging to proceed (Sections 7.1 and 7.2)

2. Design parameters and enabling assumptions that need to be clarified or verified in order to reduce the uncertainties and risks (Sections 7.1, 7.2, 7.3, and 7.6)

3. Additional design parameters that need to be more thoroughly evaluated (Sections 7.1, 7.3, 7.4, 7.5, and 7.6).

Some of the actions listed below are pertinent to project schedules and are therefore drivers for the requirements of other tank farm operations (for Projects W-211 and W-314) to be performed by the PHMC. The details are discussed in the following sections.

1. Action: Implement the transfer system upgrades (HLW Option 3) recommended in Galbraith et al. (1996).

   Consequence of not performing: *If no upgrades are made then (a) the waste pumpability rule will not be satisfied for most LAW and HLW feed staging transfers, (b) the least capable and least robust system for delivery of feed has been selected. Implementing any of the other dominant alternatives involves trade-offs between cost, ability to deliver feed on time, robustness against changing assumptions, and compliance with the waste pumpability rule (marginal hydraulics versus acceptable hydraulics)* (Certa et al. 1996).

2. Action: Install in-tank processing equipment by the recommended dates in Section 6.1.

   Consequence of not performing: Delays will be incurred in delivering the pretreated HLW feed to the private contractor feed tanks.

3. Action: Obtain and integrate information on the immobilization facility design, when available.

   Consequence of not performing: The enabling assumptions pertaining to the immobilization facility in this plan will not be confirmed and may not be accurate.

4. Action: Convene a decision board to determine if caustic leaching should be included in this plan.

   Consequence of not performing: The *Phase I High-Level Waste Pretreatment and Feed Staging Plan* will be based on water washing only, and the benefits of caustic leaching will not be adequately defined and assessed. Processing schedule delays may result if the decision is delayed.

5. Action: Define additional or alternative sources of feed in the next update of this plan.

   Consequence of not performing: The PHMC will not have a plan to provide additional sources of feed to support the maximum feed order quantity. Schedule delays in HLW pretreatment and feed staging may result.

6. Action: Integrate new inventory assumptions (Kupfer et al. 1996) into the next update of this plan.

   Consequence of not performing: The next update of this plan will not be consistent with the standardized inventory (Kupfer et al. 1996).

7.1 TRANSFER SYSTEM UPGRADES

To enable the PHMC to deliver the designated Phase I sludge feeds to the private contractor, the transfer system upgrades recommended in Galbraith et al. (1996) must be implemented. To support Privatization Phase I, these upgrades will need to be integrated with Projects W-314 and W-211. As an enabling assumption in this analysis, the transfer system upgrades will be completed in time to support the NCAW supernatant transfers and the base case feed batch delivery schedule shown Table 6-1.

Another uncertainty is whether or not 5.1-cm (2-in.) slurry lines SL-502 and SL-504 will be replaced with 7.6-cm (3-in.) lines. These lines support the transfer of the 102-AY/106-C feed to the private contractor's facility and the transfer of the NCAW supernatant from 101-AZ to 101-AY. Project W-314 will need to verify that the integrity of the lines is acceptable, to justify performing the upgrades. If the lines are not replaced, then 102-AY/106-C will need to be staged into 101-AZ before being transferred to the private contractor. This intermediate transfer may impact the pretreatment, feed staging strategy, and base case schedules recommended in this plan.

The transfer system recommended by Galbraith et al. (1996) is based on a viscosity of 10.0 cP and a specific gravity of 1.5. These values were used as a conservative basis, and measurements of these properties for the washed solids from 101-AZ and 102-AZ, as reported in tank characterization reports, are within this range. Table 7-1 shows the calculated transfer velocity, head loss, and pressure drop, compared with the design capabilities (limits) of the proposed transfer system, and the base case values used by Galbraith et al. (1996).

Table 7-1. High-Level Waste Transfer System Design Calculation Results Reynolds Number Set to 20,000 (Fowler 1995).

Case	Reynolds number	Velocity	Head loss	Pressure drop
Line Design Limit	Minimum 20,000	N/A	Maximum 140 m (450 ft)	Maximum 2.8 MPa (400 psi)
Transfer System Design Basis (SpG=1.5, Visc.=10 cP)	20,000	1.7 m/s (5.6 ft/s)	130 m (435 ft)	2.0 MPa (285 psi)
101-AZ Core 1 (SpG=1.04, Visc.=6 cP)	20,000	1.5 m/s (5.0 ft/s)	110 m (345 ft)	1.1 MPa (155 psi)
101-AZ Core 2 (SpG=1.14, Visc.=10 cP)	15,500[a]	1.8 m/s (5.8 ft/s)	140 m (465 ft)[a]	1.6 MPa (230 psi)
102-AZ (SpG=1.11, Visc.=6 cP)	20,000	1.4 m/s (4.6 ft/s)	91 m (300 ft)	1.0 MPa (145 psi)
102-AY/106-C	No data	No data	No data	No data

[a] This case is limited by the pump head capabilities (approximately 450 ft for the New Generation Transfer Pump). The Reynolds number of >20,000 therefore can not be attained.

With the exception of 101-AZ (Core 2) and 102-AY/106-C, the transfer system proposed is capable of handling washed sludge with the measured specific gravities and viscosities reported in the tank characterization reports. The uncertainty about the 102-AY/106-C wastes will need to be verified when additional data become available.

The tank characterization reports for 101-AZ and 102-AZ provide critical Reynolds numbers ranging from 4,100 to 9,400, and conclude that the washed solids can be pumped in this range. Fowler (1996) establishes a Reynolds number requirement of 20,000, referred to as the Waste Pumpability Rule. Validation of this assumption requires further hydraulic analysis, which is part of the detailed design phase of the upgrade projects. Further hydraulic analysis would be performed in the laboratory and would entail pipeline flow testing with simulated waste. A lower Reynolds number requirement would mean that the proposed transfer system far exceeds the pumpability requirements. Verifying the Waste Pumpability Rule would eliminate the uncertainty with 101-AZ (Core 2) in Table 7-1. Based on this preliminary analysis, it is assumed that the Phase I wastes can be delivered to the private contractor within the physical property limits of Waste Envelope D.

7.2 INSTALLATION AND TESTING OF IN-TANK PROCESSING EQUIPMENT

The equipment identified in this document to be utilized for in-tank processing of the Phase I sludges should be installed and tested by the recommended dates in Section 6.1. These dates are shown in Table 7-2.

Table 7-2. In-Tank Processing Equipment Installation Dates.

Tank	Installation Date (no later than)
101-AZ	September 1, 1997[a]
102-AZ	September 1, 2000
102-AY	September 1, 2001

[a] Mixer pump(s) will be installed in 101-AZ by 9/97 as part of the W-151 Project's goal to demonstrate mixer pump effectiveness.

Any modifications to the Phase I HLW pretreatment goals, such as the addition of caustic leaching, may cause schedule delays and impose additional equipment requirements. The results of mixer pump performance and process testing (i.e. Projects W-151 and W-211) may also impact the equipment needs and schedule. At least 12 months of lead time is factored into the schedules recommended in Section 6.1, to absorb delays. The potential consequences of not meeting the schedule for equipment installation is the inability to pretreat and deliver the Waste Envelope D feeds on time.

7.3 IMMOBILIZATION FACILITY DESIGN

The design of the private contractor's immobilization facility may have important impacts on the sludge pretreatment and transfer system requirements for Phase I. Some of these impacts cannot be evaluated completely without knowledge of the capabilities of the immobilization facility design. The major facility design uncertainties include the HLW processing rate, the feed/receipt tank capacity, and the HLW product formulation.

7.3.1 High-Level Waste Processing Rate

One controlling factor in the feed batch delivery schedule is the rate at which the HLW is immobilized. This rate, combined with the facility's feed/receipt capacity, can be used to determine how frequently the HLW batches will need be transferred. Once the feed delivery schedule is determined, the potential for conflicts in the transfer system can be evaluated using the model from Certa et al. (1996). An enabling assumption used in this study and in Certa et al. (1996) is the minimum immobilized HLW processing rate of 60 MT of waste oxides excluding sodium and silicon per year. The actual processing rate will be determined by the private contractor, and will be a function of the immobilization system capacity (e.g. melt rate) and product loading.

The processing rate also determines how soon the pretreatment/DST retrieval systems must be in place to support Phase I HLW immobilization. Although some contingency is factored into the pretreatment schedule (Chapter 6.0), a much higher processing rate may require the installation of in-tank processing equipment (for the second the third tanks, 102-AZ and 102-AY, respectively) sooner than anticipated. The next update of this document can integrate new assumptions for the HLW immobilization processing rate, if available.

7.3.2 Feed/Receipt Capacity

The results of the analysis in Chapter 5.0 suggest that the private contractor feed/receipt tank will have a capacity of at least 473,000 L (125,000 gal), if it is consistent with tank inventory and washed solids composition estimates and the feed dilution and concentration requirements in the RFP (DOE 1996). The actual capacity selected by the private contractor is not explicitly defined in the RFP, but any proposal of less than the minimum capacity (calculated in Chapter 5.0) may require modifications to the requirements and the HLW feed staging plan. The feed/receipt capacity has an effect on the feed batch delivery schedule, the amount of transfer water needed to dilute and transfer the waste, the feed batch size, and the ability of the transfer system to deliver the specified feeds on time (Certa et al. 1996). This plan will be modified once the capacity of the feed/receipt tank is known.

If the private contractor proposes to construct a feed/receipt tank at the minimum capacity, it is recommended to transfer the waste at much higher than the minimum concentration (25 g waste oxides/L). Figure 5-1 shows that the batch transfer volume can vary widely depending upon the composition of the waste. This variation is especially prevalent at lower concentrations. Therefore, operation close to this limit will pose some risk of not delivering the 5 MT minimum batch size, because of the feed composition variability. Operating at either limit (minimum or maximum) may pose control difficulties, as well.

The relationship between feed concentration and the feed/receipt tank capacity may be an incentive for the private contractor to negotiate for higher concentrations of feed, subject to transfer system limitations. The private contractor can build a smaller feed/receipt tank if the feed concentration is limited to higher concentrations. This may involve going outside of the RFP requirements (Waste Envelope D), and any negotiations of this design parameter are an uncertainty in this plan.

The sensitivity of the feed batch volume to the composition of the waste is based on the amount of sodium and silicon in the feed. Referring to Figure 5-1, the batch transfer volume gets smaller as the amount of sodium and silicon decreases in the feed. Most of the sodium is washed out to meet Waste Envelope D and CVS glass limits. However, water washing only reduces the soluble fraction of sodium and silicon. The feed batch volume is mostly dependent on the amount of insoluble sodium and silicon in the feed.

7.3.3 High-Level Waste Product Formulation

The formulation of the HLW product can be used to determine how much product volume reduction can be achieved by doing additional processing beyond Waste Envelope D. It can help to support a caustic leaching decision (see Section 7.4). Knowledge of the HLW product formulation can allow the pretreatment strategy to be more accurately tailored to meet additional feed processing needs. The performance of the immobilization process may be more accurately assessed in terms of its sensitivity to feed pretreatment in terms of product composition and quantity estimates.

The feed processability assessment (Lambert and Stegen 1996) describes a possible candidate glass formulation based on glass property models developed by PNNL. Based on past analyses of alternative HLW forms, it has been speculated that the product formulation in Lambert and Stegen (1996) will be similar to what the private contractor will actually propose. Therefore, these models can be used if the selected product formulation remains an unknown in the next update of this plan. A standardized method for calculating glass compositions and volumes will be based on these empirical glass property models and is planned for next year's update.

7.4 CAUSTIC LEACHING IN PHASE I HIGH-LEVEL WASTE PRETREATMENT

Caustic leaching of the Phase I feeds is considered incremental processing because the Waste Envelope D specification can be met for all of the feeds with water washing. However, there may be significant benefits to caustic leaching including:

- Product volume reduction
- Reduction in feed oxide quantity
- Obtaining process information

These and any additional criteria for pretreatment need to be evaluated by a decision board to determine if caustic leaching should be included in the Phase I pretreatment plans. Tank space must also be evaluated for this additional processing to be considered viable. A projection of DST space is planned for later this year (Koreski and Strode 1996).

If there is sufficient tank space, a decision of whether to caustic leach will require knowledge of the HLW product formulation. If reducing the feed oxide quantity or obtaining process information is significantly more important that product volume reduction, then the HLW product formulation may not be needed. Otherwise, the caustic leaching decision will need the HLW product formulation, which could be assumed to be similar to Lambert and Stegen (1996). The weighting of these factors will need to be performed by the decision board.

At a minimum, the following information is needed to support the decision to caustic leach:

1. Leach factors: Conclusive laboratory-scale testing data must show that the selected Phase I tank is a good candidate for caustic leaching. The decision board will determine whether the measured effect (i.e. reduction in aluminum, chromium, phosphate, and sodium) is large enough.

2. DST tank space evaluation: The decision will require an accurate prediction by the OWVP (Koreski and Strode 1996) that there will be adequate tank space to perform caustic leaching on one or more of the candidate feeds.

3. HLW product formulation (optional): If it is determined that product volume reduction is important to the decision, the proposed Phase I immobilized HLW product formulation is needed.

Additional information needs, such as cost implications and tank farm operational impacts, will need to be identified by the decision board.

7.5 ADDITIONAL PHASE I HIGH-LEVEL WASTE FEEDS

The results of this analysis show that the sludges from 101-AZ, 102-AZ, and 102-AY/106-C will not be sufficient to provide the maximum feed order quantity. To provide the maximum feed order quantity, an analysis of additional feed sources is necessary. The evaluation will proceed by the following steps:

1. Determine which sludges will be available (or can be made available) to support Phase I HLW processing

2. Determine which of the available sludges (if any) will satisfy Waste Envelope D

3. If the feeds do not satisfy Waste Envelope D, determine if they satisfy the Expanded Design Basis for HLW Processing (RFP Attachment 2)

4. If the feeds do not satisfy the Expanded Design Basis limits, define a separate waste envelope which will encompass the additional candidate feeds.

The next update of this plan will use this methodology to identify additional feed sources, and develop a pretreatment and staging strategy for the maximum order quantity.

7.6 BEST-BASIS INVENTORIES

It is planned for the next update of this plan to integrate the inventory assumptions from the *Best-Basis Inventories of Chemicals and Radionuclides in Hanford Site Tank Waste* (Kupfer et al. 1996). These new tank inventories may have an impact on this plan. The standardized inventories will eliminate any inventory inconsistencies in the related documents.

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APPENDIX A

TANK WASTE INVENTORY ASSUMPTIONS AND METHODOLOGY

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APPENDIX A

TANK WASTE INVENTORY ASSUMPTIONS AND METHODOLOGY

The tank waste inventories used in this analysis consist of the best analytical information available. For single-shell tank 106-C, and double-shell tanks 101-AZ and 102-AZ, the inventories and solubility data represent a change from the values reported in the *TWRS Process Flowsheet* (Orme 1995). Tables A-1 through A-4 contain the revised inventory assumptions for the Phase I high-level waste source tanks.

Table A-1. Inventory Assumptions for 241-AZ-101.

	Soluble Components	Insoluble Components
Total Mass (kg)	4.14E+06	8.66E+04
Components (kg)		
AG+		2.36E+02
AL(OH)4-	1.21E+05	
AL+3		1.16E+04
AM+3	2.52E-01	8.14E+00
AS+5	2.65E+00	1.34E+02
B+3	8.98E-01	7.09E+01
BA+2	9.51E-02	1.75E+02
BE+2	1.08E-03	4.21E+00
BI+3		
C14	4.23E-02	3.48E-03
CA+2	1.60E+00	5.85E+02
CD+2	5.88E-02	1.36E+03
CE+3	2.42E+00	2.91E+02
CL-	6.09E+02	2.68E+01
CM+3	2.36E-04	8.85E-03
CO+3	7.50E-04	8.35E-04
CO-60		
CO3-2	1.02E+05	3.67E+03
CR(OH)4-	4.80E+02	
CR+3		1.90E+02
CS+	2.03E+02	8.00E+00
CS-137	7.03E+01	2.78E+00
CU+2	2.08E-01	1.04E+02
EU-154		
F-	5.93E+03	1.48E+02
FE+3	4.84E-01	2.41E+04
H2O	3.04E+06	
I-	3.42E-01	2.50E-01
K+	6.82E+02	7.38E+02
LA+3	1.82E-01	9.11E+02
LI+	4.50E-01	1.71E+01
MG+2	8.68E-02	1.47E+02
MN+4	4.43E-02	7.28E+02
MO+6	1.37E+01	1.31E+01
NA+	3.48E+05	3.90E+03
NH3		
NI+3	1.27E-01	1.07E+03
NO2-	2.03E+05	1.69E+03
NO3-	2.36E+05	1.38E+03
NP+4		
OH-	9.94E+03	5.90E+03
PB+4	9.55E-01	1.27E+02
PD+2		
PO4-3	4.73E+03	2.30E+03
PU-238		
PU-239	1.75E-02	8.72E+00
RE+7	2.25E-01	1.36E+01
RH+3	1.61E+00	1.04E+02
RU+3	7.68E-01	2.13E+02
SB+5	2.08E+00	6.54E+02
SE+6	3.90E+00	4.29E+02
SI+4	5.66E+01	1.35E+03
SO4-2	5.80E+04	1.08E+03
SR+2	7.83E+00	1.43E+02
SR-90	2.02E+00	3.68E+01
TCO4-	6.57E+01	1.43E+01
TE+6	4.17E+00	4.61E+02
TH+4	3.37E+00	2.96E+02
TI+4	1.20E+00	1.58E+02
TL+3	4.17E+01	1.58E+03
TOC	3.60E+03	2.02E+03
UO2+2	9.27E+00	1.49E+03
V+5	1.44E-01	6.05E+00
ZN+2	2.14E-01	9.74E+01
ZR+4		
ZRO2:2H2O	1.29E-01	1.48E+04

Table A-2. Inventory Assumptions for 241-AZ-102.

	Soluble Components	Insoluble Components
Total Mass (kg)	4.08E+06	1.91E+05
Components (kg)		
AG+		2.41E+02
AL(OH)4-	1.78E+04	
AL+3		1.54E+04
AM+3	4.90E-04	4.90E+00
AS+5	4.15E+00	1.66E+02
B+3	2.30E+00	1.39E+02
BA+2	3.21E-01	1.59E+02
BE+2	2.12E-02	3.84E+00
BI+3		
C14	2.99E-02	2.79E-03
CA+2	1.12E+01	8.11E+02
CD+2	3.61E-01	4.32E+03
CE+3	4.07E+00	2.22E+02
CL-		4.23E+01
CM+3		6.68E-03
CO+3	3.74E-05	5.36E-05
CO-60		
CO3-2	9.45E+04	2.24E+04
CR(OH)4-	7.65E+03	
CR+3		3.61E+02
CS+	1.06E+02	9.58E+00
CS-137	3.67E+01	3.32E+00
CU+2	2.94E-01	1.00E+02
EU-154		
F-	3.35E+03	3.57E+01
FE+3	3.05E+00	3.77E+04
H2O	3.53E+06	
I-	8.56E-02	2.39E-01
K+	2.61E+02	3.37E+02
LA+3	6.53E-01	1.29E+03
LI+	2.95E-01	8.07E+00
MG+2	3.68E-01	2.73E+02
MN+4	2.77E-01	8.29E+02

	Soluble Components	Insoluble Components
Total Mass (kg)	4.08E+06	1.91E+05
Components (kg)		
MO+6	6.75E+00	6.75E+00
NA+	1.84E+05	1.19E+04
NH3		
NI+3	7.02E-01	2.55E+03
NO2-	9.26E+04	1.09E+03
NO3-	7.72E+04	3.02E+02
NP+4		
OH-	2.47E+03	6.83E+04
PB+4	1.44E+00	3.15E+02
PD+2		
PO4-3	1.67E+03	4.07E+03
PU-238		
PU-239	6.49E-01	7.77E+00
RE+7	2.19E-01	2.06E+01
RH+3	2.80E+00	1.19E+02
RU+3	6.95E-01	5.16E+01
SB+5		
SE+6	3.41E+00	2.93E+02
SI+4	1.80E+03	1.21E+03
SO4-2	6.15E+04	1.50E+03
SR+2	8.52E-01	9.56E+01
SR-90	6.34E-02	2.11E+01
TCO4-	2.93E+01	1.43E+01
TE+6	8.68E-01	9.84E+01
TH+4		
TI+4	2.45E-01	2.21E+01
TL+3	5.98E-01	1.59E+01
TOC	4.97E+03	7.91E+02
UO2+2	5.77E+03	3.94E+03
V+5	2.57E-01	9.14E+00
ZN+2	1.39E-01	4.04E+01
ZR+4		
ZRO2:2H2O	1.18E+00	9.12E+03

Table A-3. Inventory Assumptions for 241-AY-102.

	Soluble Components	Insoluble Components
Total Mass (kg)	4.28E+06	7.56E+04
Components (kg)		
AG+	2.82E+01	1.04E+03
AL(OH)4-	2.32E+01	
AL+3		5.49E+03
AM+3	1.05E-04	9.49E-01
AS+5		
B+3		
BA+2	2.06E+00	2.88E+02
BE+2		
BI+3		
C14		4.06E-05
CA+2	1.25E+01	2.04E+03
CD+2	3.89E-01	6.03E+01
CE+3		
CL-	2.74E+03	1.57E+02
CM+3	1.75E-07	
CO+3		
CO-60		
CO3-2		
CR(OH)4-	1.51E+02	
CR+3		4.87E+02
CS+	2.73E-01	9.74E-01
CS-137	6.23E-02	2.22E-01
CU+2		
EU-154		
F-	6.58E+02	1.86E+02
FE+3	1.22E+00	1.22E+04
H2O	4.25E+06	
I-		
K+	1.81E+02	1.47E+02
LA+3	1.73E-01	5.75E+02
LI+		
MG+2		
MN+4		1.28E+03
MO+6		
NA+	9.47E+03	2.79E+03
NH3		
NI+3	3.96E-01	4.39E+02
NO2-	3.45E+03	3.49E+01
NO3-	7.52E+02	2.69E+01
NP+4		
OH-	8.04E+03	3.77E+04
PB+4		
PD+2		
PO4-3	3.85E+02	3.89E+00
PU-238		
PU-239	7.44E-03	1.06E+01
RE+7		
RH+3		
RU+3		
SB+5		
SE+6		
SI+4	1.85E+03	3.95E+03
SO4-2	3.87E+02	2.00E+01
SR+2	5.86E-01	1.06E+02
SR-90	2.62E-02	1.40E+01
TCO4-	2.40E+00	
TE+6		
TH+4		
TI+4		
TL+3		
TOC	1.19E+03	5.64E+03
UO2+2	1.81E+03	8.89E+02
V+5		
ZN+2		
ZR+4		
ZRO2:2H2O	5.20E-01	5.26E-03

Table A-4. Inventory Assumptions for 241-C-106.

	Soluble Components	Insoluble Components
Total Mass (kg)	2.27E+05	4.87E+05
Components (kg)		
AG+	1.47E+00	5.63E+02
AL(OH)4-	7.68E+01	
AL+3		4.36E+04
AM+3	4.66E-03	3.23E-01
AS+5		
B+3	5.41E+00	1.67E+01
BA+2	3.13E+00	5.21E+03
BE+2		
BI+3	1.65E+01	5.32E+02
C14		6.59E-05
CA+2	4.83E+01	1.27E+04
CD+2	1.29E+01	3.85E+02
CE+3		
CL-		
CM+3		
CO+3		5.13E+00
CO-60	4.26E-06	1.31E-04
CO3-2		
CR(OH)4-	3.39E+00	
CR+3		1.05E+03
CS+	3.29E+00	1.42E+01
CS-137	7.72E-01	3.33E+00
CU+2	1.63E+00	1.35E+02
EU-154		
F-		
FE+3		5.55E+04
H2O	1.23E+05	
I-		
K+	1.72E+02	1.46E+03
LA+3		
LI+		
MG+2	1.19E+01	6.98E+03
MN+4	5.37E+00	1.98E+03

	Soluble Components	Insoluble Components
Total Mass (kg)	2.27E+05	4.87E+05
Components (kg)		
MO+6		
NA+	5.34E+04	8.41E+04
NH3		
NI+3	3.47E+01	1.01E+03
NO2-		
NO3-	9.89E+02	4.95E-01
NP+4		
OH-	3.67E+04	1.82E+05
PB+4	4.82E+01	2.53E+03
PD+2		1.71E+02
PO4-3	1.43E+03	8.02E+03
PU-238		
PU-239	2.60E+00	5.19E+01
RE+7		
RH+3		
RU+3		
SB+5		
SE+6		
SI+4	2.27E+01	7.57E+04
SO4-2	5.91E+03	1.21E+02
SR+2	1.10E-02	1.10E+02
SR-90	1.50E-03	1.50E+01
TCO4-	3.91E+00	2.04E+01
TE+6		
TH+4		
TI+4		
TL+3		
TOC	5.25E+03	5.26E+00
UO2+2	1.42E+01	6.24E+02
V+5		
ZN+2		4.94E+01
ZR+4	1.23E+02	2.23E+03
ZRO2:2H2O		

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APPENDIX B

PHASE I HIGH-LEVEL WASTE FEED ENVELOPE ASSESSMENT

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APPENDIX B

PHASE I HIGH-LEVEL WASTE FEED ENVELOPE D COMPARISON

This section compares the estimated compositions of the Phase I feeds with Waste Envelope D. Using the dilution ratios recommended in Chapter 4.0 for each tank, the number of wash repetitions is varied. The slurry concentrations shown in Tables B-1 through B-4 are based on 31 g/L non-volatile oxides. A blank concentration value in a particular tank indicates that no information is available for that component. A blank concentration value input for the Waste Envelope D minimum is a value which is "not estimated" in the RFP, and is assumed to be zero. Concentration values with a letter next to them are either higher ("H"), or lower ("L") than the specified Waste Envelope D ranges. Concentration values for which there is no information in the characterization database may also appear as "L" values (e.g. CO_3), but are disregarded in this analysis.

The columns shaded in Tables B-1 through B-4 are based on the recommended pretreatment strategies determined in Chapter 4.0. The recommendation is an optimized case that meets Waste Envelope D, and simultaneously minimizes the volume of wash solution, the number of wash repetitions, and the HLW product volume based on the single-component CVS glass limits. Ignoring tellurium, thallium, ^{14}C, and CO_3 (these discrepancies are discussed later), this analysis shows that the recommended pretreatment strategies will meet the Waste Envelope D specifications.

In the special case of 101-AZ, one additional wash repetition is added to reduce the estimated glass volume by 24 percent. The feed will meet Waste Envelope D with two washes, but the additional processing has a significant benefit. The low sodium value should be disregarded because the composition of the transfer solution can be altered to include sodium (currently water only is assumed).

The physical property data available for the Phase I water-washed feeds are incomplete. Waste Envelope D (RFP, Table TS-8.4) includes the design ranges for the Phase I feeds. During the sludge washing operations, the feeds will be conditioned to meet these ranges. Table 2-2 indicates that estimates of two of the properties, slurry density and pH, will meet Waste Envelope D. A future revision of this document will include a full assessment of the physical property feed envelope, if more information becomes available. Table B-5 presents the physical properties specified for Waste Envelope D.

Table B-1. In-Tank Sludge Washing of 101-AZ (90%) (3:1 Dilution) Phase I High-Level Waste Feed Envelope D Comparison (Based on 31 g/L Non-Volatile Oxides)

	Envelope D		In-Tank Sludge Washing of 101-AZ (3:1 Dilution)									
Phase I HLW Feed Tank	Minimum	Maximum	0 Washes		1 Wash		2 Washes		3 Washes		4 Washes	
Total Waste Oxides (MT)			156.2		107.2		92.2		87.4		85.8	
Feed Volume (L)			5.04E+06		3.46E+06		2.97E+06		2.82E+06		2.77E+06	
Minimum Glass Volume (m^3)			501.7		193.8		100.5		76.7		76.4	
Waste Oxide Loading^a			6.9%		15.8%		29.3%		37.8%		37.7%	
RFP Glass Volume (m^3)^b			138.5		122.5		117.8		116.0		115.2	
Chemicals (g/L)												
Ag		0.17	0.04		0.06		0.07		0.07		0.08	
Al	1.30	4.30	2.89		3.37		3.63		3.69		3.73	
Am		0.02	1.45E-03		2.11E-03		2.44E-03		2.56E-03		2.61E-03	
As		0.05	0.02		0.03		0.04		0.04		0.04	
B		0.40	0.01		0.02		0.02		0.02		0.02	
Ba		1.40	0.03		0.05		0.05		0.05		0.06	
Be		0.02	7.50E-04		1.09E-03		1.26E-03		1.33E-03		1.35E-03	
Bi		0.86										
Ca		2.20	0.10		0.15		0.18		0.18		0.19	
Cd		1.40	0.24		0.35		0.41		0.43		0.44	
Ce		0.25	0.05		0.08		0.09		0.09		0.09	
Co		0.14	1.67E-07		2.24E-07		2.53E-07		2.64E-07		2.67E-07	
Cr		0.21	0.04		0.05		0.06		0.06		0.06	
Cs		0.18	8.51E-03		5.68E-03		4.25E-03		3.72E-03		3.55E-03	
Cu		0.15	0.02		0.03		0.03		0.03		0.03	
Dy		8.00E-03										
Eu		5.00E-03										
F		1.10	0.17		0.10		0.07		0.05		0.05	
Fe	2.60	8.90	4.29		6.22		7.23		7.59		7.70	
Gd		3.00E-03										
Hg		0.03										
K		0.41	0.15		0.20		0.22		0.23		0.24	
La		0.80	0.16		0.24		0.27		0.29		0.29	
Li		0.04	3.05E-03		4.43E-03		5.11E-03		5.39E-03		5.46E-03	
Mg		0.65	0.03		0.04		0.04		0.05		0.05	
Mn		2.00	0.13		0.19		0.22		0.23		0.23	
Mo		0.20	2.65E-03		3.53E-03		3.95E-03		4.13E-03		4.20E-03	
Na	2.30	6.00	9.09	H	4.94		2.80		2.02	L	1.76	L
Nb		3.00E-03										
Nd		0.53										
Ni	0.05	0.73	0.19		0.28		0.32		0.34		0.34	
Np		0.03										
P		0.54	0.17		0.21		0.23		0.24		0.24	
Pb		0.34	0.02		0.03		0.04		0.04		0.04	
Pd		0.04										
Pm		0.03										
Pr		0.11										
Pu		0.02	1.55E-03		2.26E-03		2.62E-03		2.75E-03		2.79E-03	
Rb		0.06										
Re		0.03	2.43E-03		3.53E-03		4.10E-03		4.29E-03		4.37E-03	
Rh		0.04	0.02		0.03		0.03		0.03		0.03	
Ru		0.11	0.04		0.06		0.06		0.07		0.07	
S		0.20	0.53	H	0.30	H	0.18		0.14		0.12	
Sb		0.26	0.12		0.17		0.20		0.21		0.21	
Se		0.16	0.08		0.11		0.13		0.14		0.14	
Si		5.80	0.24		0.35		0.41		0.43		0.43	
Sm		0.05										
Sn		0.01										
Sr		0.16	0.03		0.05		0.05		0.06		0.06	
Ta		8.00E-03										
Tc		0.08	2.48E-03		2.64E-03		2.72E-03		2.76E-03		2.76E-03	
Te		0.04	0.08	H	0.12	H	0.14	H	0.15	H	0.15	H
Th		0.16	0.05		0.08		0.09		0.09		0.09	

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Table B-1. In-Tank Sludge Washing of 101-AZ (90%) (3:1 Dilution) Phase I High-Level Waste Feed Envelope D Comparison (Based on 31 g/L Non-Volatile Oxides)

	Envelope D		In-Tank Sludge Washing of 101-AZ (3:1 Dilution)									
Phase I HLW Feed Tank	Minimum	Maximum	0 Washes		1 Wash		2 Washes		3 Washes		4 Washes	
Ti		0.40	0.03		0.04		0.05		0.05		0.05	
Tl		0.14	0.28	H	0.41	H	0.47	H	0.50	H	0.51	H
U		4.20	0.23		0.34		0.39		0.41		0.42	
V		0.01	1.08E-03		1.57E-03		1.81E-03		1.90E-03		1.93E-03	
W		0.07										
Y		0.05										
Zn		0.13	0.02		0.03		0.03		0.03		0.03	
Zr		4.60	1.51		2.19		2.54		2.67		2.71	
Cl		0.10	0.02		0.01		0.01		9.17E-03		8.79E-03	
CO3	0.74	9.30	3.11		2.03		1.48		1.28		1.21	
NO2- } SUM		11.20	5.18		2.63		1.33		0.84		0.69	
NO3- }		11.20	5.92		2.86		1.29		0.72		0.53	
TOC		3.40	0.45		0.56		0.62		0.64		0.65	
CN		0.50										
NH3		0.50										

Radionuclides (Ci/L)												
Am-241		0.04	5.00E-03		7.24E-03		8.38E-03		8.80E-03		8.92E-03	
C-14		2.00E-06	7.30E-06	H	6.02E-06	H	5.35E-06	H	5.12E-06	H	5.02E-06	H
Cm-244		9.30E-04	1.28E-04		1.86E-04		2.15E-04		2.26E-04		2.29E-04	
Co-60		3.00E-03										
Cs-137		3.00	0.19		0.13		0.09		0.08		0.08	
Ba-137		3.00	0.18		0.12		0.09		0.08		0.08	
Eu-154		0.02										
Np-237		2.30E-05										
Pu-239		9.50E-04	9.63E-05		1.40E-04		1.62E-04		1.71E-04		1.73E-04	
Pu-240		2.60E-04										
Pu-241		6.90E-03										
Sr-90		3.10	0.93		1.34		1.55		1.64		1.66	
Y-90		3.10	0.93		1.34		1.55		1.64		1.66	
Tc-99		4.50E-03	4.24E-05		4.51E-05		4.66E-05		4.73E-05		4.72E-05	

[a]Non-volatile oxides excluding sodium and silicon
[b]Predicted HLW Glass Volume at 25 wt% non-volatile oxides excluding sodium and silicon
H = High, L = Low

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Table B-2. In-Tank Sludge Washing of 102-AZ (60%) (2:1 Dilution) Phase I High-Level Waste Feed Envelope D Comparison (Based on 31 g/L Non-Volatile Oxides)

	Envelope D		In-Tank Sludge Washing of 102-AZ (2:1 Dilution)									
Phase I HLW Feed Tank	Minimum	Maximum	0 Washes		1 Wash		2 Washes		3 Washes		4 Washes	
Total Waste Oxides (MT)			133.5		99.0		86.5		82.8		81.5	
Feed Volume (L)			4.31E+06		3.19E+06		2.79E+06		2.67E+06		2.63E+06	
Minimum Glass Volume (m^3)			687.3		262.0		114.1		80.0		79.8	
Waste Oxide Loading[a]			4.4%		10.4%		23.0%		32.3%		32.2%	
RFP Glass Volume (m^3)[b]			121.0		109.0		105.0		103.4		102.8	

Chemicals (g/L)

Ag		0.17	0.03		0.04		0.05		0.05		0.05	
Al	1.30	4.30	2.33		2.96		3.31		3.42		3.46	
Am		0.02	6.80E-04		9.14E-04		1.04E-03		1.09E-03		1.10E-03	
As		0.05	0.02		0.03		0.04		0.04		0.04	
B		0.40	0.02		0.03		0.03		0.03		0.03	
Ba		1.40	0.02		0.03		0.03		0.04		0.04	
Be		0.02	5.35E-04		7.17E-04		8.17E-04		8.54E-04		8.63E-04	
Bi		0.86										
Ca		2.20	0.11		0.15		0.17		0.18		0.18	
Cd		1.40	0.60		0.81		0.92		0.96		0.97	
Ce		0.25	0.03		0.04		0.05		0.05		0.05	
Co		0.14	8.85E-09		1.06E-08		1.16E-08		1.19E-08		1.20E-08	
Cr		0.21	0.18		0.12		0.10		0.09		0.08	
Cs		0.18	7.25E-03		4.81E-03		3.53E-03		3.09E-03		2.96E-03	
Cu		0.15	0.01		0.02		0.02		0.02		0.02	
Dy		8.00E-03										
Eu		5.00E-03										
F		1.10	0.13		0.06		0.03		0.01		9.56E-03	
Fe	2.60	8.90	5.25		7.05		8.03		8.35		8.48	
Gd		3.00E-03										
Hg		0.03										
K		0.41	0.06		0.07		0.07		0.08		0.08	
La		0.80	0.18		0.24		0.27		0.29		0.29	
Li		0.04	1.13E-03		1.51E-03		1.72E-03		1.79E-03		1.81E-03	
Mg		0.65	0.04		0.05		0.06		0.06		0.06	
Mn		2.00	0.12		0.15		0.18		0.18		0.19	
Mo		0.20	1.20E-03		1.37E-03		1.47E-03		1.51E-03		1.52E-03	
Na	2.30	6.00	8.64	H	5.66		4.03		3.47		3.31	
Nb		3.00E-03										
Nd		0.53										
Ni	0.05	0.73	0.35		0.48		0.54		0.57		0.57	
Np		0.03										
P		0.54	0.21		0.26		0.29		0.30		0.30	
Pb		0.34	0.04		0.06		0.07		0.07		0.07	
Pd		0.04										
Pm		0.03										
Pr		0.11										
Pu		0.02	1.10E-03		1.46E-03		1.66E-03		1.72E-03		1.75E-03	
Rb		0.06										
Re		0.03	2.86E-03		3.86E-03		4.37E-03		4.57E-03		4.64E-03	
Rh		0.04	0.02		0.02		0.03		0.03		0.03	
Ru		0.11	7.18E-03		9.62E-03		0.01		0.01		0.01	
S		0.20	0.85	H	0.44	H	0.22	H	0.14		0.12	
Sb		0.26										
Se		0.16	0.04		0.05		0.06		0.06		0.07	
Si		5.80	0.24		0.26		0.27		0.27		0.27	
Sm		0.05										
Sn		0.01										
Sr		0.16	0.02		0.02		0.02		0.03		0.03	
Ta		8.00E-03										
Tc		0.08	1.86E-03		1.90E-03		1.93E-03		1.94E-03		1.94E-03	
Te		0.04	0.01		0.02		0.02		0.02		0.02	
Th		0.16										

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Table B-2. In-Tank Sludge Washing of 102-AZ (60%) (2:1 Dilution) Phase I High-Level Waste Feed Envelope D Comparison (Based on 31 g/L Non-Volatile Oxides)

	Envelope D		In-Tank Sludge Washing of 102-AZ (2:1 Dilution)									
Phase I HLW Feed Tank	Minimum	Maximum	0 Washes		1 Wash		2 Washes		3 Washes		4 Washes	
Ti		0.40	3.07E-03		4.11E-03		4.70E-03		4.90E-03		4.94E-03	
Tl		0.14	2.22E-03		2.97E-03		3.38E-03		3.51E-03		3.56E-03	
U		4.20	0.68		0.73		0.77		0.78		0.78	
V		0.01	1.28E-03		1.71E-03		1.95E-03		2.03E-03		2.05E-03	
W		0.07										
Y		0.05										
Zn		0.13	5.62E-03		7.55E-03		8.60E-03		8.99E-03		9.09E-03	
Zr		4.60	0.72		0.97		1.11		1.16		1.17	
Cl		0.10	5.87E-03		7.89E-03		9.03E-03		9.40E-03		9.51E-03	
CO3	0.74	9.30	6.71		5.78		5.31		5.13		5.10	
NO2- } SUM		11.20	3.68		1.83		0.83		0.49		0.39	
NO3-		11.20	2.99		1.35		0.48		0.19		0.10	
TOC		3.40	0.30		0.23		0.20		0.18		0.18	
CN		0.50										
NH3		0.50										

Radionuclides (Ci/L)												
Am-241		0.04	2.32E-03		3.13E-03		3.56E-03		3.72E-03		3.77E-03	
C-14		2.00E-06	6.82E-06	H	4.56E-06	H	3.38E-06	H	2.98E-06	H	2.86E-06	H
Cm-244		9.30E-04	7.52E-05		1.01E-04		1.15E-04		1.20E-04		1.22E-04	
Co-60		3.00E-03										
Cs-137		3.00	0.16		0.11		0.08		0.07		0.07	
Ba-137		3.00	0.15		0.10		0.07		0.07		0.06	
Eu-154		0.02										
Np-237		2.30E-05										
Pu-239		9.50E-04	6.84E-05		9.05E-05		1.03E-04		1.07E-04		1.08E-04	
Pu-240		2.60E-04										
Pu-241		6.90E-03										
Sr-90		3.10	0.41		0.55		0.63		0.66		0.67	
Y-90		3.10	0.41		0.55		0.63		0.66		0.67	
Tc-99		4.50E-03	3.19E-05		3.25E-05		3.30E-05		3.31E-05		3.32E-05	

[a] Non-volatile oxides excluding sodium and silicon
[b] Predicted HLW Glass Volume at 25 wt% non-volatile oxides excluding sodium and silicon
H = High, L = Low

Table B-3. In-Tank Sludge Washing of 102-AY/106-C (36%/75%) (0.4:1 Dilution) Phase I High-Level Waste Feed Envelope D Comparison (Based on 31 g/L Non-Volatile Oxides)

	Envelope D		In-Tank Sludge Washing of 102-AY/106-C (0.4:1 Dilution)									
Phase I HLW Feed Tank	Minimum	Maximum	0 Washes		1 Wash		2 Washes		3 Washes		4 Washes	
Total Waste Oxides (MT)			424.8		414.5		408.8		400.9		396.4	
Feed Volume (L)			1.37E+07		1.34E+07		1.31E+07		1.29E+07		1.28E+07	
Minimum Glass Volume (m^3)			221.6		209.4		204.3		200.5		197.7	
Waste Oxide Loading[a]			30.8%		32.3%		32.8%		33.2%		33.5%	
RFP Glass Volume (m^3)[b]			273.0		270.5		268.0		266.3		264.9	

Chemicals (g/L)

Ag		0.17	0.06		0.06		0.06		0.06		0.06	
Al	1.30	4.30	2.52		2.57		2.61		2.64		2.67	
Am		0.02	4.26E-05		4.35E-05		4.41E-05		4.46E-05		4.50E-05	
As		0.05										
B		0.40	1.06E-03		1.04E-03		1.02E-03		1.02E-03		1.00E-03	
Ba		1.40	0.29		0.30		0.30		0.31		0.31	
Be		0.02										
Bi		0.86	0.03		0.03		0.03		0.03		0.03	
Ca		2.20	0.75		0.76		0.77		0.78		0.78	
Cd		1.40	0.02		0.02		0.02		0.02		0.02	
Ce		0.25										
Co		0.14	2.79E-04		2.86E-04		2.90E-04		2.93E-04		2.96E-04	
Cr		0.21	0.07		0.07		0.07		0.07		0.07	
Cs		0.18	1.11E-03		1.10E-03		1.08E-03		1.08E-03		1.07E-03	
Cu		0.15	7.42E-03		7.51E-03		7.64E-03		7.73E-03		7.79E-03	
Dy		8.00E-03										
Eu		5.00E-03										
F		1.10	0.02		0.02		0.01		0.01		0.01	
Fe	2.60	8.90	3.35		3.43		3.47		3.52		3.54	
Gd		3.00E-03										
Hg		0.03										
K		0.41	0.09		0.09		0.09		0.09		0.09	
La		0.80	0.02		0.02		0.02		0.02		0.02	
Li		0.04										
Mg		0.65	0.38		0.39		0.39		0.40		0.40	
Mn		2.00	0.14		0.14		0.15		0.15		0.15	
Mo		0.20										
Na	2.30	6.00	6.38	H	6.10	H	5.90		5.75		5.64	
Nb		3.00E-03										
Nd		0.53										
Ni	0.05	0.73	0.07		0.07		0.07		0.07		0.07	
Np		0.03										
P		0.54	0.16		0.16		0.16		0.16		0.16	
Pb		0.34	0.14		0.14		0.14		0.15		0.15	
Pd		0.04	9.34E-03		9.50E-03		9.68E-03		9.74E-03		9.85E-03	
Pm		0.03										
Pr		0.11										
Pu		0.02	3.18E-03		3.23E-03		3.27E-03		3.29E-03		3.31E-03	
Rb		0.06										
Re		0.03										
Rh		0.04										
Ru		0.11										
S		0.20	0.06		0.04		0.03		0.02		0.02	
Sb		0.26										
Se		0.16										
Si		5.80	4.28		4.37		4.42		4.47		4.50	
Sm		0.05										
Sn		0.01										
Sr		0.16	9.94E-03		0.01		0.01		0.01		0.01	
Ta		8.00E-03										
Tc		0.08	7.73E-04		7.59E-04		7.48E-04		7.41E-04		7.35E-04	
Te		0.04										
Th		0.16										

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Table B-3. In-Tank Sludge Washing of 102-AY/106-C (36%/75%) (0.4:1 Dilution) Phase I High-Level Waste Feed Envelope D Comparison (Based on 31 g/L Non-Volatile Oxides)

	Envelope D		In-Tank Sludge Washing of 102-AY/106-C (0.4:1 Dilution)									
Phase I HLW Feed Tank	Minimum	Maximum	0 Washes		1 Wash		2 Washes		3 Washes		4 Washes	
Ti		0.40										
Tl		0.14										
U		4.20	0.09		0.08		0.08		0.07		0.07	
V		0.01										
W		0.07										
Y		0.05										
Zn		0.13	2.69E-03		2.75E-03		2.80E-03		2.83E-03		2.85E-03	
Zr		4.60	0.12		0.13		0.13		0.13		0.13	
Cl		0.10	0.08		0.06		0.04		0.03		0.02	
CO3	0.74	9.30		L		L		L		L		L
NO2- } sum		11.20	0.10		0.09		0.08		0.07		0.07	
NO3-		11.20	0.05		0.04		0.03		0.02		0.01	
TOC		3.40	0.32		0.28		0.25		0.22		0.21	
CN		0.50										
NH3		0.50										

Radionuclides (Ci/L)

Am-241		0.04	1.46E-04		1.49E-04		1.51E-04		1.53E-04		1.54E-04	
C-14		2.00E-06	2.08E-08		2.12E-08		2.16E-08		2.18E-08		2.20E-08	
Cm-244		9.30E-04	3.88E-10		2.83E-10		2.05E-10		1.48E-10		1.06E-10	
Co-60		3.00E-03	8.23E-06		8.40E-06		8.45E-06		8.56E-06		8.64E-06	
Cs-137		3.00	0.02		0.02		0.02		0.02		0.02	
Ba-137		3.00	0.02		0.02		0.02		0.02		0.02	
Eu-154		0.02										
Np-237		2.30E-05										
Pu-239		9.50E-04	1.97E-04		2.00E-04		2.03E-04		2.04E-04		2.05E-04	
Pu-240		2.60E-04										
Pu-241		6.90E-03										
Sr-90		3.10	0.17		0.17		0.17		0.18		0.18	
Y-90		3.10	0.17		0.17		0.17		0.18		0.18	
Tc-99		4.50E-03	1.32E-05		1.30E-05		1.28E-05		1.27E-05		1.26E-05	

[a] Non-volatile oxides excluding sodium and silicon

[b] Predicted HLW Glass Volume at 25 wt% non-volatile oxides excluding sodium and silicon

H = High, L = Low

Table B-4. In-Tank Sludge Washing of 102-AY/106-C (36%/99%) (0.3:1 Dilution) Phase I High-Level Waste Feed Envelope D Comparison (Based on 31 g/L Non-Volatile Oxides)

	Envelope D		In-Tank Sludge Washing of 102-AY/106-C (0.3:1 Dilution)									
Phase I HLW Feed Tank	**Minimum**	**Maximum**	**0 Washes**		**1 Wash**		**2 Washes**		**3 Washes**		**4 Washes**	
Total Waste Oxides (MT)			553.7		542.7		533.9		526.8		520.9	
Feed Volume (L)			1.79E+07		1.75E+07		1.72E+07		1.70E+07		1.68E+07	
Minimum Glass Volume (m^3)			289.2		273.9		268.2		263.6		259.9	
Waste Oxide Loading[a]			30.6%		32.0%		32.5%		32.8%		33.1%	
RFP Glass Volume (m^3)[b]			354.0		350.6		348.7		345.8		344.1	

Chemicals (g/L)

Ag		0.17	0.05		0.05		0.05		0.05		0.05	
Al	1.30	4.30	2.52		2.55		2.60		2.62		2.65	
Am		0.02	3.71E-05		3.75E-05		3.81E-05		3.85E-05		3.88E-05	
As		0.05										
B		0.40	1.07E-03		1.02E-03		1.04E-03		1.03E-03		1.02E-03	
Ba		1.40	0.29		0.30		0.30		0.31		0.31	
Be		0.02										
Bi		0.86	0.03		0.03		0.03		0.03		0.03	
Ca		2.20	0.75		0.75		0.77		0.77		0.78	
Cd		1.40	0.02		0.02		0.02		0.02		0.02	
Ce		0.25										
Co		0.14	2.83E-04		2.87E-04		2.92E-04		2.95E-04		2.98E-04	
Cr		0.21	0.07		0.07		0.07		0.07		0.07	
Cs		0.18	1.11E-03		1.08E-03		1.09E-03		1.09E-03		1.09E-03	
Cu		0.15	7.55E-03		7.62E-03		7.75E-03		7.79E-03		7.87E-03	
Dy		8.00E-03										
Eu		5.00E-03										
F		1.10	0.02		0.01		0.01		0.01		0.01	
Fe	2.60	8.90	3.31		3.36		3.41		3.45		3.48	
Gd		3.00E-03										
Hg		0.03										
K		0.41	0.09		0.09		0.09		0.09		0.09	
La		0.80	0.01		0.01		0.01		0.01		0.01	
Li		0.04										
Mg		0.65	0.39		0.39		0.40		0.40		0.40	
Mn		2.00	0.14		0.14		0.14		0.14		0.14	
Mo		0.20										
Na	2.30	6.00	6.39	H	5.91		6.00	H	5.87		5.77	
Nb		3.00E-03										
Nd		0.53										
Ni	0.05	0.73	0.07		0.07		0.07		0.07		0.07	
Np		0.03										
P		0.54	0.16		0.16		0.16		0.16		0.16	
Pb		0.34	0.14		0.14		0.14		0.15		0.15	
Pd		0.04	9.41E-03		9.54E-03		9.70E-03		9.77E-03		9.88E-03	
Pm		0.03										
Pr		0.11										
Pu		0.02	3.15E-03		3.17E-03		3.22E-03		3.24E-03		3.26E-03	
Rb		0.06										
Re		0.03										
Rh		0.04										
Ru		0.11										
S		0.20	0.06		0.04		0.04		0.03		0.02	
Sb		0.26										
Se		0.16										
Si		5.80	4.31		4.35		4.42		4.46		4.49	
Sm		0.05										
Sn		0.01										
Sr		0.16	9.31E-03		9.44E-03		9.59E-03		9.72E-03		9.77E-03	
Ta		8.00E-03										
Tc		0.08	7.79E-04		7.47E-04		7.59E-04		7.55E-04		7.52E-04	
Te		0.04										
Th		0.16										

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Table B-4. In-Tank Sludge Washing of 102-AY/106-C (36%/99%) (0.3:1 Dilution) Phase I High-Level Waste Feed Envelope D Comparison (Based on 31 g/L Non-Volatile Oxides)

	Envelope D		In-Tank Sludge Washing of 102-AY/106-C (0.3:1 Dilution)									
Phase I HLW Feed Tank	Minimum	Maximum	0 Washes		1 Wash		2 Washes		3 Washes		4 Washes	
Ti		0.40										
Tl		0.14										
U		4.20	0.09		0.07		0.07		0.07		0.06	
V		0.01										
W		0.07										
Y		0.05										
Zn		0.13	2.73E-03		2.78E-03		2.81E-03		2.84E-03		2.86E-03	
Zr		4.60	0.13		0.13		0.13		0.13		0.13	
Cl		0.10	0.08		0.05		0.05		0.04		0.03	
CO3	0.74	9.30		L		L		L		L		L
NO2- } SUM		11.20	0.09		0.08		0.08		0.08		0.07	
NO3-		11.20	0.05		0.03		0.03		0.02		0.02	
TOC		3.40	0.29		0.22		0.22		0.20		0.18	
CN		0.50										
NH3		0.50										

Radionuclides (Ci/L)

Am-241		0.04	1.27E-04		1.29E-04		1.31E-04		1.32E-04		1.33E-04	
C-14		2.00E-06	1.99E-08		2.01E-08		2.04E-08		2.07E-08		2.08E-08	
Cm-244		9.30E-04	3.80E-10		2.28E-10		2.32E-10		1.81E-10		1.40E-10	
Co-60		3.00E-03	8.30E-06		8.36E-06		8.50E-06		8.59E-06		8.62E-06	
Cs-137		3.00	0.02		0.02		0.02		0.02		0.02	
Ba-137		3.00	0.02		0.02		0.02		0.02		0.02	
Eu-154		0.02										
Np-237		2.30E-05										
Pu-239		9.50E-04	1.95E-04		1.96E-04		1.99E-04		2.01E-04		2.02E-04	
Pu-240		2.60E-04										
Pu-241		6.90E-03										
Sr-90		3.10	0.16		0.16		0.16		0.16		0.16	
Y-90		3.10	0.16		0.16		0.16		0.16		0.16	
Tc-99		4.50E-03	1.33E-05		1.28E-05		1.30E-05		1.29E-05		1.28E-05	

[a] Non-volatile oxides excluding sodium and silicon

[b] Predicted HLW Glass Volume at 25 wt% non-volatile oxides excluding sodium and silicon

H = High, L = Low

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Table B-5. High-Level Waste Feed Physical Properties.

Property	Design Range
Total solids (wt %) dried at approximately 100°C	2.5-13
Total equivalent non-volatile oxides (g/l)	25-100
Slurry density (g/ml)	1.02-1.10
Settled solids (vol %)	7-95
Apparent viscosity (cP at 25°C)	
at 10 s^{-1} (50 rpm agitator)	6-94
at 25 s^{-1} (130 rpm agitator)	3-50
at 183 s^{-1}	1-50
Yield stress, (dyne/cm^2)	1-150
Settled solids shear strength after 2 days (dyne/cm^2)	20-200
Heat capacity (cal/g-°C)	0.79-0.97
pH	>10

CHEMICAL COMPOSITION LIMITS

Reduction of HWVP Glass Based Feed Limits

Design basis feed limits previously established for the Hanford Waste Vitrification Plant (HWVP) were used as a starting point in developing feed limits in the RFP. A number of HWVP feed limits were originally established based on estimated glass composition limits and a target 25 wt% waste loading in glass. Higher waste loading is currently being targeted, and it is known that a number of the HWVP glass-based feed limits are excessively high compared to any actual feeds expected to be processed by the HLW plant. A group of feed components was therefore reduced from the HWVP glass-based limits as follows: CaO, CdO, MnO_2, NiO, TiO_2, U_3O_8, ZrO_2, and F all reduced to 50 percent of the HWVP feed limit. Other components and percentage reduction from HWVP basis are: BaO (75 percent), MoO_3 (87.5 percent), noble metals (30 percent), Sulfur (25 percent reduction in operating limit only) and Cr_2O_3 (50 percent reduction in operating limit only). For all components that were reduced compared to the HWVP design limits, core sample analyses, and other sources of information were consulted to assure that expected feeds are well within the reduced limits.

Noble Metals, Tellurium, and Silver

These values are based on a review of core sample data and estimates of what is expected based on fission yield. Estimated concentrations for the maximum waste (from 101-AZ with no credit for blending) are about 30 percent lower than the maximum values. Some additional reduction in the design basis may be considered in the future if a decision is made to take credit for blending the 101-AZ waste with lower concentration waste or to reduce the contingency margin between the best estimate values and the design limits. Potential further reductions would likely be in the 20 to 40 percent range.

The tellurium (Te) limit remains about 40 percent above the HWVP design basis value. The design basis Te value is somewhat of an anomaly in that it does not bound all data in existing databases (e.g., core sample and tank characterization report data). The problem is that some of the existing databases include data that are either below the detection limit or approximately at the detection limit and therefore has a high uncertainty. To develop a more realistic value, data on fission yields were used to estimate the Te quantity expected in the AZ tanks and ratio of Te to Ru. An additional contingency factor of about 25 percent was added to the Te estimate above that applied to the other noble metals in defining the recommended Te feed limit, so there is good confidence that actual feed will not exceed the proposed limit. There also may be some room to reduce the Te limit further if needed in the future if better feed samples and analytical data become available.

Review of data on silver content of Phase I feeds revealed significant differences between data sources. Silver levels were also surprisingly high. The recommended value is on the high end of the uncertainty range and may be at a level that results in impacts to the vitrification process. This component should be given a high priority in future characterization work. The recommended feed specification limit bounds all core sample analyses except for 102-AY. It will be necessary to blend feed from 102-AY with lower silver feeds to stay within the feed specification.

Thallium

In general, the design basis ranges have been found to bound all other data sources that have been identified. One exception is thallium (Tl). High Tl values in the tank characterization reports and some TWRS databases results from high "less than detection limit" values being used as actual analyses. There is no known source of thallium near this level and the estimated concentrations in the sludge are thought to be high.

Mercury

Analyses of a waste sample from 106-C for mercury were performed in 1988 (McCown 1988). Mercury was detected using both the EP Toxicity test, and atomic absorption analysis of acid digested sample. Based on these tests, it appears essentially certain that mercury is present in the 106-C waste. However, actual concentrations measures varied significantly between different analyses. The recommended maximum design basis concentration bounds all identified analyses. Additional analysis is needed to refine the expected mercury content. The actual value may be 50 percent to 90+ percent lower than the currently recommended design maximum.

RADIONUCLIDE LIMITS

Two primary sources were used to develop radionuclide limits in the RFP:

1. The HWVP design basis *Reference Feed Maximum Radionuclide Composition*, HWV-SD-HWV-DP-001, Rev. 6, Table 13-6. Note that this table requires lower isotope limits for general design purposes than the HWVP shielding source term in Table 12-1 of HWV-SD-HWV-DP-001, Rev. 6.

2. A recent recommendation developed by WHC based on Origen 2 calculations (via the RADNUC 95 code) for pretreated waste from tank 101-AZ with upward adjustment factors for conservatism, processing scenarios that could increase concentrations, core sample results, and consideration of other potential feed sources.

For most isotopes, the higher of the two data sources was used as the RFP value. There were a few exceptions where the RADNUC 95 estimates were determined to have excessive conservatism, and a lower value was therefore used (but in all cases greater than or equal to the HWVP limit).

Most changes were made by starting with the HWVP values, and allowing 10.5 years additional decay time. The decayed HWVP value was then compared to the RADNUC 95 estimates and core sample data (when available). With a few exceptions discussed below, a recommended design basis value was then selected that bounded all three values. Based on this method, a number of isotopes that were relatively high in the HWVP design basis were reduced to levels expected to be of minor or negligible importance. Note that the 10.5 years of additional decay applied to the HWVP values, is conservative, i.e., actual decay time between reactor discharge and waste processing in the HLW plant will be more than 10.5 years longer than assumed when the HWVP design basis feed composition was developed.

Cesium-137

Recommended ^{137}Cs limit of 3 Ci/L at 31 g total oxide/L is based on the HWVP Table 13-6 maximum reduced by an additional 10.5 years decay. The level will allow processing of feeds with Cs from ion exchange blended back in, however. A large spike of accumulated Cs in a small quantity of HLW sludge could not be accommodated. The HWVP shielding basis and the WHC recommendation were based on a "spike" scenario and were therefore much higher than the recommended value (approximately 10 X).

Strontium-90

The recommended design basis value of 3.1 Ci/L is equal to the HWVP design basis value. This value is about 25 percent above the average of the two most recent core sample analyses for 101-AZ (after allowing for decay to mid-2002) and is about 7 percent above the highest core sample analysis. The recommended value is also about 50 percent higher than Sr levels currently carried in the TWRS process flowsheet for 101-AZ. Overall, this therefore appears to be a moderately conservative design basis value without taking credit for any blending of 101-AZ. If credit is taken for blending of 101-AZ with 106-C, an additional reduction of about half or possibly more could be justified. At the recommended revised isotope levels, ^{90}Sr and ^{137}Cs produce nearly all decay heat. The recommended levels are within the preliminary canister storage facility limit of 1,000 W per canister for any reasonably expected glass waste loadings.

Plutonium

Plutonium isotopic limits were calculated starting with the chemical plutonium limit of .06 wt% oxide, or .016 g/L at 31 G oxide/L. Isotopic ratios were then calculated based on the Origen 2 predictions reported by WHC. In all cases the resulting recommended concentrations were greater than the HWVP limits.

REFERENCES

Bacon, R. F., 1995, *Double-Shell Tank Waste Consolidation and Retrieval Planning Base Case*, 75510-95-017 (August 30, 1995), Westinghouse Hanford Company, Richland, Washington.

DOE, 1995, *TWRS Privatization Request for Proposals - Draft*, DE-RP06-96RL13308, U.S. Department of Energy, Richland Operations, Richland, Washington.

McCown, J. J., 1988, *Final Report on Single-Shell Tank Sample (241-C-106)*, memo to R. S. Wegeng (August 31, 1988), Pacific Northwest Laboratory, Richland, Washington.

APPENDIX C

PHASE I HIGH-LEVEL WASTE PRETREATMENT FLOWSHEETS

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APPENDIX C

PHASE I HIGH-LEVEL WASTE PRETREATMENT FLOWSHEETS

The following tables contain the detailed material balances referenced in Chapter 4.0. The feed streams (#1) in each of the tables represent the retrievable masses of components from the tank inventories. The total tank inventories are presented in Appendix A. Stream #21 represents an estimate of the Intermediate Waste Products (IWP) resulting from LAW services, taken from Certa 1996. For the IWP streams, it is assumed that the total is equally distributed between each of the 14 HLW batches. In reality, the IWP batch concentrations will vary, depending on how the LAW and HLW processing schedules line up.

The data from these tables are to be integrated into the next revision of the TWRS baseline flowsheets, Operational Waste Volume Projections, projected tank inventories, and other related Phase I activities. Any relevant conclusions from these other activities will be integrated into a future revision of this document.

Table C-1. Phase I In-Tank Sludge Washing of Double-Shell Tank 241-AZ-101. (90% Retrieval)

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STREAM NAME	1	2	3	4	5	6	7	8	9	10
LIQUID COMPONENTS										
Total Mass Flow (kg) Volume (L) Specific Gravity	3.93E+06 3.12E+06 1.26E+00	2.43E+05 2.43E+05 1.00E+00	3.68E+06 2.88E+06 1.28E+00	3.68E+06 2.88E+06 1.28E+00	3.21E+06 2.51E+06 1.28E+00	4.71E+05 3.68E+05 1.28E+00	9.97E+05 9.94E+05 1.00E+00	1.47E+06 1.36E+06 1.08E+00	1.02E+06 9.49E+05 1.08E+00	4.44E+05 4.12E+05 1.08E+00
Radionuclides (Ci)										
Am-241 C-14 Cm-244 Cs-137 Ba-137 Eu-154 Np-237 Pu-239 Pu-240 Pu-241 Sr-90 Y-90 Tc-99 Total Curies	8.21E+02 1.79E+02 1.82E+01 5.78E+06 5.50E+06 1.03E+00 2.70E+05 2.70E+05 6.41E+02 1.18E+07		8.21E+02 1.79E+02 1.82E+01 5.78E+06 5.50E+06 1.03E+00 2.70E+05 2.70E+05 6.41E+02 1.18E+07	8.21E+02 1.79E+02 1.82E+01 5.78E+06 5.50E+06 1.03E+00 2.70E+05 2.70E+05 6.41E+02 1.18E+07	7.16E+02 1.56E+02 1.59E+01 5.05E+06 4.79E+06 8.97E-01 2.36E+05 2.36E+05 5.59E+02 1.03E+07	1.05E+02 2.29E+01 2.33E+00 7.39E+05 7.02E+05 1.31E-01 3.46E+04 3.46E+04 8.19E+01 1.51E+06		1.05E+02 2.29E+01 2.33E+00 7.39E+05 7.02E+05 1.31E-01 3.46E+04 3.46E+04 8.19E+01 1.51E+06	7.31E+01 1.60E+01 1.62E+00 5.15E+05 4.89E+05 9.16E-02 2.41E+04 2.41E+04 5.71E+01 1.05E+06	3.18E+01 6.97E+00 7.04E-01 2.24E+05 2.13E+05 3.98E-02 1.05E+04 1.05E+04 2.48E+01 4.57E+05
Chemicals (kg)										
Ag+ Am+3 As+5 B+3 Ba+2 Be+2 Bi+3 Ca+2 Cd+2 Ce+3 Cm+3 Co+3 Cs+ Cu+2 Eu+3 Fe+3 Hg+2 K+ La+3 Li+ Mg+2 Mn+4 Mo+6 Na+ Ni+3 Np+4 Pb+4 Pu+4 Re+7 Rh+3 Ru+3 Sb+5 Se+6 Si+4 Sn+4 Sr+2 Te+6 Th+4 Ti+4 Tl+3 UO2+2 V+5 W+6 Zn+2 Zr+4 Al(OH)4- Cl- CO3-2 Cr(OH)4- F- I- NO2- NO3- OH- PO4-3 SO4-2 TcO4- H2O Organic Carbon ZrO2:2H2O Hg Cl2 CO2 F2 I2 N2 NO O2 NH3	2.39E-01 2.51E+00 8.53E-01 9.07E-02 1.03E-03 1.52E+00 5.59E-02 2.30E+00 2.25E-04 7.12E-04 2.60E+02 1.98E-01 4.60E-01 6.48E+02 1.73E-01 4.28E-01 8.24E-02 4.21E-02 1.31E+01 3.31E+05 1.21E-01 9.07E-01 1.66E-02 2.13E-01 1.53E+00 7.29E-01 1.98E+00 3.71E+00 5.37E+01 9.36E+00 3.97E+00 3.21E+00 1.14E+00 3.97E+01 8.81E+00 1.37E-01 2.03E-01 1.15E+05 5.79E+02 9.68E+04 4.52E+02 5.63E+03 3.25E-01 1.93E+05 2.24E+05 9.42E+03 4.49E+03 5.51E+04 6.24E+01 2.89E+06 3.42E+03 1.23E-01	2.43E+05	2.39E-01 2.51E+00 8.53E-01 9.07E-02 1.03E-03 1.52E+00 5.59E-02 2.30E+00 2.25E-04 7.12E-04 2.60E+02 1.98E-01 4.60E-01 6.48E+02 1.73E-01 4.28E-01 8.24E-02 4.21E-02 1.31E+01 3.31E+05 1.21E-01 9.07E-01 1.66E-02 2.13E-01 1.53E+00 7.29E-01 1.98E+00 3.71E+00 5.37E+01 9.36E+00 3.97E+00 3.21E+00 1.14E+00 3.97E+01 8.81E+00 1.37E-01 2.03E-01 1.15E+05 5.79E+02 9.68E+04 4.52E+02 5.63E+03 3.25E-01 1.93E+05 2.24E+05 9.42E+03 4.49E+03 5.51E+04 6.24E+01 2.64E+06 3.42E+03 1.23E-01	2.39E-01 2.51E+00 8.53E-01 9.07E-02 1.03E-03 1.52E+00 5.59E-02 2.30E+00 2.25E-04 7.12E-04 2.60E+02 1.98E-01 4.60E-01 6.48E+02 1.73E-01 4.28E-01 8.24E-02 4.21E-02 1.31E+01 3.31E+05 1.21E-01 9.07E-01 1.66E-02 2.13E-01 1.53E+00 7.29E-01 1.98E+00 3.71E+00 5.37E+01 9.36E+00 3.97E+00 3.21E+00 1.14E+00 3.97E+01 8.81E+00 1.37E-01 2.03E-01 1.15E+05 5.79E+02 9.68E+04 4.52E+02 5.63E+03 3.25E-01 1.93E+05 2.24E+05 9.42E+03 4.49E+03 5.51E+04 6.24E+01 2.64E+06 3.42E+03 1.23E-01	2.09E-01 2.19E+00 7.44E-01 7.91E-02 8.97E-04 1.33E+00 4.88E-02 2.01E+00 1.96E-04 6.21E-04 2.24E+02 1.73E-01 4.01E-01 5.65E+02 1.51E-01 3.73E-01 7.19E-02 3.67E-02 1.14E+01 2.89E+05 1.06E-01 7.91E-01 1.45E-02 1.86E-01 1.33E+00 6.36E-01 1.73E+00 3.23E+00 4.69E+01 8.16E+00 3.46E+00 2.80E+00 9.95E-01 3.46E+01 7.69E+00 1.19E-01 1.77E-01 1.00E+05 5.05E+02 8.44E+04 3.94E+02 4.91E+03 2.83E-01 1.68E+05 1.95E+05 8.21E+03 3.92E+03 4.81E+04 5.44E+01 2.31E+06 2.98E+03 1.07E-01	3.06E-02 3.21E-01 1.09E-01 1.16E-02 1.31E-04 1.94E-01 7.14E-03 2.94E-01 2.87E-05 9.10E-05 3.32E+01 2.53E-02 5.87E-02 8.28E+01 2.21E-02 5.48E-02 1.05E-02 5.38E-03 1.67E+00 4.23E+04 1.55E-02 1.16E-01 2.12E-03 2.73E-02 1.95E-01 9.32E-02 2.53E-01 4.74E-01 6.87E+00 1.20E+00 5.07E-01 4.10E-01 1.46E-01 5.07E+00 1.13E+00 1.74E-02 2.59E-02 1.47E+04 7.40E+01 1.24E+04 5.83E+01 7.20E+02 4.15E-02 2.46E+04 2.86E+04 1.20E+03 5.74E+02 7.04E+03 7.97E+00 3.38E+05 4.37E+02 1.57E-02	2.51E+03 4.57E+02 1.69E+03 9.92E+05	3.06E-02 3.21E-01 1.09E-01 1.16E-02 1.31E-04 1.94E-01 7.14E-03 2.94E-01 2.87E-05 9.10E-05 3.32E+01 2.53E-02 5.87E-02 8.28E+01 2.21E-02 5.48E-02 1.05E-02 5.38E-03 1.67E+00 4.48E+04 1.55E-02 1.16E-01 2.12E-03 2.73E-02 1.95E-01 9.32E-02 2.53E-01 4.74E-01 6.87E+00 1.20E+00 5.07E-01 4.10E-01 1.46E-01 5.07E+00 1.13E+00 1.74E-02 2.59E-02 1.47E+04 7.40E+01 1.24E+04 5.83E+01 7.20E+02 4.15E-02 2.51E+04 2.86E+04 2.89E+03 5.74E+02 7.04E+03 7.97E+00 1.33E+06 4.37E+02 1.57E-02	2.13E-02 2.24E-01 7.60E-02 8.08E-03 9.16E-05 1.36E-01 4.98E-03 2.05E-01 2.00E-05 6.34E-05 2.31E+01 1.76E-02 4.09E-02 5.77E+01 1.54E-02 3.81E-02 7.34E-03 3.75E-03 1.16E+00 3.12E+04 1.08E-02 8.08E-02 1.48E-03 1.90E-02 1.36E-01 6.50E-02 1.76E-01 3.30E-01 4.79E+00 8.34E-01 3.53E-01 2.86E-01 1.02E-01 3.53E+00 7.85E-01 1.22E-02 1.81E-02 1.02E+04 5.16E+01 8.62E+03 4.06E+01 5.02E+02 2.89E-02 1.75E+04 1.99E+04 2.02E+03 4.00E+02 4.91E+03 5.54E+00 9.27E+05 3.05E+02 1.09E-02	9.26E-03 9.73E-02 3.30E-02 3.51E-03 3.98E-05 5.88E-02 2.16E-03 8.89E-02 8.69E-06 2.75E-05 1.00E+01 7.65E-03 1.78E-02 2.51E+01 6.69E-03 1.65E-02 3.19E-03 1.63E-03 5.05E-01 1.36E+04 4.68E-03 3.51E-02 6.42E-04 8.25E-03 5.92E-02 2.82E-02 7.65E-02 1.43E-01 2.08E+00 3.62E-01 1.53E-01 1.24E-01 4.41E-02 1.53E+00 3.41E-01 5.28E-03 7.85E-03 4.45E+03 2.24E+01 3.74E+03 1.76E+01 2.18E+02 1.26E-02 7.59E+03 8.64E+03 8.76E+02 1.74E+02 2.13E+03 2.41E+00 4.03E+05 1.32E+02 4.75E-03

STREAM NAME	1	2	3	4	5	6	7	8	9	10
SOLID COMPONENTS										
Total Mass Flow (kg)	7.79E+04		7.79E+04	7.79E+04	2.57E+02	7.77E+04		7.77E+04	2.56E+02	7.74E+04
Radionuclides (Ci)										
Am-241	2.51E+04		2.51E+04	2.51E+04	8.29E+01	2.51E+04		2.51E+04	8.27E+01	2.50E+04
C-14	1.40E+01		1.40E+01	1.40E+01	4.60E-02	1.39E+01		1.39E+01	4.59E-02	1.39E+01
Cm-244	6.45E+02		6.45E+02	6.45E+02	2.13E+00	6.43E+02		6.43E+02	2.12E+00	6.41E+02
Cs-137	2.16E+05		2.16E+05	2.16E+05	7.14E+02	2.16E+05		2.16E+05	7.11E+02	2.15E+05
Ba-137	2.05E+05		2.05E+05	2.05E+05	6.78E+02	2.05E+05		2.05E+05	6.76E+02	2.04E+05
Eu-154										
Np-237										
Pu-239	4.87E+02		4.87E+02	4.87E+02	1.61E+00	4.85E+02		4.85E+02	1.60E+00	4.84E+02
Pu-240										
Pu-241										
Sr-90	4.67E+06		4.67E+06	4.67E+06	1.54E+04	4.65E+06		4.65E+06	1.54E+04	4.64E+06
Y-90	4.67E+06		4.67E+06	4.67E+06	1.54E+04	4.65E+06		4.65E+06	1.54E+04	4.64E+06
Tc-99	1.32E+02		1.32E+02	1.32E+02	4.36E-01	1.32E+02		1.32E+02	4.35E-01	1.31E+02
Total Curies	9.78E+06		9.78E+06	9.78E+06	3.23E+04	9.75E+06		9.75E+06	3.22E+04	9.72E+06
Chemicals (kg)										
Ag+	2.13E+02		2.13E+02	2.13E+02	7.01E-01	2.12E+02		2.12E+02	6.99E-01	2.11E+02
Al+3	1.05E+04		1.05E+04	1.05E+04	3.45E+01	1.04E+04		1.04E+04	3.44E+01	1.04E+04
Am+3	7.33E+00		7.33E+00	7.33E+00	2.42E-02	7.30E+00		7.30E+00	2.41E-02	7.26E+00
As+5	1.21E+02		1.21E+02	1.21E+02	3.99E-01	1.21E+02		1.21E+02	3.98E-01	1.20E+02
B+3	6.39E+01		6.39E+01	6.39E+01	2.11E-01	6.37E+01		6.37E+01	2.10E-01	6.33E+01
Ba+2	1.57E+02		1.57E+02	1.57E+02	5.19E-01	1.57E+02		1.57E+02	5.17E-01	1.56E+02
Be+2	3.79E+00		3.79E+00	3.79E+00	1.25E-02	3.78E+00		3.78E+00	1.25E-02	3.76E+00
Ca+2	5.26E+02		5.26E+02	5.26E+02	1.74E+00	5.24E+02		5.24E+02	1.73E+00	5.21E+02
Cd+2	1.23E+03		1.23E+03	1.23E+03	4.05E+00	1.22E+03		1.22E+03	4.04E+00	1.22E+03
Ce+3	2.62E+02		2.62E+02	2.62E+02	8.64E-01	2.61E+02		2.61E+02	8.61E-01	2.60E+02
Cm+3	7.97E-03		7.97E-03	7.97E-03	2.63E-05	7.94E-03		7.94E-03	2.62E-05	7.91E-03
Co+3	7.52E-04		7.52E-04	7.52E-04	2.48E-06	7.49E-04		7.49E-04	2.47E-06	7.47E-04
Cr+3	1.71E+02		1.71E+02	1.71E+02	5.65E-01	1.71E+02		1.71E+02	5.63E-01	1.70E+02
Cs+	9.70E+00		9.70E+00	9.70E+00	3.20E-02	9.67E+00		9.67E+00	3.19E-02	9.64E+00
Cu+2	9.33E+01		9.33E+01	9.33E+01	3.08E-01	9.30E+01		9.30E+01	3.07E-01	9.27E+01
Fe+3	2.17E+04		2.17E+04	2.17E+04	7.16E+01	2.16E+04		2.16E+04	7.13E+01	2.15E+04
K+	6.64E+02		6.64E+02	6.64E+02	2.19E+00	6.62E+02		6.62E+02	2.19E+00	6.60E+02
La+3	8.20E+02		8.20E+02	8.20E+02	2.71E+00	8.17E+02		8.17E+02	2.70E+00	8.15E+02
Li+	1.54E+01		1.54E+01	1.54E+01	5.08E-02	1.53E+01		1.53E+01	5.06E-02	1.53E+01
Mg+2	1.32E+02		1.32E+02	1.32E+02	4.36E-01	1.32E+02		1.32E+02	4.35E-01	1.31E+02
Mn+4	6.55E+02		6.55E+02	6.55E+02	2.16E+00	6.53E+02		6.53E+02	2.15E+00	6.51E+02
Mo+6	1.18E+01		1.18E+01	1.18E+01	3.88E-02	1.17E+01		1.17E+01	3.87E-02	1.17E+01
Na+	3.51E+03		3.51E+03	3.51E+03	1.16E+01	3.50E+03		3.50E+03	1.15E+01	3.49E+03
Ni+3	9.59E+02		9.59E+02	9.59E+02	3.17E+00	9.56E+02		9.56E+02	3.15E+00	9.53E+02
Pb+4	1.14E+02		1.14E+02	1.14E+02	3.76E-01	1.14E+02		1.14E+02	3.75E-01	1.13E+02
Pu+4	7.85E+00		7.85E+00	7.85E+00	2.59E-02	7.83E+00		7.83E+00	2.58E-02	7.80E+00
Re+7	1.23E+01		1.23E+01	1.23E+01	4.05E-02	1.22E+01		1.22E+01	4.04E-02	1.22E+01
Rh+3	9.33E+01		9.33E+01	9.33E+01	3.08E-01	9.30E+01		9.30E+01	3.07E-01	9.27E+01
Ru+3	1.92E+02		1.92E+02	1.92E+02	6.33E-01	1.91E+02		1.91E+02	6.31E-01	1.91E+02
Sb+5	5.88E+02		5.88E+02	5.88E+02	1.94E+00	5.86E+02		5.86E+02	1.93E+00	5.85E+02
Se+6	3.86E+02		3.86E+02	3.86E+02	1.27E+00	3.85E+02		3.85E+02	1.27E+00	3.84E+02
Si+4	1.22E+03		1.22E+03	1.22E+03	4.02E+00	1.21E+03		1.21E+03	4.01E+00	1.21E+03
Sr+2	1.62E+02		1.62E+02	1.62E+02	5.34E-01	1.61E+02		1.61E+02	5.32E-01	1.61E+02
Te+6	4.15E+02		4.15E+02	4.15E+02	1.37E+00	4.13E+02		4.13E+02	1.36E+00	4.12E+02
Th+4	2.68E+02		2.68E+02	2.68E+02	8.78E-01	2.66E+02		2.65E+02	8.75E-01	2.64E+02
Ti+4	1.43E+02		1.43E+02	1.43E+02	4.70E-01	1.42E+02		1.42E+02	4.69E-01	1.42E+02
Tl+3	1.43E+03		1.43E+03	1.43E+03	4.70E+00	1.42E+03		1.42E+03	4.69E+00	1.42E+03
UO2+2	1.37E+03		1.37E+03	1.37E+03	4.42E+00	1.37E+03		1.37E+03	4.41E+00	1.36E+03
V+5	5.44E+00		5.44E+00	5.44E+00	1.80E-02	5.43E+00		5.43E+00	1.79E-02	5.41E+00
Zn+2	8.73E+01		8.73E+01	8.73E+01	2.88E-01	8.70E+01		8.70E+01	2.87E-01	8.67E+01
Cl-	2.41E+01		2.41E+01	2.41E+01	7.98E-02	2.40E+01		2.40E+01	7.93E-02	2.40E+01
CO3-2	3.30E+03		3.30E+03	3.30E+03	1.09E+01	3.29E+03		3.29E+03	1.08E+01	3.28E+03
F-	1.33E+02		1.33E+02	1.33E+02	4.39E-01	1.33E+02		1.33E+02	4.38E-01	1.32E+02
I-	2.25E-01		2.25E-01	2.25E-01	7.41E-04	2.24E-01		2.24E-01	7.39E-04	2.23E-01
NO2-	1.52E+03		1.52E+03	1.52E+03	5.02E+00	1.52E+03		1.52E+03	5.00E+00	1.51E+03
NO3-	1.24E+03		1.24E+03	1.24E+03	4.11E+00	1.24E+03		1.24E+03	4.08E+00	1.24E+03
OH-	5.31E+03		5.31E+03	5.31E+03	1.75E+01	5.29E+03		5.29E+03	1.75E+01	5.27E+03
PO4-3	2.07E+03		2.07E+03	2.07E+03	6.84E+00	2.07E+03		2.07E+03	6.82E+00	2.06E+03
SO4-2	9.68E+02		9.68E+02	9.68E+02	3.19E+00	9.66E+02		9.66E+02	3.18E+00	9.61E+02
TcO4-	1.29E+01		1.29E+01	1.29E+01	4.25E-02	1.28E+01		1.28E+01	4.25E-02	1.28E+01
MnO2										
Organic Carbon	1.81E+03		1.81E+03	1.81E+03	5.99E+00	1.81E+03		1.81E+03	5.97E+00	1.80E+03
ZrO2:2H2O	1.33E+04		1.33E+04	1.33E+04	4.39E+01	1.33E+04		1.33E+04	4.38E+01	1.32E+04
Ag2O										
Al2O3										

STREAM NAME	1	2	3	4	5	6	7	8	9	10
SOLID COMPONENTS										
Chemicals Continued (kg)										
Am2O3										
As2O5										
B2O3										
BaO										
BeO										
Bi2O3										
CaO										
CdO										
Ce2O3										
Cm2O3										
Co2O3										
Cr2O3										
Cs2O										
CuO										
Eu2O3										
Fe2O3										
K2O										
La2O3										
Li2O										
MgO										
MoO3										
Na2O										
Ni2O3										
NpO2										
P2O5										
PbO2										
PuO2										
Re2O7										
Rh2O3										
Ru2O3										
Sb2O5										
SeO3										
SiO2										
SO3										
SrO										
Tc2O7										
TeO3										
ThO2										
TiO2										
Tl2O3										
UO3										
V2O5										
WO3										
ZnO										
ZrO2										

STREAM NAME	11	12	13	14	15	16	17	18	19	20
LIQUID COMPONENTS										
Total Mass Flow (kg)	9.97E+05	1.44E+06	1.00E+06	4.37E+05	9.97E+05	1.43E+06	1.00E+06	4.34E+05	4.45E+05	8.79E+05
Volume (L)	9.94E+05	1.41E+06	9.80E+05	4.24E+05	9.94E+05	1.42E+06	9.90E+05	4.30E+05	4.45E+05	8.75E+05
Specific Gravity	1.00E+00	1.03E+00	1.03E+00	1.03E+00	1.00E+00	1.01E+00	1.01E+00	1.01E+00	1.00E+00	1.01E+00
Radionuclides (Ci)										
Am-241		3.18E+01	2.21E+01	9.62E+00		9.62E+00	6.71E+00	2.91E+00		2.91E+00
C-14		6.95E+00	4.83E+00	2.10E+00		2.10E+00	1.47E+00	6.36E-01		6.36E-01
Cm-244		7.04E-01	4.91E-01	2.13E-01		2.13E-01	1.49E-01	6.45E-02		6.45E-02
Cs-137		2.24E+05	1.56E+05	6.78E+04		6.78E+04	4.73E+04	2.05E+04		2.05E+04
Ba-137		2.13E+05	1.48E+05	6.44E+04		6.44E+04	4.49E+04	1.95E+04		1.95E+04
Eu-154										
Np-237										
Pu-239		3.98E-02	2.77E-02	1.21E-02		1.21E-02	8.41E-03	3.65E-03		3.65E-03
Pu-240										
Pu-241										
Sr-90		1.05E+04	7.29E+03	3.17E+03		3.17E+03	2.21E+03	9.59E+02		9.59E+02
Y-90		1.05E+04	7.29E+03	3.17E+03		3.17E+03	2.21E+03	9.59E+02		9.59E+02
Tc-99		2.48E+01	1.73E+01	7.51E+00		7.51E+00	5.24E+00	2.27E+00		2.27E+00
Total Curies		4.57E+05	3.19E+05	1.39E+05		1.39E+05	9.66E+04	4.19E+04		4.19E+04
Chemicals (kg)										
Ag+										
Am+3		9.26E-03	6.45E-03	2.81E-03		2.81E-03	1.96E-03	8.49E-04		8.49E-04
As+5		9.73E-02	6.78E-02	2.95E-02		2.95E-02	2.06E-02	8.92E-03		8.92E-03
B+3		3.30E-02	2.30E-02	9.99E-03		9.99E-03	6.97E-03	3.02E-03		3.02E-03
Ba+2		3.51E-03	2.45E-03	1.06E-03		1.06E-03	7.42E-04	3.22E-04		3.22E-04
Be+2		3.98E-05	2.77E-05	1.21E-05		1.21E-05	8.40E-06	3.65E-06		3.65E-06
Bi+3										
Ca+2		5.89E-02	4.10E-02	1.78E-02		1.78E-02	1.24E-02	5.39E-03		5.39E-03
Cd+2		2.16E-03	1.51E-03	6.55E-04		6.55E-04	4.57E-04	1.98E-04		1.98E-04
Ce+3		8.89E-02	6.20E-02	2.69E-02		2.69E-02	1.88E-02	8.15E-03		8.15E-03
Cm+3		8.69E-06	6.06E-06	2.63E-06		2.63E-06	1.84E-06	7.97E-07		7.97E-07
Co+3		2.75E-05	1.92E-05	8.34E-06		8.34E-06	5.82E-06	2.52E-06		2.52E-06
Cs+		1.00E+01	7.00E+00	3.04E+00		3.04E+00	2.12E+00	9.20E-01		9.20E-01
Cu+2		7.65E-03	5.33E-03	2.32E-03		2.32E-03	1.62E-03	7.02E-04		7.02E-04
Eu+3										
Fe+3		1.78E-02	1.24E-02	5.39E-03		5.39E-03	3.76E-03	1.63E-03		1.63E-03
Hg+2										
K+		2.51E+01	1.75E+01	7.59E+00		7.59E+00	5.30E+00	2.30E+00		2.30E+00
La+3		6.69E-03	4.66E-03	2.03E-03		2.03E-03	1.41E-03	6.13E-04		6.13E-04
Li+		1.65E-02	1.15E-02	5.01E-03		5.01E-03	3.50E-03	1.52E-03		1.52E-03
Mg+2		3.19E-03	2.22E-03	9.66E-04		9.66E-04	6.74E-04	2.92E-04		2.92E-04
Mn+4		1.63E-03	1.13E-03	4.92E-04		4.92E-04	3.44E-04	1.49E-04		1.49E-04
Mo+6		5.05E-01	3.52E-01	1.53E-01		1.53E-01	1.07E-01	4.63E-02		4.63E-02
Na+	2.51E+03	1.61E+04	1.12E+04	4.87E+03	2.51E+03	7.38E+03	5.15E+03	2.23E+03		2.23E+03
Ni+3		4.68E-03	3.26E-03	1.42E-03		1.42E-03	9.89E-04	4.29E-04		4.29E-04
Np+4										
Pb+4		3.51E-02	2.45E-02	1.06E-02		1.06E-02	7.42E-03	3.22E-03		3.22E-03
Pu+4		6.42E-04	4.47E-04	1.94E-04		1.94E-04	1.35E-04	5.88E-05		5.88E-05
Re+7		8.25E-03	5.75E-03	2.50E-03		2.50E-03	1.74E-03	7.57E-04		7.57E-04
Rh+3		5.92E-02	4.12E-02	1.79E-02		1.79E-02	1.25E-02	5.42E-03		5.42E-03
Ru+3		2.82E-02	1.97E-02	8.55E-03		8.55E-03	5.96E-03	2.59E-03		2.59E-03
Sb+5		7.66E-02	5.33E-02	2.32E-02		2.32E-02	1.62E-02	7.02E-03		7.02E-03
Se+6		1.43E-01	9.98E-02	4.34E-02		4.34E-02	3.03E-02	1.31E-02		1.31E-02
Si+4		2.08E+00	1.45E+00	6.30E-01		6.30E-01	4.39E-01	1.91E-01		1.91E-01
Sn+4										
Sr+2		3.62E-01	2.52E-01	1.10E-01		1.10E-01	7.65E-02	3.32E-02		3.32E-02
Te+6		1.53E-01	1.07E-01	4.65E-02		4.65E-02	3.24E-02	1.41E-02		1.41E-02
Th+4		1.24E-01	8.64E-02	3.76E-02		3.76E-02	2.62E-02	1.14E-02		1.14E-02
Ti+4		4.41E-02	3.08E-02	1.34E-02		1.34E-02	9.32E-03	4.04E-03		4.04E-03
Tl+3		1.53E+00	1.07E+00	4.65E-01		4.65E-01	3.24E-01	1.41E-01		1.41E-01
UO2+2		3.41E-01	2.38E-01	1.03E-01		1.03E-01	7.20E-02	3.13E-02		3.13E-02
V+5		5.28E-03	3.68E-03	1.60E-03		1.60E-03	1.12E-03	4.84E-04		4.84E-04
W+6										
Zn+2		7.85E-03	5.47E-03	2.38E-03		2.38E-03	1.66E-03	7.20E-04		7.20E-04
Zr+4										
Al(OH)4-		4.45E+03	3.10E+03	1.35E+03		1.35E+03	9.39E+02	4.08E+02		4.08E+02
Cl-		2.24E+01	1.56E+01	6.78E+00		6.78E+00	4.73E+00	2.05E+00		2.05E+00
CO3-2		3.74E+03	2.61E+03	1.13E+03		1.13E+03	7.91E+02	3.43E+02		3.43E+02
Cr(OH)4-		1.77E+01	1.23E+01	5.35E+00		5.35E+00	3.73E+00	1.62E+00		1.62E+00
F-		2.18E+02	1.52E+02	6.60E+01		6.60E+01	4.60E+01	2.00E+01		2.00E+01
I-		1.26E-02	8.76E-03	3.81E-03		3.81E-03	2.66E-03	1.15E-03		1.15E-03
NO2-	4.57E+02	8.05E+03	5.61E+03	2.44E+03	4.57E+02	2.90E+03	2.02E+03	8.76E+02		8.76E+02
NO3-		8.66E+03	6.03E+03	2.62E+03		2.62E+03	1.83E+03	7.94E+02		7.94E+02
OH-	1.69E+03	2.57E+03	1.79E+03	7.77E+02	1.69E+03	2.47E+03	1.72E+03	7.46E+02		7.46E+02
PO4-3		1.74E+02	1.21E+02	5.27E+01		5.27E+01	3.67E+01	1.59E+01		1.59E+01
SO4-2		2.13E+03	1.49E+03	6.46E+02		6.46E+02	4.51E+02	1.96E+02		1.96E+02
TcO4-		2.41E+00	1.68E+00	7.31E-01		7.31E-01	5.10E-01	2.21E-01		2.21E-01
H2O	9.92E+05	1.40E+06	9.72E+05	4.23E+05	9.92E+05	1.42E+06	9.87E+05	4.28E+05	4.45E+05	8.73E+05
Organic Carbon		1.32E+02	9.22E+01	4.01E+01		4.01E+01	2.80E+01	1.21E+01		1.21E+01
ZrO2:2H2O		4.75E-03	3.31E-03	1.44E-03		1.44E-03	1.00E-03	4.35E-04		4.35E-04
Hg										
Cl2										
CO2										
F2										
I2										
N2										
NO										
O2										
NH3										

STREAM NAME	11	12	13	14	15	16	17	18	19	20
SOLID COMPONENTS										
Total Mass Flow (kg)		7.74E+04	2.55E+02	7.72E+04		7.72E+04	2.55E+02	7.69E+04		7.69E+04
Radionuclides (Ci)										
Am-241		2.50E+04	8.24E+01	2.49E+04		2.49E+04	8.21E+01	2.48E+04		2.48E+04
C-14		1.39E+01	4.57E-02	1.38E+01		1.38E+01	4.56E-02	1.38E+01		1.38E+01
Cm-244		6.41E+02	2.12E+00	6.39E+02		6.39E+02	2.11E+00	6.37E+02		6.37E+02
Cs-137		2.15E+05	7.09E+02	2.14E+05		2.14E+05	7.07E+02	2.13E+05		2.13E+05
Ba-137		2.04E+05	6.73E+02	2.03E+05		2.03E+05	6.71E+02	2.03E+05		2.03E+05
Eu-154										
Np-237										
Pu-239		4.84E+02	1.60E+00	4.82E+02		4.82E+02	1.59E+00	4.81E+02		4.81E+02
Pu-240										
Pu-241										
Sr-90		4.64E+06	1.53E+04	4.62E+06		4.62E+06	1.53E+04	4.61E+06		4.61E+06
Y-90		4.64E+06	1.53E+04	4.62E+06		4.62E+06	1.53E+04	4.61E+06		4.61E+06
Tc-99		1.31E+02	4.34E-01	1.31E+02		1.31E+02	4.32E-01	1.31E+02		1.31E+02
Total Curies		9.72E+06	3.21E+04	9.68E+06		9.68E+06	3.20E+04	9.65E+06		9.65E+06
Chemicals (kg)										
Ag+		2.11E+02	6.97E-01	2.10E+02		2.10E+02	6.95E-01	2.10E+02		2.10E+02
Al+3		1.04E+04	3.43E+01	1.04E+04		1.04E+04	3.42E+01	1.03E+04		1.03E+04
Am+3		7.28E+00	2.40E-02	7.25E+00		7.25E+00	2.39E-02	7.23E+00		7.23E+00
As+5		1.20E+02	3.97E-01	1.20E+02		1.20E+02	3.95E-01	1.19E+02		1.19E+02
B+3		6.34E+01	2.09E-01	6.32E+01		6.32E+01	2.09E-01	6.30E+01		6.30E+01
Ba+2		1.52E+02	5.16E-01	1.52E+02		1.52E+02	5.14E-01	1.52E+02		1.52E+02
Be+2		3.77E+00	1.24E-02	3.76E+00		3.76E+00	1.24E-02	3.74E+00		3.74E+00
Ca+2		5.23E+02	1.73E+00	5.21E+02		5.21E+02	1.72E+00	5.19E+02		5.19E+02
Cd+2		1.22E+03	4.02E+00	1.22E+03		1.22E+03	4.01E+00	1.21E+03		1.21E+03
Ce+3		2.60E+02	8.58E-01	2.59E+02		2.59E+02	8.55E-01	2.58E+02		2.58E+02
Cm+3		7.91E-03	2.61E-05	7.89E-03		7.89E-03	2.60E-05	7.86E-03		7.86E-03
Co+3		7.47E-04	2.46E-06	7.44E-04		7.44E-04	2.46E-06	7.42E-04		7.42E-04
Cr+3		1.70E+02	5.61E-01	1.69E+02		1.69E+02	5.59E-01	1.68E+02		1.68E+02
Cs+		9.64E+00	3.18E-02	9.61E+00		9.61E+00	3.17E-02	9.58E+00		9.58E+00
Cu+2		9.27E+01	3.06E-01	9.24E+01		9.24E+01	3.05E-01	9.21E+01		9.21E+01
Fe+3		2.15E+04	7.11E+01	2.15E+04		2.15E+04	7.09E+01	2.14E+04		2.14E+04
K+		6.60E+02	2.18E+00	6.58E+02		6.58E+02	2.17E+00	6.56E+02		6.56E+02
La+3		8.15E+02	2.69E+00	8.12E+02		8.12E+02	2.68E+00	8.09E+02		8.09E+02
Li+		1.53E+01	5.04E-02	1.52E+01		1.52E+01	5.03E-02	1.52E+01		1.52E+01
Mg+2		1.31E+02	4.33E-01	1.31E+02		1.31E+02	4.32E-01	1.31E+02		1.31E+02
Mn+4		6.51E+02	2.15E+00	6.49E+02		6.49E+02	2.14E+00	6.46E+02		6.46E+02
Mo+6		1.17E+01	3.85E-02	1.16E+01		1.16E+01	3.84E-02	1.16E+01		1.16E+01
Na+		3.49E+03	1.15E+01	3.47E+03		3.47E+03	1.15E+01	3.46E+03		3.46E+03
Ni+3		9.53E+02	3.14E+00	9.50E+02		9.50E+02	3.13E+00	9.46E+02		9.46E+02
Pb+4		1.13E+02	3.74E-01	1.13E+02		1.13E+02	3.73E-01	1.13E+02		1.13E+02
Pu+4		7.80E+00	2.58E-02	7.78E+00		7.78E+00	2.57E-02	7.75E+00		7.75E+00
Re+7		1.22E+01	4.02E-02	1.22E+01		1.22E+01	4.01E-02	1.21E+01		1.21E+01
Rh+3		9.27E+01	3.06E-01	9.24E+01		9.24E+01	3.05E-01	9.21E+01		9.21E+01
Ru+3		1.91E+02	6.29E-01	1.90E+02		1.90E+02	6.27E-01	1.89E+02		1.89E+02
Sb+5		5.85E+02	1.93E+00	5.83E+02		5.83E+02	1.92E+00	5.81E+02		5.81E+02
Se+6		3.84E+02	1.27E+00	3.82E+02		3.82E+02	1.26E+00	3.81E+02		3.81E+02
Si+4		1.21E+03	3.99E+00	1.21E+03		1.21E+03	3.98E+00	1.20E+03		1.20E+03
Sr+2		1.61E+02	5.31E-01	1.60E+02		1.60E+02	5.29E-01	1.60E+02		1.60E+02
Te+6		4.12E+02	1.36E+00	4.11E+02		4.11E+02	1.36E+00	4.09E+02		4.09E+02
Th+4		2.64E+02	8.72E-01	2.64E+02		2.64E+02	8.70E-01	2.63E+02		2.63E+02
Ti+4		1.42E+02	4.64E-01	1.41E+02		1.41E+02	4.66E-01	1.41E+02		1.41E+02
Tl+3		1.42E+03	4.67E+00	1.41E+03		1.41E+03	4.66E+00	1.41E+03		1.41E+03
UO2+2		1.33E+03	4.39E+00	1.33E+03		1.33E+03	4.38E+00	1.32E+03		1.32E+03
V+5		5.41E+00	1.78E-02	5.39E+00		5.39E+00	1.78E-02	5.37E+00		5.37E+00
Zn+2		8.67E+01	2.86E-01	8.64E+01		8.64E+01	2.85E-01	8.61E+01		8.61E+01
Cl-		2.40E+01	7.90E-02	2.39E+01		2.39E+01	7.88E-02	2.38E+01		2.38E+01
CO3-2		3.28E+03	1.08E+01	3.27E+03		3.27E+03	1.08E+01	3.26E+03		3.26E+03
F-		1.32E+02	4.34E-01	1.32E+02		1.32E+02	4.35E-01	1.31E+02		1.31E+02
I-		2.23E-01	7.34E-04	2.22E-01		2.22E-01	7.34E-04	2.22E-01		2.22E-01
NO2-		1.51E+03	4.98E+00	1.51E+03		1.51E+03	4.97E+00	1.50E+03		1.50E+03
NO3-		1.24E+03	4.08E+00	1.23E+03		1.23E+03	4.07E+00	1.23E+03		1.23E+03
OH-		5.27E+03	1.74E+01	5.25E+03		5.25E+03	1.73E+01	5.24E+03		5.24E+03
PO4-3		2.06E+03	6.80E+00	2.05E+03		2.05E+03	6.78E+00	2.05E+03		2.05E+03
SO4-2		9.61E+02	3.17E+00	9.58E+02		9.58E+02	3.16E+00	9.55E+02		9.55E+02
TcO4-		1.28E+01	4.22E-02	1.28E+01		1.28E+01	4.21E-02	1.27E+01		1.27E+01
MnO2										
Organic Carbon		1.80E+03	5.95E+00	1.80E+03		1.80E+03	5.93E+00	1.79E+03		1.79E+03
ZrO2:2H2O		1.32E+04	4.36E+01	1.32E+04		1.32E+04	4.35E+01	1.31E+04		1.31E+04
Ag2O										
Al2O3										

STREAM NAME	11	12	13	14	15	16	17	18	19	20
SOLID COMPONENTS										
Chemicals Continued (kg)										
Am2O3										
As2O5										
B2O3										
BaO										
BeO										
Bi2O3										
CaO										
CdO										
Ce2O3										
Cm2O3										
Co2O3										
Cr2O3										
Cs2O										
CuO										
Eu2O3										
Fe2O3										
K2O										
La2O3										
Li2O										
MgO										
MoO3										
Na2O										
Ni2O3										
NpO2										
P2O5										
PbO2										
PuO2										
Re2O7										
Rh2O3										
Ru2O3										
Sb2O5										
SeO3										
SiO2										
SO3										
SrO										
Tc2O7										
TeO3										
ThO2										
TiO2										
Tl2O3										
UO3										
V2O5										
WO3										
ZrO										
ZrO2										

STREAM NAME	21	22	23	24	25
LIQUID COMPONENTS					
Total Mass Flow (kg)	1.59E+04		2.28E+04	8.97E+05	
Volume (L)	6.62E+03		2.28E+04	8.97E+05	
Specific Gravity	2.41E+00		1.00E+00	1.00E+00	
Radionuclides (Ci)					
Am-241	3.32E-03				
C-14	1.91E-04				
Cm-244					
Cs-137	1.31E+06				
Ba-137	1.24E+06				
Eu-154	1.13E-02				
Np-237	8.41E-08				
Pu-239	7.39E-04				
Pu-240	1.84E-04				
Pu-241	1.42E-03				
Sr-90	4.86E-01				
Y-90	4.86E-01				
Tc-99	1.19E+02				
Total Curies	2.55E+06				
Chemicals (kg)					
Ag+	6.18E-07				
Am+3	9.68E-07				
As+5	5.44E-07				
B+3	5.76E-06				
Ba+2	8.20E-06				
Be+2	5.17E-14				
Bi+3	9.59E-07				
Ca+2	7.32E-02				
Cd+2	1.05E-02				
Ce+3	2.23E-06				
Cm+3					
Co+3					
Cs+	1.51E+01				
Cu+2	8.36E-07				
Eu+3	4.28E-08				
Fe+3	1.54E-02				
Hg+2	1.08E-06				
K+	7.55E-02				
La+3	8.20E-05				
Li+					
Mg+2	2.38E-05				
Mn+4	5.12E-03				
Mo+6	6.63E-06				
Na+	7.63E+03				
Ni+3	8.33E-03				
Np+4	1.19E-07				
Pb+4	3.39E-03				
Pu+4	1.28E-05				
Re+7					
Rh+3					
Ru+3					
Sb+5					
Se+6	4.00E-08				
Si+4	4.09E-04				
Sn+4	3.19E-16				
Sr+2	3.45E-06				
Te+6					
Th+4					
Ti+4	3.94E-08				
Tl+3					
UO2+2	3.35E-03				
V+5					
W+6	1.40E-05				
Zn+2	4.69E-05				
Zr+4	3.58E-07				
Al(OH)4-	1.26E+00				
Cl-	7.40E-02				
CO3-2	2.05E+00				
Cr(OH)4-	1.37E-02				
F-	5.05E-02				
I-					
NO2-	2.51E+00				
NO3-	7.41E+00				
OH-	5.64E+03				
PO4-3	1.24E-01				
SO4-2	4.22E-01				
TcO4-	1.15E+01				
H2O	2.61E+03			8.85E+05	
Organic Carbon	1.19E+00				
ZrO2:2H2O					
Hg				1.08E-06	
Cl2				2.59E+01	
CO2				6.22E+03	
F2				1.51E+02	
I2				2.23E-01	
N2				2.86E+02	
NO				1.91E+03	
O2			2.28E+04		
NH3				5.75E+00	

STREAM NAME	21	22	23	24	25
SOLID COMPONENTS					
Total Mass Flow (kg)	4.22E-01	2.11E+05			3.09E+05

Radionuclides (Ci)					
Am-241	7.79E+01				2.49E+04
C-14					
Cm-244					6.37E+02
Cs-137					1.55E+06
Ba-137					1.47E+06
Eu-154					1.13E-02
Np-237					8.41E-08
Pu-239	3.51E+00				4.84E+02
Pu-240	8.77E-01				8.77E-01
Pu-241					1.42E-03
Sr-90	3.24E+04				4.64E+06
Y-90	3.24E+04				4.64E+06
Tc-99					2.51E+02
Total Curies	6.49E+04				1.23E+07

Chemicals (kg)					
Ag+					
Al+3					
Am+3	2.27E-02				
As+5					
B+3					
Ba+2					
Be+2					
Ca+2					
Cd+2					
Ce+3					
Cm+3					
Co+3					
Cr+3					
Cs+					
Cu+2					
Fe+3					
K+					
La+3					
Li+					
Mg+2					
Mn+4					
Mo+6					
Na+					
Ni+3					
Pb+4					
Pu+4	6.05E-02				
Re+7					
Rh+3					
Ru+3					
Sb+5					
Se+6					
Si+4					
Sr+2	2.30E-01				
Te+6					
Th+4					
Ti+4					
Tl+3					
UO2+2					
V+5					
Zn+2					
Cl-					
CO3-2					
F-					
I-					
NO2-					
NO3-					
OH-	1.09E-01				
PO4-3					
SO4-2					
TcO4-					
MnO2					1.02E+03
Organic Carbon					
ZrO2:2H2O					
Ag2O					2.25E+02
Al2O3					1.97E+04

STREAM NAME	21	22	23	24	25
SOLID COMPONENTS					
Chemicals Continued (kg)					
Am2O3					7.98E+00
As2O5					1.83E+02
B2O3		3.45E+04			3.47E+04
BaO					1.73E+02
BeO					1.04E+01
Bi2O3					1.07E-06
CaO					7.27E+02
CdO					1.39E+03
Ce2O3					3.05E+02
Cm2O3					8.63E-03
Co2O3					1.06E-03
Cr2O3					2.48E+02
Cs2O					2.71E+01
CuO					1.15E+02
Eu2O3					4.92E-08
Fe2O3					3.06E+04
K2O					7.93E+02
La2O3					6.49E+02
Li2O		3.06E+03			3.09E+03
MgO					2.16E+02
MoO3					1.75E+01
Na2O					1.80E+04
Ni2O3					1.33E+03
NpO2					1.35E-07
P2O5					1.54E+03
PbO2					1.30E+02
PuO2					8.88E+00
Re2O7					1.58E+01
Rh2O3					1.14E+02
Ru2O3					2.34E+02
Sb2O5					7.71E+02
SeO3					6.13E+02
SiO2		1.73E+05			1.76E+05
SO3					9.58E+02
SrO					1.88E+02
Tc2O7					2.33E+01
TeO3					5.63E+02
ThO2					2.98E+02
TiO2					2.35E+02
Tl2O3					1.57E+03
UO3					1.40E+03
V2O5					9.52E+00
WO3					1.77E-05
ZnO					1.07E+02
ZrO2					1.02E+04

Table C-2. Phase I In-Tank Sludge Washing of Double-Shell Tank 241-AZ-102 (60 Percent Retrieval).

16-Aug-96 07:32:10

STREAM NAME	1	2	3	4	5	6	7	8	9	10
LIQUID COMPONENTS										
Total Mass Flow (kg)	3.88E+06	1.98E+06	1.90E+06	1.57E+06	3.27E+05	1.46E+06	1.79E+06	1.79E+06	1.21E+06	5.85E+05
Volume (L)	3.50E+06	1.98E+06	1.52E+06	1.26E+06	2.62E+05	1.46E+06	1.72E+06	1.72E+06	1.16E+06	5.62E+05
Specific Gravity	1.11E+00	1.00E+00	1.25E+00	1.25E+00	1.25E+00	1.00E+00	1.04E+00	1.04E+00	1.04E+00	1.04E+00
Radionuclides (Ci)										
Am-241	1.60E+00		1.60E+00	1.32E+00	2.76E-01		2.76E-01	2.76E-01	1.86E-01	9.00E-02
C-14	1.27E+02		1.27E+02	1.05E+02	2.19E+01		2.19E+01	2.19E+01	1.47E+01	7.14E+00
Cs-137	3.02E+06		3.02E+06	2.50E+06	5.21E+05		5.21E+05	5.21E+05	3.51E+05	1.70E+05
Ba-137	2.87E+06		2.87E+06	2.38E+06	4.95E+05		4.95E+05	4.95E+05	3.34E+05	1.62E+05
Eu-154										
Np-237										
Pu-239	3.83E+01		3.83E+01	3.17E+01	6.60E+00		6.60E+00	6.60E+00	4.44E+00	2.15E+00
Pu-240										
Pu-241										
Sr-90	8.49E+03		8.49E+03	7.03E+03	1.46E+03		1.46E+03	1.46E+03	9.86E+02	4.78E+02
Y-90	8.49E+03		8.49E+03	7.03E+03	1.46E+03		1.46E+03	1.46E+03	9.86E+02	4.78E+02
Tc-99	2.86E+02		2.86E+02	2.37E+02	4.93E+01		4.93E+01	4.93E+01	3.32E+01	1.61E+01
Total Curies	5.91E+06		5.91E+06	4.89E+06	1.02E+06		1.02E+06	1.02E+06	6.87E+05	3.33E+05
Chemicals (kg)										
Ag+										
Am+3	4.66E-04		4.66E-04	3.85E-04	8.03E-05		8.03E-05	8.03E-05	5.41E-05	2.62E-05
As+5	3.94E+00		3.94E+00	3.26E+00	6.80E-01		6.80E-01	6.80E-01	4.58E-01	2.22E-01
B+3	2.19E+00		2.19E+00	1.81E+00	3.77E-01		3.77E-01	3.77E-01	2.54E-01	1.23E-01
Ba+2	3.05E-01		3.05E-01	2.52E-01	5.24E-02		5.24E-02	5.24E-02	3.54E-02	1.72E-02
Be+2	2.01E-02		2.01E-02	1.67E-02	3.47E-03		3.47E-03	3.47E-03	2.34E-03	1.13E-03
Bi+3										
Ca+2	1.06E+01		1.06E+01	8.79E+00	1.83E+00		1.83E+00	1.83E+00	1.23E+00	5.98E-01
Cd+2	3.43E-01		3.43E-01	2.84E-01	5.92E-02		5.92E-02	5.92E-02	3.98E-02	1.93E-02
Ce+3	3.87E+00		3.87E+00	3.20E+00	6.68E-01		6.68E-01	6.68E-01	4.50E-01	2.18E-01
Co+3	3.55E-05		3.55E-05	2.94E-05	6.12E-06		6.12E-06	6.12E-06	4.13E-06	2.00E-06
Cs+	1.36E+02		1.36E+02	1.13E+02	2.35E+01		2.35E+01	2.35E+01	1.58E+01	7.66E+00
Cu+2	2.79E-01		2.79E-01	2.31E-01	4.81E-02		4.81E-02	4.81E-02	3.24E-02	1.57E-02
Eu+3										
Fe+3	2.89E+00		2.89E+00	2.40E+00	4.99E-01		4.99E-01	4.99E-01	3.36E-01	1.63E-01
Hg+2										
K+	2.48E+02		2.48E+02	2.05E+02	4.28E+01		4.28E+01	4.28E+01	2.88E+01	1.40E+01
La+3	6.20E-01		6.20E-01	5.13E-01	1.07E-01		1.07E-01	1.07E-01	7.21E-02	3.49E-02
Li+	2.80E-01		2.80E-01	2.32E-01	4.83E-02		4.83E-02	4.83E-02	3.25E-02	1.58E-02
Mg+2	3.50E-01		3.50E-01	2.90E-01	6.04E-02		6.04E-02	6.04E-02	4.06E-02	1.97E-02
Mn+4	2.64E-01		2.64E-01	2.18E-01	4.55E-02		4.55E-02	4.55E-02	3.06E-02	1.48E-02
Mo+6	6.41E+00		6.41E+00	5.31E+00	1.11E+00		1.11E+00	1.11E+00	7.45E-01	3.61E-01
Na+	1.75E+05		1.75E+05	1.44E+05	3.01E+04	3.69E+03	3.38E+04	3.38E+04	2.28E+04	1.10E+04
Ni+3	6.67E-01		6.67E-01	5.52E-01	1.15E-01		1.15E-01	1.15E-01	7.75E-02	3.76E-02
Np+4										
Pb+4	1.37E+00		1.37E+00	1.13E+00	2.35E-01		2.35E-01	2.35E-01	1.59E-01	7.69E-02
Pu+4	6.17E-01		6.17E-01	5.11E-01	1.06E-01		1.06E-01	1.06E-01	7.17E-02	3.47E-02
Re+7	2.08E-01		2.08E-01	1.72E-01	3.59E-02		3.59E-02	3.59E-02	2.42E-02	1.17E-02
Rh+3	2.66E+00		2.66E+00	2.20E+00	4.59E-01		4.59E-01	4.59E-01	3.09E-01	1.50E-01
Ru+3	6.60E-01		6.60E-01	5.46E-01	1.14E-01		1.14E-01	1.14E-01	7.67E-02	3.72E-02
Se+6	3.24E+00		3.24E+00	2.68E+00	5.59E-01		5.59E-01	5.59E-01	3.76E-01	1.82E-01
Si+4	1.71E+03		1.71E+03	1.42E+03	2.95E+02		2.95E+02	2.95E+02	1.99E+02	9.63E+01
Sn+4										
Sr+2	8.70E-01		8.70E-01	7.20E-01	1.50E-01		1.50E-01	1.50E-01	1.01E-01	4.90E-02
Te+6	8.24E-01		8.24E-01	6.82E-01	1.42E-01		1.42E-01	1.42E-01	9.57E-02	4.64E-02
Ti+4	2.32E-01		2.32E-01	1.92E-01	4.01E-02		4.01E-02	4.01E-02	2.70E-02	1.31E-02
Tl+3	5.69E-01		5.69E-01	4.71E-01	9.81E-02		9.81E-02	9.81E-02	6.60E-02	3.20E-02
UO2+2	5.48E+03		5.48E+03	4.53E+03	9.45E+02		9.45E+02	9.45E+02	6.36E+02	3.09E+02
V+5	2.45E-01		2.45E-01	2.02E-01	4.22E-02		4.22E-02	4.22E-02	2.84E-02	1.38E-02
W+6										
Zn+2	1.32E-01		1.32E-01	1.09E-01	2.28E-02		2.28E-02	2.28E-02	1.54E-02	7.44E-03
Zr+4										
Al(OH)4-	1.69E+04		1.69E+04	1.39E+04	2.91E+03		2.91E+03	2.91E+03	1.96E+03	9.49E+02
Cl-										
CO3-2	8.99E+04		8.99E+04	7.44E+04	1.55E+04		1.55E+04	1.55E+04	1.04E+04	5.06E+03
Cr(OH)4-	7.27E+03		7.27E+03	6.01E+03	1.25E+03		1.25E+03	1.25E+03	8.44E+02	4.09E+02
F-	3.18E+03		3.18E+03	2.63E+03	5.48E+02		5.48E+02	5.48E+02	3.69E+02	1.79E+02
I-	8.13E-02		8.13E-02	6.73E-02	1.40E-02		1.40E-02	1.40E-02	9.44E-03	4.58E-03
NO2-	8.81E+04		8.81E+04	7.29E+04	1.52E+04	6.72E+02	1.59E+04	1.59E+04	1.07E+04	5.18E+03
NO3-	7.34E+04		7.34E+04	6.07E+04	1.27E+04		1.27E+04	1.27E+04	8.54E+03	4.15E+03
OH-	2.34E+03		2.34E+03	1.94E+03	4.04E+02	2.48E+03	2.89E+03	2.89E+03	1.94E+03	9.42E+02
PO4-3	1.59E+03		1.59E+03	1.32E+03	2.74E+02		2.74E+02	2.74E+02	1.85E+02	8.95E+01
SO4-2	5.84E+04		5.84E+04	4.83E+04	1.01E+04		1.01E+04	1.01E+04	6.78E+03	3.29E+03
TcO4-	2.78E+01		2.78E+01	2.30E+01	4.80E+00		4.80E+00	4.80E+00	3.23E+00	1.57E+00
H2O	3.35E+06	1.98E+06	1.37E+06	1.13E+06	2.36E+05	1.46E+06	1.69E+06	1.69E+06	1.14E+06	5.53E+05
Organic Carbon	4.72E+03		4.72E+03	3.90E+03	8.14E+02		8.14E+02	8.14E+02	5.48E+02	2.66E+02
ZrO2:2H2O	1.12E+00		1.12E+00	9.30E-01	1.94E-01		1.94E-01	1.94E-01	1.31E-01	6.33E-02
Hg										
Cl2										
CO2										
F2										
I2										
N2										
NO										
O2										
NH3										

STREAM NAME	1	2	3	4	5	6	7	8	9	10
SOLID COMPONENTS										
Total Mass Flow (kg)	1.15E+05		1.15E+05	3.78E+02	1.14E+05		1.14E+05	1.14E+05	3.77E+02	1.14E+05
Radionuclides (Ci)										
Am-241	1.01E+04		1.01E+04	3.33E+01	1.00E+04		1.00E+04	1.00E+04	3.31E+01	1.00E+04
C-14	7.48E+00		7.48E+00	2.47E-02	7.45E+00		7.45E+00	7.45E+00	2.46E-02	7.43E+00
Cm-244	3.25E+02		3.25E+02	1.07E+00	3.24E+02		3.24E+02	3.24E+02	1.07E+00	3.23E+02
Cs-137	1.73E+05		1.73E+05	5.70E+02	1.72E+05		1.72E+05	1.72E+05	5.69E+02	1.72E+05
Ba-137	1.64E+05		1.64E+05	5.42E+02	1.64E+05		1.64E+05	1.64E+05	5.40E+02	1.63E+05
Eu-154										
Np-237										
Pu-239	2.89E+02		2.89E+02	9.55E-01	2.88E+02		2.88E+02	2.88E+02	9.51E-01	2.87E+02
Pu-240										
Pu-241										
Sr-90	1.78E+06		1.78E+06	5.87E+03	1.77E+06		1.77E+06	1.77E+06	5.85E+03	1.77E+06
Y-90	1.78E+06		1.78E+06	5.87E+03	1.77E+06		1.77E+06	1.77E+06	5.85E+03	1.77E+06
Tc-99	8.83E+01		8.83E+01	2.91E-01	8.80E+01		8.80E+01	8.80E+01	2.90E-01	8.77E+01
Total Curies	3.91E+06		3.91E+06	1.29E+04	3.89E+06		3.89E+06	3.89E+06	1.28E+04	3.88E+06
Chemicals (kg)										
Ag+	1.44E+02		1.44E+02	4.76E-01	1.44E+02		1.44E+02	1.44E+02	4.75E-01	1.43E+02
Al+3	9.25E+03		9.25E+03	3.05E+01	9.21E+03		9.21E+03	9.21E+03	3.04E+01	9.18E+03
Am+3	2.94E+00		2.94E+00	9.69E-03	2.93E+00		2.93E+00	2.93E+00	9.66E-03	2.92E+00
As+5	9.94E+01		9.94E+01	3.28E-01	9.90E+01		9.90E+01	9.90E+01	3.27E-01	9.87E+01
B+3	8.34E+01		8.34E+01	2.75E-01	8.31E+01		8.31E+01	8.31E+01	2.74E-01	8.28E+01
Ba+2	9.50E+01		9.50E+01	3.14E-01	9.47E+01		9.47E+01	9.47E+01	3.13E-01	9.44E+01
Be+2	2.31E+00		2.31E+00	7.61E-03	2.30E+00		2.30E+00	2.30E+00	7.59E-03	2.29E+00
Ca+2	4.86E+02		4.86E+02	1.61E+00	4.85E+02		4.85E+02	4.85E+02	1.60E+00	4.83E+02
Cd+2	2.59E+03		2.59E+03	8.55E+00	2.58E+03		2.58E+03	2.58E+03	8.53E+00	2.57E+03
Ce+3	1.33E+02		1.33E+02	4.39E-01	1.33E+02		1.33E+02	1.33E+02	4.38E-01	1.32E+02
Cm+3	4.01E-03		4.01E-03	1.32E-05	4.00E-03		4.00E-03	4.00E-03	1.32E-05	3.98E-03
Co+3	3.21E-05		3.21E-05	1.06E-07	3.20E-05		3.20E-05	3.20E-05	1.06E-07	3.19E-05
Cr+3	2.17E+02		2.17E+02	7.16E-01	2.16E+02		2.16E+02	2.16E+02	7.13E-01	2.15E+02
Cs+	7.74E+00		7.74E+00	2.56E-02	7.72E+00		7.72E+00	7.72E+00	2.55E-02	7.69E+00
Cu+2	6.00E+01		6.00E+01	1.98E-01	5.98E+01		5.98E+01	5.98E+01	1.97E-01	5.96E+01
Fe+3	2.26E+04		2.26E+04	7.47E+01	2.26E+04		2.26E+04	2.26E+04	7.45E+01	2.25E+04
K+	2.02E+02		2.02E+02	6.67E-01	2.02E+02		2.02E+02	2.02E+02	6.65E-01	2.01E+02
La+3	7.74E+02		7.74E+02	2.56E+00	7.72E+02		7.72E+02	7.72E+02	2.55E+00	7.69E+02
Li+	4.84E+00		4.84E+00	1.60E-02	4.82E+00		4.82E+00	4.82E+00	1.59E-02	4.81E+00
Mg+2	1.64E+02		1.64E+02	5.42E-01	1.64E+02		1.64E+02	1.64E+02	5.40E-01	1.63E+02
Mn+4	4.98E+02		4.98E+02	1.64E+00	4.96E+02		4.96E+02	4.96E+02	1.64E+00	4.94E+02
Mo+6	4.05E+00		4.05E+00	1.34E-02	4.04E+00		4.04E+00	4.04E+00	1.33E-02	4.03E+00
Na+	7.14E+03		7.14E+03	2.36E+01	7.11E+03		7.11E+03	7.11E+03	2.35E+01	7.09E+03
Ni+3	1.53E+03		1.53E+03	5.05E+00	1.52E+03		1.52E+03	1.52E+03	5.03E+00	1.52E+03
Pb+4	1.89E+02		1.89E+02	6.24E-01	1.88E+02		1.88E+02	1.88E+02	6.22E-01	1.88E+02
Pu+4	4.67E+00		4.67E+00	1.54E-02	4.65E+00		4.65E+00	4.65E+00	1.54E-02	4.64E+00
Re+7	1.24E+01		1.24E+01	4.08E-02	1.23E+01		1.23E+01	1.23E+01	4.06E-02	1.23E+01
Rh+3	7.14E+01		7.14E+01	2.36E-01	7.11E+01		7.11E+01	7.11E+01	2.35E-01	7.09E+01
Ru+3	3.09E+01		3.09E+01	1.02E-01	3.08E+01		3.08E+01	3.08E+01	1.02E-01	3.07E+01
Se+6	1.75E+02		1.75E+02	5.78E-01	1.75E+02		1.75E+02	1.75E+02	5.77E-01	1.74E+02
Si+4	7.26E+02		7.26E+02	2.40E+00	7.23E+02		7.23E+02	7.23E+02	2.39E+00	7.21E+02
Sr+2	7.00E+01		7.00E+01	2.31E-01	6.98E+01		6.98E+01	6.98E+01	2.30E-01	6.96E+01
Te+6	5.90E+01		5.90E+01	1.95E-01	5.88E+01		5.88E+01	5.88E+01	1.94E-01	5.86E+01
Ti+4	1.32E+01		1.32E+01	4.36E-02	1.32E+01		1.32E+01	1.32E+01	4.35E-02	1.31E+01
Tl+3	9.50E+00		9.50E+00	3.14E-02	9.47E+00		9.47E+00	9.47E+00	3.13E-02	9.44E+00
UO2+2	2.37E+03		2.37E+03	7.81E+00	2.36E+03		2.36E+03	2.36E+03	7.79E+00	2.35E+03
V+5	5.49E+00		5.49E+00	1.81E-02	5.47E+00		5.47E+00	5.47E+00	1.81E-02	5.45E+00
Zn+2	2.43E+01		2.43E+01	8.01E-02	2.42E+01		2.42E+01	2.42E+01	7.99E-02	2.41E+01
Cl-	2.54E+01		2.54E+01	8.38E-02	2.53E+01		2.53E+01	2.53E+01	8.36E-02	2.52E+01
CO3-2	1.35E+04		1.35E+04	4.45E+01	1.34E+04		1.34E+04	1.34E+04	4.43E+01	1.34E+04
F-	2.14E+01		2.14E+01	7.07E-02	2.14E+01		2.14E+01	2.14E+01	7.05E-02	2.13E+01
I-	1.43E-01		1.43E-01	4.73E-04	1.43E-01		1.43E-01	1.43E-01	4.72E-04	1.43E-01
NO2-	6.54E+02		6.54E+02	2.16E+00	6.52E+02		6.52E+02	6.52E+02	2.15E+00	6.50E+02
NO3-	1.81E+02		1.81E+02	5.99E-01	1.81E+02		1.81E+02	1.81E+02	5.97E-01	1.80E+02
OH-	4.10E+04		4.10E+04	1.35E+02	4.08E+04		4.08E+04	4.08E+04	1.35E+02	4.07E+04
PO4-3	2.45E+03		2.45E+03	8.07E+00	2.44E+03		2.44E+03	2.44E+03	8.04E+00	2.43E+03
SO4-2	8.99E+02		8.99E+02	2.97E+00	8.96E+02		8.96E+02	8.96E+02	2.96E+00	8.93E+02
TcO4-	8.60E+00		8.60E+00	2.84E-02	8.57E+00		8.57E+00	8.57E+00	2.83E-02	8.54E+00
MnO2										
Organic Carbon	4.74E+02		4.74E+02	1.57E+00	4.73E+02		4.73E+02	4.73E+02	1.56E+00	4.71E+02
ZrO2:2H2O	5.47E+03		5.47E+03	1.81E+01	5.45E+03		5.45E+03	5.45E+03	1.80E+01	5.43E+03
Ag2O										
Al2O3										
Am2O3										
As2O5										

STREAM NAME	1	2	3	4	5	6	7	8	9	10
SOLID COMPONENTS										
Chemicals Continued (kg)										
B2O3										
BaO										
BeO										
Bi2O3										
CaO										
CdO										
Ce2O3										
Cm2O3										
Co2O3										
Cr2O3										
Cs2O										
CuO										
Eu2O3										
Fe2O3										
K2O										
La2O3										
Li2O										
MgO										
MoO3										
Na2O										
Ni2O3										
NpO2										
P2O5										
PbO2										
PuO2										
Re2O7										
Rh2O3										
Ru2O3										
SeO3										
SiO2										
SO3										
SrO										
Tc2O7										
TeO3										
TiO2										
Tl2O3										
UO3										
V2O5										
WO3										
ZnO										
ZrO2										

STREAM NAME	11	12	13	14	15	16	17	18	19	20
LIQUID COMPONENTS										
Total Mass Flow (kg)	1.46E+06	2.05E+06	1.47E+06	5.80E+05	1.46E+06	2.04E+06	1.47E+06	5.78E+05	2.54E+05	8.31E+05
Volume (L)	1.46E+06	2.02E+06	1.45E+06	5.72E+05	1.46E+06	2.03E+06	1.46E+06	5.74E+05	2.54E+05	8.28E+05
Specific Gravity	1.00E+00	1.01E+00	1.01E+00	1.01E+00	1.00E+00	1.01E+00	1.01E+00	1.01E+00	1.00E+00	1.00E+00
Radionuclides (Ci)										
Am-241		9.00E-02	6.45E-02	2.55E-02		2.55E-02	1.83E-02	7.19E-03		7.19E-03
C-14		7.14E+00	5.12E+00	2.02E+00		2.02E+00	1.45E+00	5.71E-01		5.71E-01
Cs-137		1.70E+05	1.22E+05	4.82E+04		4.82E+04	3.46E+04	1.36E+04		1.36E+04
Ba-137		1.62E+05	1.16E+05	4.58E+04		4.58E+04	3.28E+04	1.29E+04		1.29E+04
Eu-154										
Np-237										
Pu-239		2.15E+00	1.54E+00	6.10E-01		6.10E-01	4.37E-01	1.72E-01		1.72E-01
Pu-240										
Pu-241										
Sr-90		4.78E+02	3.43E+02	1.35E+02		1.35E+02	9.71E+01	3.82E+01		3.82E+01
Y-90		4.78E+02	3.43E+02	1.35E+02		1.35E+02	9.71E+01	3.82E+01		3.82E+01
Tc-99		1.61E+01	1.15E+01	4.56E+00		4.56E+00	3.27E+00	1.29E+00		1.29E+00
Total Curies		3.33E+05	2.39E+05	9.42E+04		9.42E+04	6.76E+04	2.66E+04		2.66E+04
Chemicals (kg)										
Ag+										
Am+3		2.62E-05	1.88E-05	7.42E-06		7.42E-06	5.33E-06	2.10E-06		2.10E-06
As+5		2.22E-01	1.59E-01	6.28E-02		6.28E-02	4.51E-02	1.77E-02		1.77E-02
B+3		1.23E-01	8.83E-02	3.48E-02		3.48E-02	2.50E-02	9.85E-03		9.85E-03
Ba+2		1.72E-02	1.23E-02	4.86E-03		4.86E-03	3.49E-03	1.37E-03		1.37E-03
Be+2		1.13E-03	8.13E-04	3.21E-04		3.21E-04	2.30E-04	9.07E-05		9.07E-05
Bi+3										
Ca+2		5.98E-01	4.29E-01	1.69E-01		1.69E-01	1.22E-01	4.79E-02		4.79E-02
Cd+2		1.93E-02	1.39E-02	5.47E-03		5.47E-03	3.92E-03	1.55E-03		1.55E-03
Ce+3		2.18E-01	1.56E-01	6.17E-02		6.17E-02	4.43E-02	1.74E-02		1.74E-02
Co+3		2.00E-06	1.43E-06	5.66E-07		5.66E-07	4.06E-07	1.60E-07		1.60E-07
Cs+		7.64E+00	5.49E+00	2.17E+00		2.17E+00	1.56E+00	6.13E-01		6.13E-01
Cu+2		1.57E-02	1.13E-02	4.45E-03		4.45E-03	3.19E-03	1.26E-03		1.26E-03
Eu+3										
Fe+3		1.63E-01	1.17E-01	4.61E-02		4.61E-02	3.31E-02	1.30E-02		1.30E-02
Hg+2										
K+		1.40E+01	1.00E+01	3.95E+00		3.95E+00	2.84E+00	1.12E+00		1.12E+00
La+3		3.49E-02	2.50E-02	9.89E-03		9.89E-03	7.09E-03	2.79E-03		2.79E-03
Li+		1.58E-02	1.13E-02	4.46E-03		4.46E-03	3.20E-03	1.26E-03		1.26E-03
Mg+2		1.97E-02	1.41E-02	5.58E-03		5.58E-03	4.00E-03	1.58E-03		1.58E-03
Mn+4		1.48E-02	1.06E-02	4.20E-03		4.20E-03	3.01E-03	1.19E-03		1.19E-03
Mo+6		3.61E-01	2.59E-01	1.02E-01		1.02E-01	7.33E-02	2.89E-02		2.89E-02
Na+	3.69E+03	1.47E+04	1.06E+04	4.17E+03	3.69E+03	7.86E+03	5.64E+03	2.22E+03		2.22E+03
Ni+3		3.76E-02	2.69E-02	1.06E-02		1.06E-02	7.63E-03	3.00E-03		3.00E-03
Np+4										
Pb+4		7.69E-02	5.51E-02	2.18E-02		2.18E-02	1.56E-02	6.15E-03		6.15E-03
Pu+4		3.47E-02	2.49E-02	9.83E-03		9.83E-03	7.06E-03	2.78E-03		2.78E-03
Re+7		1.17E-02	8.41E-03	3.32E-03		3.32E-03	2.38E-03	9.38E-04		9.38E-04
Rh+3		1.50E-01	1.07E-01	4.24E-02		4.24E-02	3.04E-02	1.20E-02		1.20E-02
Ru+3		3.72E-02	2.67E-02	1.05E-02		1.05E-02	7.55E-03	2.97E-03		2.97E-03
Se+6		1.82E-01	1.31E-01	5.16E-02		5.16E-02	3.71E-02	1.46E-02		1.46E-02
Si+4		9.63E+01	6.91E+01	2.73E+01		2.73E+01	1.96E+01	7.71E+00		7.71E+00
Sn+4										
Sr+2		4.90E-02	3.51E-02	1.39E-02		1.39E-02	9.95E-03	3.92E-03		3.92E-03
Te+6		4.64E-02	3.33E-02	1.31E-02		1.31E-02	9.43E-03	3.71E-03		3.71E-03
Ti+4		1.31E-02	9.38E-03	3.71E-03		3.71E-03	2.66E-03	1.05E-03		1.05E-03
Tl+3		3.20E-02	2.30E-02	9.06E-03		9.06E-03	6.50E-03	2.56E-03		2.56E-03
UO2+2		3.09E+02	2.21E+02	8.73E+01		8.73E+01	6.26E+01	2.47E+01		2.47E+01
V+5		1.38E-02	9.87E-03	3.90E-03		3.90E-03	2.80E-03	1.10E-03		1.10E-03
W+6										
Zn+2		7.44E-03	5.34E-03	2.11E-03		2.11E-03	1.51E-03	5.95E-04		5.95E-04
Zr+4										
Al(OH)4-		9.49E+02	6.80E+02	2.69E+02		2.69E+02	1.93E+02	7.59E+01		7.59E+01
Cl-										
CO3-2		5.06E+03	3.63E+03	1.43E+03		1.43E+03	1.03E+03	4.05E+02		4.05E+02
Cr(OH)4-		4.09E+02	2.93E+02	1.16E+02		1.16E+02	8.31E+01	3.27E+01		3.27E+01
F-		1.79E+02	1.28E+02	5.07E+01		5.07E+01	3.64E+01	1.43E+01		1.43E+01
I-		4.58E-03	3.28E-03	1.30E-03		1.30E-03	9.30E-04	3.66E-04		3.66E-04
NO2-	6.72E+02	5.85E+03	4.20E+03	1.66E+03	6.72E+02	2.33E+03	1.67E+03	6.58E+02		6.58E+02
NO3-		4.13E+03	2.96E+03	1.17E+03		1.17E+03	8.39E+02	3.30E+02		3.30E+02
OH-	2.48E+03	3.42E+03	2.46E+03	9.69E+02	2.48E+03	3.45E+03	2.48E+03	9.75E+02		9.75E+02
PO4-3		8.95E+01	6.42E+01	2.53E+01		2.53E+01	1.82E+01	7.16E+00		7.16E+00
SO4-2		3.29E+03	2.36E+03	9.31E+02		9.31E+02	6.68E+02	2.63E+02		2.63E+02
TcO4-		1.57E+00	1.12E+00	4.44E-01		4.44E-01	3.18E-01	1.25E-01		1.25E-01
H2O	1.46E+06	2.01E+06	1.44E+06	5.69E+05	1.46E+06	2.03E+06	1.45E+06	5.73E+05	2.54E+05	8.26E+05
Organic Carbon		2.66E+02	1.90E+02	7.52E+01		7.52E+01	5.40E+01	2.13E+01		2.13E+01
ZrO2:2H2O		6.33E-02	4.53E-02	1.79E-02		1.79E-02	1.28E-02	5.06E-03		5.06E-03
Hg										
Cl2										
CO2										
F2										
I2										
N2										
NO										
O2										
NH3										

STREAM NAME	11	12	13	14	15	16	17	18	19	20
SOLID COMPONENTS										
Total Mass Flow (kg)		1.14E+05	3.75E+02	1.13E+05		1.13E+05	3.74E+02	1.13E+05		1.13E+05
Radionuclides (Ci)										
Am-241		1.00E+04	3.30E+01	9.98E+03		9.98E+03	3.29E+01	9.94E+03		9.94E+03
C-14		7.43E+00	2.45E-02	7.40E+00		7.40E+00	2.44E-02	7.38E+00		7.38E+00
Cm-244		3.23E+02	1.07E+00	3.22E+02		3.22E+02	1.06E+00	3.21E+02		3.21E+02
Cs-137		1.72E+05	5.67E+02	1.71E+05		1.71E+05	5.65E+02	1.71E+05		1.71E+05
Ba-137		1.63E+05	5.38E+02	1.63E+05		1.63E+05	5.37E+02	1.62E+05		1.62E+05
Eu-154										
Np-237										
Pu-239		2.87E+02	9.48E-01	2.86E+02		2.86E+02	9.45E-01	2.86E+02		2.86E+02
Pu-240										
Pu-241										
Sr-90		1.77E+06	5.83E+03	1.76E+06		1.76E+06	5.81E+03	1.76E+06		1.76E+06
Y-90		1.77E+06	5.83E+03	1.76E+06		1.76E+06	5.81E+03	1.76E+06		1.76E+06
Tc-99		8.77E+01	2.90E-01	8.74E+01		8.74E+01	2.89E-01	8.71E+01		8.71E+01
Total Curies		3.88E+06	1.28E+04	3.87E+06		3.87E+06	1.28E+04	3.85E+06		3.85E+06
Chemicals (kg)										
Ag+		1.43E+02	4.73E-01	1.43E+02		1.43E+02	4.72E-01	1.42E+02		1.42E+02
Al+3		9.18E+03	3.03E+01	9.15E+03		9.15E+03	3.02E+01	9.12E+03		9.12E+03
Am+3		2.92E+00	9.63E-03	2.91E+00		2.91E+00	9.60E-03	2.90E+00		2.90E+00
As+5		9.87E+01	3.26E-01	9.84E+01		9.84E+01	3.25E-01	9.81E+01		9.81E+01
B+3		8.29E+01	2.73E-01	8.26E+01		8.26E+01	2.72E-01	8.23E+01		8.23E+01
Ba+2		9.44E+01	3.12E-01	9.41E+01		9.41E+01	3.11E-01	9.38E+01		9.38E+01
Be+2		2.29E+00	7.56E-03	2.28E+00		2.28E+00	7.54E-03	2.28E+00		2.28E+00
Ca+2		4.85E+02	1.60E+00	4.82E+02		4.82E+02	1.59E+00	4.80E+02		4.80E+02
Cd+2		2.58E+03	8.50E+00	2.57E+03		2.57E+03	8.47E+00	2.56E+03		2.56E+03
Ce+3		1.32E+02	4.36E-01	1.32E+02		1.32E+02	4.35E-01	1.31E+02		1.31E+02
Cm+3		3.98E-03	1.31E-05	3.97E-03		3.97E-03	1.31E-05	3.96E-03		3.96E-03
Co+3		3.19E-05	1.05E-07	3.18E-05		3.18E-05	1.05E-07	3.17E-05		3.17E-05
Cr+3		2.15E+02	7.11E-01	2.15E+02		2.15E+02	7.09E-01	2.14E+02		2.14E+02
Cs+		7.69E+00	2.54E-02	7.67E+00		7.67E+00	2.53E-02	7.64E+00		7.64E+00
Cu+2		5.96E+01	1.97E-01	5.94E+01		5.94E+01	1.96E-01	5.92E+01		5.92E+01
Fe+3		2.25E+04	7.42E+01	2.24E+04		2.24E+04	7.40E+01	2.23E+04		2.23E+04
K+		2.01E+02	6.63E-01	2.00E+02		2.00E+02	6.61E-01	2.00E+02		2.00E+02
La+3		7.69E+02	2.54E+00	7.67E+02		7.67E+02	2.53E+00	7.64E+02		7.64E+02
Li+		4.81E+00	1.59E-02	4.79E+00		4.79E+00	1.58E-02	4.78E+00		4.78E+00
Mg+2		1.63E+02	5.38E-01	1.63E+02		1.63E+02	5.36E-01	1.62E+02		1.62E+02
Mn+4		4.94E+02	1.63E+00	4.93E+02		4.93E+02	1.63E+00	4.91E+02		4.91E+02
Mo+6		4.03E+00	1.33E-02	4.01E+00		4.01E+00	1.32E-02	4.00E+00		4.00E+00
Na+		7.09E+03	2.34E+01	7.07E+03		7.07E+03	2.33E+01	7.04E+03		7.04E+03
Ni+3		1.52E+03	5.01E+00	1.51E+03		1.51E+03	5.00E+00	1.51E+03		1.51E+03
Pb+4		1.88E+02	6.20E-01	1.87E+02		1.87E+02	6.18E-01	1.87E+02		1.87E+02
Pu+4		4.64E+00	1.53E-02	4.62E+00		4.62E+00	1.52E-02	4.60E+00		4.60E+00
Re+7		1.23E+01	4.05E-02	1.22E+01		1.22E+01	4.04E-02	1.22E+01		1.22E+01
Rh+3		7.09E+01	2.34E-01	7.07E+01		7.07E+01	2.33E-01	7.04E+01		7.04E+01
Ru+3		3.07E+01	1.01E-01	3.06E+01		3.06E+01	1.01E-01	3.05E+01		3.05E+01
Se+6		1.74E+02	5.75E-01	1.74E+02		1.74E+02	5.73E-01	1.73E+02		1.73E+02
Si+4		7.21E+02	2.38E+00	7.19E+02		7.19E+02	2.37E+00	7.16E+02		7.16E+02
Sr+2		6.95E+01	2.29E-01	6.93E+01		6.93E+01	2.28E-01	6.91E+01		6.91E+01
Te+6		5.84E+01	1.94E-01	5.84E+01		5.84E+01	1.93E-01	5.82E+01		5.82E+01
Ti+4		1.31E+01	4.33E-02	1.31E+01		1.31E+01	4.32E-02	1.31E+01		1.31E+01
Tl+3		9.44E+00	3.12E-02	9.41E+00		9.41E+00	3.11E-02	9.38E+00		9.38E+00
UO2+2		2.35E+03	7.76E+00	2.34E+03		2.34E+03	7.74E+00	2.34E+03		2.34E+03
V+5		5.75E+00	1.80E-02	5.73E+00		5.73E+00	1.79E-02	5.71E+00		5.71E+00
Zn+2		2.41E+01	7.96E-02	2.40E+01		2.40E+01	7.93E-02	2.40E+01		2.40E+01
Cl-		2.52E+01	8.33E-02	2.52E+01		2.52E+01	8.30E-02	2.51E+01		2.51E+01
CO3-2		1.34E+04	4.42E+01	1.34E+04		1.34E+04	4.40E+01	1.33E+04		1.33E+04
F-		2.13E+01	7.02E-02	2.12E+01		2.12E+01	7.00E-02	2.12E+01		2.12E+01
I-		1.43E-01	4.70E-04	1.42E-01		1.42E-01	4.69E-04	1.42E-01		1.42E-01
NO2-		6.50E+02	2.14E+00	6.48E+02		6.48E+02	2.14E+00	6.44E+02		6.44E+02
NO3-		1.80E+02	5.95E-01	1.80E+02		1.80E+02	5.93E-01	1.79E+02		1.79E+02
OH-		4.07E+04	1.34E+02	4.06E+04		4.06E+04	1.34E+02	4.04E+04		4.04E+04
PO4-3		2.43E+03	8.02E+00	2.42E+03		2.42E+03	7.99E+00	2.41E+03		2.41E+03
SO4-2		8.93E+02	2.95E+00	8.90E+02		8.90E+02	2.94E+00	8.87E+02		8.87E+02
TcO4-		8.54E+00	2.82E-02	8.51E+00		8.51E+00	2.81E-02	8.48E+00		8.48E+00
MnO2										
Organic Carbon		4.71E+02	1.56E+00	4.70E+02		4.70E+02	1.55E+00	4.68E+02		4.68E+02
ZrO2:2H2O		5.43E+03	1.79E+01	5.42E+03		5.42E+03	1.79E+01	5.40E+03		5.40E+03
Ag2O										
Al2O3										
Am2O3										
As2O5										

STREAM NAME	11	12	13	14	15	16	17	18	19	20
SOLID COMPONENTS										
Chemicals Continued (kg)										
B_2O_3										
BaO										
BeO										
Bi_2O_3										
CaO										
CdO										
Ce_2O_3										
Cm_2O_3										
Co_2O_3										
Cr_2O_3										
Cs_2O										
CuO										
Eu_2O_3										
Fe_2O_3										
K_2O										
La_2O_3										
Li_2O										
MgO										
MoO_3										
Na_2O										
Ni_2O_3										
NpO_2										
P_2O_5										
PbO_2										
PuO_2										
Re_2O_7										
Rh_2O_3										
Ru_2O_3										
SeO_3										
SiO_2										
SO_3										
SrO										
Tc_2O_7										
TeO_3										
TiO_2										
Tl_2O_3										
UO_3										
V_2O_5										
WO_3										
ZnO										
ZrO_2										

STREAM NAME	21	22	23	24	25
LIQUID COMPONENTS					
Total Mass Flow (kg)	1.59E+04		7.66E+02	8.68E+05	
Volume (L)	6.62E+03		7.66E+02	8.68E+05	
Specific Gravity	2.41E+00		1.00E+00	1.00E+00	
Radionuclides (Ci)					
Am-241	3.32E-03				
C-14	1.91E-04				
Cs-137	1.31E+06				
Ba-137	1.24E+06				
Eu-154	1.13E-02				
Np-237	8.41E-08				
Pu-239	7.39E-04				
Pu-240	1.84E-04				
Pu-241	1.42E-03				
Sr-90	4.86E-01				
Y-90	4.86E-01				
Tc-99	1.19E+02				
Total Curies	2.55E+06				
Chemicals (kg)					
Ag+	6.18E-07				
Am+3	9.68E-07				
As+5	5.46E-07				
B+3	5.76E-06				
Ba+2	8.20E-06				
Be+2	5.17E-14				
Bi+3	9.59E-07				
Ca+2	1.05E-02				
Cd+2	2.23E-06				
Ce+3					
Co+3					
Cs+	1.51E+01				
Cu+2	8.36E-07				
Eu+3	4.28E-08				
Fe+3	1.54E-02				
Hg+2	1.08E-06				
K+	7.55E-02				
La+3	8.20E-05				
Li+					
Mg+2	2.38E-05				
Mn+4	5.12E-03				
Mo+6	6.63E-06				
Na+	7.65E+03				
Ni+3	8.33E-03				
Np+4	1.19E-07				
Pb+4	3.39E-03				
Pu+4	1.28E-06				
Re+7					
Rh+3					
Ru+3					
Se+6	4.00E-08				
Si+4	4.09E-04				
Sn+4	3.19E-16				
Sr+2	3.45E-06				
Te+6					
Ti+4	3.94E-08				
Tl+3					
UO2+2	3.35E-03				
V+5					
W+6	1.40E-05				
Zn+2	4.69E-05				
Zr+4	3.58E-07				
Al(OH)4-	1.26E+00				
Cl-	7.40E-02				
CO3-2	2.05E+00				
Cr(OH)4-	1.37E-02				
F-	5.05E-02				
I-					
NO2-	2.51E+00				
NO3-	7.41E+00				
OH-	5.64E+03				
PO4-3	1.24E-01				
SO4-2	4.22E-01				
TcO4-	1.15E+01				
H2O	2.61E+03			8.55E+05	
Organic Carbon	1.19E+00				
ZrO2:2H2O					
Hg				1.08E-06	
Cl2				2.51E+01	
CO2				1.19E+04	
F2				3.55E+01	
I2				1.42E-01	
N2				1.29E+02	
NO				8.31E+02	
O2			7.66E+02		
NH3				2.50E+00	

STREAM NAME	21	22	23	24	25
SOLID COMPONENTS					
Total Mass Flow (kg)	4.22E-01	1.82E+05			2.75E+05
Radionuclides (Ci)					
Am-241	7.79E+01				1.00E+04
C-14					
Cm-244					3.21E+02
Cs-137					1.49E+06
Ba-137					1.42E+06
Eu-154					1.13E-02
Np-237					8.41E-08
Pu-239	3.51E+00				2.89E+02
Pu-240	8.77E-01				8.77E-01
Pu-241					1.42E-03
Sr-90	3.24E+04				1.79E+06
Y-90	3.24E+04				1.79E+06
Tc-99					2.07E+02
Total Curies	6.49E+04				6.50E+06
Chemicals (kg)					
Ag+					
Al+3					
Am+3	2.27E-02				
As+5					
B+3					
Ba+2					
Be+2					
Ca+2					
Cd+2					
Ce+3					
Cm+3					
Co+3					
Cr+3					
Cs+					
Cu+2					
Fe+3					
K+					
La+3					
Li+					
Mg+2					
Mn+4					
Mo+6					
Na+					
Ni+3					
Pb+4					
Pu+4	6.05E-02				
Re+7					
Rh+3					
Ru+3					
Se+6					
Si+4					
Sr+2	2.30E-01				
Te+6					
Ti+4					
Tl+3					
UO2+2					
V+5					
Zn+2					
Cl-					
CO3-2					
F-					
I-					
NO2-					
NO3-					
OH-	1.09E-01				
PO4-3					
SO4-2					
TcO4-					
MnO2					7.77E+02
Organic Carbon					
ZrO2:2H2O					
Ag2O					1.53E+02
Al2O3					1.79E+04
Am2O3					3.21E+00
As2O5					1.50E+02

STREAM NAME	21	22	23	24	25
SOLID COMPONENTS					
Chemicals Continued (kg)					
B2O3		2.39E+04			2.42E+04
BaO					1.05E+02
BeO					6.32E+00
Bi2O3					1.07E-06
CaO					6.72E+02
CdO					2.92E+03
Ce2O3					1.57E+02
Cm2O3					4.34E-03
Co2O3					4.49E-06
Cr2O3					3.34E+02
Cs2O					2.78E+01
CuO					7.41E+01
Eu2O3					4.95E-08
Fe2O3					3.19E+04
K2O					2.42E+02
La2O3					8.92E+02
Li2O		2.74E+03			2.72E+03
MgO					2.69E+02
MoO3					6.04E+00
Na2O					2.28E+04
Ni2O3					2.13E+03
NpO2					1.35E-07
P2O5					1.81E+03
PbO2					2.16E+02
PuO2					5.29E+00
Re2O7					1.59E+01
Rh2O3					8.69E+01
Ru2O3					3.78E+01
SeO3					2.78E+02
SiO2		1.55E+05			1.57E+05
SO3					9.59E+02
SrO					8.16E+01
Tc2O7					1.92E+01
TeO3					8.02E+01
TiO2					2.18E+01
Tl2O3					1.05E+01
UO3					2.50E+03
V2O5					9.67E+00
WO3					1.77E-05
ZnO					2.98E+01
ZrO2					4.18E+03

Table C-3. Phase I In-Tank Sludge Washing of Tank 241-AY-102/241-C-106 (36 Percent/99 Percent Retrieval).

16-Aug-96 07:32:26

STREAM NAME	1	3	4	5	6	7	8	9	10	19
LIQUID COMPONENTS										
Total Mass Flow (kg)	4.28E+06	4.28E+06	2.12E+06	2.16E+06	6.43E+05	2.80E+06	2.80E+06	6.50E+05	2.15E+06	3.31E+06
Volume (L)	4.20E+06	4.20E+06	2.08E+06	2.12E+06	6.40E+05	2.76E+06	2.76E+06	6.40E+05	2.12E+06	3.31E+06
Specific Gravity	1.02E+00	1.02E+00	1.02E+00	1.02E+00	1.00E+00	1.02E+00	1.02E+00	1.02E+00	1.02E+00	1.00E+00
Radionuclides (Ci)										
Am-241	1.55E+01	1.55E+01	7.67E+00	7.83E+00		7.83E+00	7.83E+00	1.82E+00	6.02E+00	
C-14										
Cm-244	1.34E-02	1.34E-02	6.65E-03	6.79E-03		6.79E-03	6.79E-03	1.57E-03	5.22E-03	
Co-60	4.57E+00	4.57E+00	2.28E+00	2.31E+00		2.31E+00	2.31E+00	5.35E-01	1.77E+00	
Cs-137	6.86E+04	6.86E+04	3.40E+04	3.47E+04		3.47E+04	3.47E+04	8.03E+03	2.66E+04	
Ba-137	6.52E+04	6.52E+04	3.23E+04	3.29E+04		3.29E+04	3.29E+04	7.63E+03	2.53E+04	
Eu-154										
Np-237										
Pu-239	1.54E+02	1.54E+02	7.61E+01	7.77E+01		7.77E+01	7.77E+01	1.80E+01	5.97E+01	
Pu-240										
Pu-241										
Sr-90	3.72E+03	3.72E+03	1.84E+03	1.88E+03		1.88E+03	1.88E+03	4.35E+02	1.44E+03	
Y-90	3.72E+03	3.72E+03	1.84E+03	1.88E+03		1.88E+03	1.88E+03	4.35E+02	1.44E+03	
Tc-99	6.16E+01	6.16E+01	3.05E+01	3.11E+01		3.11E+01	3.11E+01	7.21E+00	2.39E+01	
Total Curies	1.42E+05	1.42E+05	7.00E+04	7.15E+04		7.15E+04	7.15E+04	1.66E+04	5.49E+04	
Chemicals (kg)										
Ag+	2.83E+01	2.83E+01	1.40E+01	1.43E+01		1.43E+01	1.43E+01	3.31E+00	1.10E+01	
Am+3	4.52E-03	4.52E-03	2.24E-03	2.28E-03		2.28E-03	2.28E-03	5.29E-04	1.75E-03	
As+5										
B+3	5.14E+00	5.14E+00	2.54E+00	2.60E+00		2.60E+00	2.60E+00	6.02E-01	2.00E+00	
Ba+2	4.93E+00	4.93E+00	2.44E+00	2.49E+00		2.49E+00	2.49E+00	5.78E-01	1.92E+00	
Be+2										
Bi+3	1.56E+01	1.56E+01	7.74E+00	7.90E+00		7.90E+00	7.90E+00	1.83E+00	6.07E+00	
Ca+2	5.78E+01	5.78E+01	2.86E+01	2.92E+01		2.92E+01	2.92E+01	6.77E+00	2.24E+01	
Cd+2	1.26E+01	1.26E+01	6.24E+00	6.37E+00		6.37E+00	6.37E+00	1.48E+00	4.90E+00	
Cm+3	1.66E-07	1.66E-07	8.21E-08	8.38E-08		8.38E-08	8.38E-08	1.94E-08	6.44E-08	
Co+3	4.04E-06	4.04E-06	2.00E-06	2.04E-06		2.04E-06	2.04E-06	4.73E-07	1.57E-06	
Cs+	4.18E+00	4.18E+00	2.07E+00	2.11E+00		2.11E+00	2.11E+00	4.89E-01	1.62E+00	
Cu+2	1.55E+00	1.55E+00	7.65E-01	7.81E-01		7.81E-01	7.81E-01	1.81E-01	6.00E-01	
Eu+3										
Fe+3	1.16E+00	1.16E+00	5.73E-01	5.85E-01		5.85E-01	5.85E-01	1.36E-01	4.49E-01	
Hg+2										
K+	3.35E+02	3.35E+02	1.66E+02	1.69E+02		1.69E+02	1.69E+02	3.93E+01	1.30E+02	
La+3	1.64E-01	1.64E-01	8.12E-02	8.29E-02		8.29E-02	8.29E-02	1.92E-02	6.37E-02	
Mg+2	1.13E+01	1.13E+01	5.60E+00	5.72E+00		5.72E+00	5.72E+00	1.33E+00	4.39E+00	
Mn+4	5.11E+00	5.11E+00	2.53E+00	2.58E+00		2.58E+00	2.58E+00	5.98E-01	1.98E+00	
Mo+6										
Na+	5.97E+04	5.97E+04	2.95E+04	3.02E+04	1.62E+03	3.18E+04	3.18E+04	7.37E+03	2.44E+04	
Ni+3	3.33E+01	3.33E+01	1.65E+01	1.68E+01		1.68E+01	1.68E+01	3.89E+00	1.29E+01	
Np+4										
Pb+2	4.57E+01	4.57E+01	2.26E+01	2.31E+01		2.31E+01	2.31E+01	5.35E+00	1.77E+01	
Pu+4	2.48E+00	2.48E+00	1.23E+00	1.25E+00		1.25E+00	1.25E+00	2.90E-01	9.62E-01	
Se+6										
Si+4	1.78E+03	1.78E+03	8.81E+02	8.99E+02		8.99E+02	8.99E+02	2.08E+02	6.91E+02	
Sn+4										
Sr+2	5.93E-01	5.93E-01	2.94E-01	3.00E-01		3.00E-01	3.00E-01	6.94E-02	2.30E-01	
Ti+4										
UO2+2	1.74E+03	1.74E+03	8.59E+02	8.77E+02		8.77E+02	8.77E+02	2.03E+02	6.74E+02	
W+6										
Zn+2										
Zr+4	1.17E+02	1.17E+02	5.77E+01	5.89E+01		5.89E+01	5.89E+01	1.37E+01	4.53E+01	
Al(OH)4-	9.50E+01	9.50E+01	4.70E+01	4.80E+01		4.80E+01	4.80E+01	1.11E+01	3.69E+01	
Cl-	2.61E+03	2.61E+03	1.29E+03	1.32E+03		1.32E+03	1.32E+03	3.06E+02	1.01E+03	
CO3-2										
Cr(OH)4-	1.47E+02	1.47E+02	7.27E+01	7.42E+01		7.42E+01	7.42E+01	1.72E+01	5.70E+01	
F-	6.26E+02	6.26E+02	3.10E+02	3.16E+02		3.16E+02	3.16E+02	7.32E+01	2.43E+02	
NO2-	3.28E+03	3.28E+03	1.63E+03	1.66E+03	2.95E+02	1.95E+03	1.95E+03	4.53E+02	1.50E+03	
NO3-	1.65E+03	1.65E+03	8.17E+02	8.34E+02		8.34E+02	8.34E+02	1.93E+02	6.41E+02	
OH-	4.25E+04	4.25E+04	2.10E+04	2.15E+04	1.09E+03	2.24E+04	2.24E+04	5.23E+03	1.73E+04	
PO4-3	1.72E+03	1.72E+03	8.51E+02	8.69E+02		8.69E+02	8.69E+02	2.01E+02	6.67E+02	
SO4-2	5.98E+03	5.98E+03	2.96E+03	3.02E+03		3.02E+03	3.02E+03	7.00E+02	2.32E+03	
TcO4-	6.00E+00	6.00E+00	2.97E+00	3.03E+00		3.03E+00	3.03E+00	7.02E-01	2.33E+00	
H2O	4.15E+06	4.15E+06	2.05E+06	2.10E+06	6.40E+05	2.74E+06	2.74E+06	6.34E+05	2.10E+06	3.31E+06
Organic Carbon	6.12E+03	6.12E+03	3.03E+03	3.09E+03		3.09E+03	3.09E+03	7.16E+02	2.37E+03	
ZrO2:2H2O	4.94E-01	4.94E-01	2.45E-01	2.50E-01		2.50E-01	2.50E-01	5.79E-02	1.92E-01	
Hg										
Cl2										
CO2										
F2										
N2										
NO										
O2										
NH3										

STREAM NAME	1	3	4	5	6	7	8	9	10	19
SOLID COMPONENTS										
Total Mass Flow (kg)	5.10E+05	5.10E+05	1.68E+03	5.08E+05		5.08E+05	5.08E+05	1.68E+03	5.07E+05	
Radionuclides (Ci)										
Am-241	2.27E+03	2.27E+03	7.49E+00	2.26E+03		2.26E+03	2.26E+03	7.47E+00	2.26E+03	
C-14	3.56E-01	3.56E-01	1.18E-03	3.55E-01		3.55E-01	3.55E-01	1.17E-03	3.54E-01	
Cm-244										
Co-60	1.46E+02	1.46E+02	4.83E-01	1.46E+02		1.46E+02	1.46E+02	4.82E-01	1.46E+02	
Cs-137	2.92E+05	2.92E+05	9.63E+02	2.91E+05		2.91E+05	2.91E+05	9.60E+02	2.90E+05	
Ba-137	2.77E+05	2.77E+05	9.15E+02	2.76E+05		2.76E+05	2.76E+05	9.12E+02	2.75E+05	
Eu-154										
Np-237										
Pu-239	3.42E+03	3.42E+03	1.13E+01	3.41E+03		3.41E+03	3.41E+03	1.13E+01	3.40E+03	
Pu-240										
Pu-241										
Sr-90	2.81E+06	2.81E+06	9.29E+03	2.81E+06		2.81E+06	2.81E+06	9.26E+03	2.80E+06	
Y-90	2.81E+06	2.81E+06	9.29E+03	2.81E+06		2.81E+06	2.81E+06	9.26E+03	2.80E+06	
Tc-99	2.08E+02	2.08E+02	6.85E-01	2.07E+02		2.07E+02	2.07E+02	6.83E-01	2.06E+02	
Total Curies	6.20E+06	6.20E+06	2.05E+04	6.18E+06		6.18E+06	6.18E+06	2.04E+04	6.16E+06	
Chemicals (kg)										
Ag+	9.33E+02	9.33E+02	3.08E+00	9.30E+02		9.30E+02	9.30E+02	3.07E+00	9.27E+02	
Al+3	4.52E+04	4.52E+04	1.49E+02	4.50E+04		4.50E+04	4.50E+04	1.49E+02	4.49E+04	
Am+3	6.62E-01	6.62E-01	2.18E-03	6.60E-01		6.60E-01	6.60E-01	2.18E-03	6.58E-01	
B+3	1.65E+01	1.65E+01	5.45E-02	1.65E+01		1.65E+01	1.65E+01	5.43E-02	1.64E+01	
Ba+2	5.24E+03	5.24E+03	1.74E+01	5.24E+03		5.24E+03	5.24E+03	1.74E+01	5.23E+03	
Bi+3	5.27E+02	5.27E+02	1.74E+00	5.25E+02		5.25E+02	5.25E+02	1.74E+00	5.24E+02	
Ca+2	1.33E+04	1.33E+04	4.39E+01	1.33E+04		1.33E+04	1.33E+04	4.38E+01	1.32E+04	
Cd+2	4.03E+02	4.03E+02	1.33E+00	4.01E+02		4.01E+02	4.01E+02	1.32E+00	4.00E+02	
Co+3	5.08E+00	5.08E+00	1.68E-02	5.06E+00		5.06E+00	5.06E+00	1.67E-02	5.05E+00	
Cr+3	1.21E+03	1.21E+03	3.99E+00	1.21E+03		1.21E+03	1.21E+03	3.98E+00	1.20E+03	
Cs+	1.78E+01	1.78E+01	5.87E-02	1.77E+01		1.77E+01	1.77E+01	5.85E-02	1.77E+01	
Cu+2	1.34E+02	1.34E+02	4.42E-01	1.34E+02		1.34E+02	1.34E+02	4.41E-01	1.33E+02	
Fe+3	5.94E+04	5.94E+04	1.96E+02	5.92E+04		5.92E+04	5.92E+04	1.95E+02	5.90E+04	
K+	1.50E+03	1.50E+03	4.95E+00	1.49E+03		1.49E+03	1.49E+03	4.92E+00	1.49E+03	
La+3	2.07E+02	2.07E+02	6.84E-01	2.07E+02		2.07E+02	2.07E+02	6.84E-01	2.06E+02	
Mg+2	6.91E+03	6.91E+03	2.28E+01	6.89E+03		6.89E+03	6.89E+03	2.27E+01	6.87E+03	
Mn+4	2.43E+03	2.43E+03	8.01E+00	2.42E+03		2.42E+03	2.42E+03	7.99E+00	2.41E+03	
Na+	8.42E+04	8.42E+04	2.78E+02	8.40E+04		8.40E+04	8.40E+04	2.77E+02	8.37E+04	
Ni+3	1.16E+03	1.16E+03	3.82E+00	1.15E+03		1.15E+03	1.15E+03	3.81E+00	1.15E+03	
Pb+4	2.51E+03	2.51E+03	8.27E+00	2.50E+03		2.50E+03	2.50E+03	8.24E+00	2.49E+03	
Pd+2	1.69E+02	1.69E+02	5.56E-01	1.68E+02		1.68E+02	1.68E+02	5.54E-01	1.67E+02	
Pu+4	5.52E+01	5.52E+01	1.82E-01	5.50E+01		5.50E+01	5.50E+01	1.82E-01	5.49E+01	
Si+4	7.64E+04	7.64E+04	2.52E+02	7.61E+04		7.61E+04	7.61E+04	2.51E+02	7.59E+04	
Sr+2	1.67E+02	1.67E+02	5.51E-01	1.66E+02		1.66E+02	1.66E+02	5.49E-01	1.66E+02	
UO2+2	9.42E+02	9.42E+02	3.11E+00	9.39E+02		9.39E+02	9.39E+02	3.10E+00	9.36E+02	
Zn+2	4.89E+01	4.89E+01	1.61E-01	4.87E+01		4.87E+01	4.87E+01	1.61E-01	4.86E+01	
Zr+4	2.20E+03	2.20E+03	7.27E+00	2.20E+03		2.20E+03	2.20E+03	7.25E+00	2.19E+03	
Cl-	5.64E+01	5.64E+01	1.86E-01	5.62E+01		5.62E+01	5.62E+01	1.86E-01	5.61E+01	
F-	6.71E+01	6.71E+01	2.22E-01	6.69E+01		6.69E+01	6.69E+01	2.21E-01	6.67E+01	
NO2-	1.25E+01	1.25E+01	4.13E-02	1.25E+01		1.25E+01	1.25E+01	4.12E-02	1.25E+01	
NO3-	1.02E+01	1.02E+01	3.36E-02	1.02E+01		1.02E+01	1.02E+01	3.35E-02	1.01E+01	
OH-	1.94E+05	1.94E+05	6.42E+02	1.94E+05		1.94E+05	1.94E+05	6.39E+02	1.93E+05	
PO4-3	7.94E+03	7.94E+03	2.62E+01	7.91E+03		7.91E+03	7.91E+03	2.61E+01	7.89E+03	
SO4-2	1.22E+02	1.22E+02	4.16E-01	1.22E+02		1.22E+02	1.22E+02	4.15E-01	1.22E+02	
TcO4-	2.02E+01	2.02E+01	6.67E-02	2.02E+01		2.02E+01	2.02E+01	6.65E-02	2.01E+01	
MnO2										
Organic Carbon	2.04E+03	2.04E+03	6.73E+00	2.03E+03		2.03E+03	2.03E+03	6.71E+00	2.03E+03	
ZrO2:2H2O	1.89E-03	1.89E-03	6.24E-06	1.89E-03		1.89E-03	1.89E-03	6.22E-06	1.88E-03	
Ag2O										

STREAM NAME	1	3	4	5	6	7	8	9	10	19
SOLID COMPONENTS										
Chemicals Continued (kg)										
Al2O3										
Am2O3										
As2O5										
B2O3										
BaO										
BeO										
Bi2O3										
CaO										
CdO										
Cm2O3										
Co2O3										
Cr2O3										
Cs2O										
CuO										
Eu2O3										
Fe2O3										
K2O										
La2O3										
Li2O										
MgO										
MoO3										
Na2O										
Ni2O3										
NpO2										
P2O5										
PbO2										
PdO										
PuO2										
SeO3										
SiO2										
SO3										
SrO										
Tc2O7										
TiO2										
UO3										
WO3										
ZnO										
ZrO2										

STREAM NAME	20	21	22	23	24	25
LIQUID COMPONENTS						
Total Mass Flow (kg)	5.46E+06	9.56E+04		1.14E+05	5.57E+06	
Volume (L)	5.43E+06	3.98E+04		1.14E+05	5.57E+06	
Specific Gravity	1.01E+00	2.41E+00		1.00E+00	1.00E+00	
Radionuclides (Ci)						
Am-241	6.02E+00	1.99E-02				
C-14		1.15E-03				
Cm-244	5.22E-03					
Co-60	1.77E+00					
Cs-137	2.67E+04	7.86E+06				
Ba-137	2.53E+04	7.44E+06				
Eu-154		6.77E-02				
Np-237		5.05E-07				
Pu-239	5.97E+01	4.43E-03				
Pu-240		1.11E-03				
Pu-241		8.51E-03				
Sr-90	1.44E+03	2.92E+00				
Y-90	1.44E+03	2.92E+00				
Tc-99	2.39E+01	7.14E+02				
Total Curies	5.49E+04	1.53E+07				
Chemicals (kg)						
Ag+	1.10E+01	3.71E-06				
Am+3	1.75E-03	5.79E-06				
As+5		3.28E-06				
B+3	2.00E+00	3.46E-05				
Ba+2	1.92E+00	4.92E-05				
Be+2		3.10E-13				
Bi+3	6.07E+00	5.77E-06				
Ca+2	2.24E+01	6.28E-02				
Cd+2	4.90E+00	1.34E-05				
Cm+3	6.44E-08					
Co+3	1.57E-06					
Cs+	1.62E+00	9.07E+01				
Cu+2	6.00E-01	5.02E-06				
Eu+3		2.57E-07				
Fe+3	4.49E-01	9.25E-02				
Hg+2		6.50E-06				
K+	1.30E+02	4.53E-01				
La+3	6.37E-02	4.92E-04				
Mg+2	4.38E+00	1.43E-04				
Mn+4	1.98E+00	3.08E-02				
Mo+6		3.97E-05				
Na+	2.44E+04	4.58E+04				
Ni+3	1.29E+01	4.98E-02				
Np+4		7.16E-07				
Pb+4	1.77E+01	2.03E-02				
Pu+4	9.62E-01	7.64E-05				
Se+6		2.40E-07				
Si+4	6.91E+02	2.45E-03				
Sn+4		1.91E-15				
Sr+2	2.30E-01	2.07E-05				
Ti+4		2.36E-07				
UO2+2	6.74E+02	2.01E-02				
W+6		8.40E-05				
Zn+2		2.82E-04				
Zr+4	4.53E+01	2.14E-06				
Al(OH)4-	3.69E+01	7.58E+00				
Cl-	1.01E+03	4.44E-01				
CO3-2		1.23E+01				
Cr(OH)4-	5.70E+01	8.25E-02				
F-	2.43E+02	3.03E-01				
NO2-	1.50E+03	1.50E+01				
NO3-	6.41E+02	4.45E+01				
OH-	1.73E+04	3.39E+04				
PO4-3	6.67E+02	7.47E-01				
SO4-2	2.32E+03	2.53E+00				
TcO4-	2.33E+00	6.92E+01				
H2O	5.41E+06	1.57E+04			5.55E+06	
Organic Carbon	2.37E+03	7.18E+00				
ZrO2:2H2O	1.92E-01					
Hg					6.50E-06	
Cl2					1.07E+03	
CO2					1.62E+04	
F2					3.10E+02	
N2					1.51E+02	
NO					1.01E+03	
O2				1.14E+05		
NH3					3.03E+00	

STREAM NAME	20	21	22	23	24	25
SOLID COMPONENTS						
Total Mass Flow (kg)	5.07E+05	2.53E+00	3.28E+05			9.33E+05
Radionuclides (Ci)						
Am-241	2.26E+03	4.68E+02				2.73E+03
C-14	3.54E-01					
Cm-244						5.22E-03
Co-60	1.46E+02					1.50E+02
Cs-137	2.90E+05					8.17E+06
Ba-137	2.75E+05					7.76E+06
Eu-154						6.72E-02
Np-237						5.05E-07
Pu-239	3.40E+03	2.11E+01				3.48E+03
Pu-240		5.26E+00				5.26E+00
Pu-241						8.51E-03
Sr-90	2.80E+06	1.95E+05				2.99E+06
Y-90	2.80E+06	1.95E+05				2.99E+06
Tc-99	2.06E+02					9.44E+02
Total Curies	6.16E+06	3.90E+05				2.19E+07
Chemicals (kg)						
Ag+	9.27E+02					
Al+3	4.49E+04					
Am+3	6.58E-01	1.37E-01				
B+3	1.64E+01					
Ba+2	5.23E+03					
Bi+3	5.24E+02					
Ca+2	1.32E+04					
Cd+2	4.00E+02					
Co+3	5.05E+00					
Cr+3	1.20E+03					
Cs+	1.77E+01					
Cu+2	1.33E+02					
Fe+3	5.90E+04					
K+	1.49E+03					
La+3	2.06E+02					
Mg+2	6.87E+03					
Mn+4	2.41E+03					
Na+	8.37E+04					
Ni+3	1.15E+03					
Pb+4	2.49E+03					
Pd+2	1.67E+02					
Pu+4	5.49E+01	3.63E-01				
Si+4	7.59E+04					
Sr+2	1.66E+02	1.38E+00				
UO2+2	9.32E+02					
Zn+2	4.86E+01					
Zr+4	2.19E+03					
Cl-	5.61E+01					
F-	6.67E+01					
NO2-	1.25E+01					
NO3-	1.01E+01					
OH-	1.93E+05	6.52E-01				
PO4-3	7.89E+03					
SO4-2	1.25E+02					
TcO4-	2.01E+01					
MnO2						3.82E+03
Organic Carbon	2.03E+03					
ZrO2:2H2O	1.88E-03					
Ag2O						1.01E+03

STREAM NAME	20	21	22	23	24	25
SOLID COMPONENTS						
Chemicals Continued (kg)						
Al2O3						8.48E+04
Am2O3						8.75E-01
As2O5						5.02E-06
B2O3			4.66E+04			4.67E+04
BaO						5.84E+03
BeO						8.61E-13
Bi2O3						5.91E+02
CaO						1.85E+04
CdO						4.63E+02
Cm2O3						7.04E-08
Co2O3						7.10E+00
Cr2O3						1.79E+03
Cs2O						1.17E+02
CuO						1.67E+02
Eu2O3						2.97E-07
Fe2O3						8.43E+04
K2O						1.92E+03
La2O3						2.42E+02
Li2O			9.33E+03			9.33E+03
MgO						1.14E+04
MoO3						5.98E-05
Na2O						2.08E+05
Ni2O3						1.64E+03
NpO2						8.13E-07
P2O5						6.39E+03
PbO2						2.89E+03
PdO						1.93E+02
PuO2						6.37E+01
SeO3						3.86E-07
SiO2			2.72E+05			4.33E+05
SO3						2.04E+03
SrO						1.97E+02
Tc2O7						8.74E+01
TiO2						3.93E-07
UO3						1.71E+03
WO3						1.06E-04
ZrO						6.05E+01
ZrO2						3.02E+03

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APPENDIX D

PHASE I HIGH-LEVEL WASTE INVENTORY AND GLASS COMPOSITION ESTIMATES

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APPENDIX D

GLASS COMPOSITION ESTIMATES

This document discusses the relationships between the high-level waste (HLW) glass formulation and the pretreatment strategy. The following data tables (Tables D-2 through D-5) provide example glass compositions based on Composition Variation Study (CVS) glass limits and 25 wt% oxide loading excluding sodium and silicon. Table D-1 presents example low-temperature glass formulations.

Table D-1. Low-Temperature Glass Formulations for High-Level Waste. (2 sheets)

	Low-temperature glass formulation			
	Flowsheet (Orme 1995)[a]		CVS (1150°C)[b]	
Oxide component[c]	Lower limit	Upper limit	Lower limit	Upper limit
Single-component constraints				
SiO_2	46.0	56.0	42.0	57.0
B_2O_3	7.0	17.0	5.0	20.0
Na_2O+K_2O	7.0	12.5	5.0	20.0
Li_2O	2.0	6.0	1.0	7.0
CaO	0.0	7.0	0.0	10.0
MgO	0.0	5.0	0.0	8.0
Fe_2O_3	4.0	12.0	2.0	15.0
Al_2O_3	1.0	11.0	0.0	15.0
ZrO_2	--	10.0	--	13.0
Others[d,e]	2.5	8.0	1.0	10.0
Multiple-component constraints[i]				
Viscosity: $(Li_2O+Na_2O)/(SiO_2+Al_2O_3+ZrO_2)$[e]	0.152	0.342	0.152	0.342
Crystallinity:				
SiO_2/Al_2O_3[e]	4.5	--	3.0	--
MgO+CaO	--	8.0	--	10.0
$Al_2O_3+ZrO_2$[f]	--	14.0	--	16.0
$Al_2O_3+Fe_2O_3+ZrO_2$[f]	--	21.0	--	24.0
Solubility limits				
Cr_2O_3	--	0.5	--	0.5
F	--	1.7	--	1.7
P_2O_5[g,h]	--	3.0[h]	--	3.0[h]
$Rh_2O_3+PdO+Ru_2O_3$	--	0.25	--	0.25
SO_3	--	0.5	--	0.5

Table D-1. Low-Temperature Glass Formulations for High-Level Waste. (2 sheets)

	Low-temperature glass formulation			
	Flowsheet (Orme 1995)[a]		CVS (1150°C)[b]	
Oxide component[c]	Lower limit	Upper limit	Lower limit	Upper limit
Redox constraints				
Reductants (formic acid, oxalic acid, and sugar)	TBD	--	TBD	--

[a] Based on Table 13-11 of the *Hanford Waste Vitrification Plant Project Technical Data Package*, Rev. 6, dated February 1994 (WHC-SD-HWV-DP-001).

[b] Based on Tables 4.2 and 4.3 of *Property/Composition Relationships for Hanford High-Level Waste Glasses Melting at 1150°C*, Vol. 1, dated December 1994 (PNL-10359).

[c] g of oxide component per 100 g of nonvolatile (glass forming) oxides, halides, sulfate, and phosphate.

[d] All other glass components not specifically identified.

[e] Not currently used in the flowsheets.

[f] The Fe_2O_3, Al_2O_3, ZrO_2 and Others will not simultaneously be at their respective maximums.

[g] The phosphorous contributions from non-feed sources shall not exceed 0.066 wt% (as PO_4^{-3}) of the total glass-forming oxides in a melter feed batch.

[h] The phosphorus limit used in the flowsheets (Orme 1995) is 3.0 wt% PO_4^{-3} (5.2 wt% as $AlPO_4$). In the references above, the phosphorus limit is listed as 1.0 wt% P_2O_5 - equivalent to 1.33 wt% as PO_4^{-3}.

[i] Multiple component constraints are ignored for the CVS glass formulation (TBD).

Table D-2. Feed Oxide Quantities and Estimated Composition Variation Study Glass Compositions Immobilization of Tank 241-AZ-101 (90 Percent Retrieval) (2 Sheets)

Stream Oxide Components	HLW Oxides	LAW Oxides [a]	Formers [b]	Glass
Total Mass (MT)	8.75E+01	1.03E+01	2.11E+02	3.09E+02
MnO2	1.02E+00	8.11E-06		1.02E+00
Ag2O	2.25E-01	6.64E-10		2.25E-01
Al2O3	1.97E+01	6.77E-04		1.97E+01
Am2O3	7.95E-03	2.50E-05		7.98E-03
As2O5	1.83E-01	8.38E-10		1.83E-01
B2O3	2.03E-01	1.86E-08	3.45E+01	3.47E+01
BaO	1.73E-01	9.16E-09		1.73E-01
BeO	1.04E-02	1.43E-16		1.04E-02
Bi2O3		1.07E-09		1.07E-09
CaO	7.27E-01	1.46E-05		7.27E-01
CdO	1.38E+00	2.55E-09		1.38E+00
Ce2O3	3.03E-01			3.03E-01
Cm2O3	8.63E-06			8.63E-06
Co2O3	1.05E-06			1.05E-06
Cr2O3	2.48E-01	8.70E-06		2.48E-01
Cs2O	1.11E-02	1.60E-02		2.71E-02
CuO	1.15E-01	1.05E-09		1.15E-01
Eu2O3		4.95E-11		4.95E-11
Fe2O3	3.06E+01	2.20E-05		3.06E+01
K2O	7.93E-01	9.10E-05		7.93E-01
La2O3	9.49E-01	9.62E-08		9.49E-01
Li2O	3.27E-02		3.06E+00	3.09E+00
MgO	2.16E-01	3.94E-08		2.16E-01
MoO3	1.75E-02	9.94E-09		1.75E-02
Na2O	7.68E+00	1.03E+01		1.80E+01
Ni2O3	1.33E+00	1.17E-05		1.33E+00
NpO2		1.35E-10		1.35E-10
P2O5	1.54E+00	9.30E-05		1.54E+00
PbO2	1.30E-01	3.91E-06		1.30E-01
PdO				

Table D-2. Feed Oxide Quantities and Estimated Composition Variation Study Glass Compositions Immobilization of Tank 241-AZ-101 (90 Percent Retrieval) (2 Sheets)

Stream Oxide Components	HLW Oxides	LAW Oxides [a]	Formers [b]	Glass
PuO2	8.79E-03	6.86E-05		8.86E-03
Re2O7	1.58E-02			1.58E-02
Rh2O3	1.14E-01			1.14E-01
Ru2O3	2.34E-01			2.34E-01
Sb2O5	7.71E-01			7.71E-01
SeO3	6.13E-01	6.43E-11		6.13E-01
SiO2	2.57E+00	8.74E-07	1.73E+02	1.76E+02
SO3	9.59E-01	3.51E-04		9.59E-01
SrO	1.88E-01	2.71E-04		1.88E-01
Tc2O7	1.23E-02	1.10E-02		2.33E-02
TeO3	5.63E-01			5.63E-01
ThO2	2.99E-01			2.99E-01
TiO2	2.35E-01	6.57E-11		2.35E-01
Tl2O3	1.57E+00			1.57E+00
UO3	1.40E+00	3.55E-06		1.40E+00
V2O5	9.59E-03			9.59E-03
WO3		1.77E-08		1.77E-08
ZnO	1.07E-01	5.84E-08		1.07E-01
ZrO2	1.02E+01	4.83E-10		1.02E+01

HLW = High-level waste

LAW = Low-activity waste

[a] The LAW oxides are an estimate of the Intermediate Waste Products from LAW services that the HLW/LAW private contractor is required to incorporate into the HLW product. A bulk composition is calculated, based on Certa et al. (1996), and the mass is partitioned equally between the 14 HLW feed batches.

[b] The composition of glass formers have not been optimized to consider the physical properties of the glass.

Table D-3. Feed Oxide Quantities and Estimated Composition Variation Study Glass Compositions Immobilization of Tank 241-AZ-102. (60 Percent Retrieval) (2 sheets)

Stream oxide components	HLW oxides	LAW oxides [a]	Formers [b]	Glass
Total Mass (MT)	8.28E+01	1.03E+01	1.82E+02	2.75E+02
MnO2	7.77E-01	8.11E-06		7.77E-01
Ag2O	1.53E-01	6.64E-10		1.53E-01
Al2O3	1.73E+01	6.77E-04		1.73E+01
Am2O3	3.19E-03	2.50E-05		3.21E-03
As2O5	1.50E-01	8.38E-10		1.50E-01
B2O3	2.65E-01	1.86E-08	2.39E+01	2.42E+01
BaO	1.05E-01	9.16E-09		1.05E-01
BeO	6.32E-03	1.43E-16		6.32E-03
Bi2O3		1.07E-09		1.07E-09
CaO	6.72E-01	1.46E-05		6.72E-01
CdO	2.92E+00	2.55E-09		2.92E+00
Ce2O3	1.54E-01			1.54E-01
Cm2O3	4.34E-06			4.34E-06
Co2O3	4.49E-08			4.49E-08
Cr2O3	3.34E-01	8.70E-06		3.34E-01
Cs2O	8.75E-03	1.60E-02		2.48E-02
CuO	7.41E-02	1.05E-09		7.41E-02
Eu2O3		4.95E-11		4.95E-11
Fe2O3	3.19E+01	2.20E-05		3.19E+01
K2O	2.42E-01	9.10E-05		2.42E-01
La2O3	8.96E-01	9.62E-08		8.96E-01
Li2O	1.03E-02		2.74E+00	2.75E+00
MgO	2.69E-01	3.94E-08		2.69E-01
MoO3	6.04E-03	9.94E-09		6.04E-03
Na2O	1.25E+01	1.03E+01		2.28E+01
Ni2O3	2.13E+00	1.17E-05		2.13E+00
NpO2		1.35E-10		1.35E-10
P2O5	1.81E+00	9.30E-05		1.81E+00
PbO2	2.16E-01	3.91E-06		2.16E-01
PdO				
PuO2	5.22E-03	6.86E-05		5.29E-03
Re2O7	1.59E-02			1.59E-02

Table D-3. Feed Oxide Quantities and Estimated Composition Variation Study Glass Compositions Immobilization of Tank 241-AZ-102.
(60 Percent Retrieval) (2 sheets)

Stream oxide components	HLW oxides	LAW oxides [a]	Formers [b]	Glass
Rh2O3	8.69E-02			8.69E-02
Ru2O3	3.78E-02			3.78E-02
Sb2O5				
SeO3	2.78E-01	6.43E-11		2.78E-01
SiO2	1.55E+00	8.74E-07	1.55E+02	1.57E+02
SO3	9.58E-01	3.51E-04		9.59E-01
SrO	8.14E-02	2.71E-04		8.16E-02
Tc2O7	8.19E-03	1.10E-02		1.92E-02
TeO3	8.02E-02			8.02E-02
ThO2				
TiO2	2.18E-02	6.57E-11		2.18E-02
Tl2O3	1.05E-02			1.05E-02
UO3	2.50E+00	3.55E-06		2.50E+00
V2O5	9.67E-03			9.67E-03
WO3		1.77E-08		1.77E-08
ZnO	2.98E-02	5.84E-08		2.98E-02
ZrO2	4.18E+00	4.83E-10		4.18E+00

HLW = High-level waste

LAW = Low-activity waste.

[a] The LAW oxides are an estimate of the Intermediate Waste Products from LAW services that the HLW/LAW private contractor is required to incorporate into the HLW product. A bulk composition is calculated, based on Certa et al. (1996), and the mass is partitioned equally between the 14 HLW feed batches.

[b] The composition of glass formers have not been optimized to consider the physical properties of the glass.

Table D-4. Feed Oxide Quantities and Estimated Composition Variation Study Glass Compositions Immobilization of Tank 241-AY-102/241-C-106 (36 Percent/75 Percent Retrieval) (2 sheets)

Stream oxide components	HLW oxides	LAW oxides [a]	Formers [b]	Glass
Total Mass (MT)	4.15E+02	6.19E+01	2.42E+02	7.19E+02
MnO2	3.06E+00	4.87E-05		3.06E+00
Ag2O	8.60E-01	3.98E-09		8.60E-01
Al2O3	6.51E+01	4.07E-03		6.51E+01
Am2O3	6.39E-04	1.50E-04		7.90E-04
As2O5		5.02E-09		5.02E-09
B2O3	4.47E-02	1.11E-07	3.59E+01	3.59E+01
BaO	4.45E+00	5.49E-08		4.45E+00
BeO		8.61E-16		8.61E-16
Bi2O3	4.47E-01	6.43E-09		4.47E-01
CaO	1.42E+01	8.79E-05		1.42E+01
CdO	3.56E-01	1.53E-08		3.56E-01
Ce2O3				
Cm2O3	5.13E-11			5.13E-11
Co2O3	5.38E-03			5.38E-03
Cr2O3	1.42E+00	5.22E-05		1.42E+00
Cs2O	1.55E-02	9.60E-02		1.12E-01
CuO	1.26E-01	6.28E-09		1.26E-01
Eu2O3		2.97E-10		2.97E-10
Fe2O3	6.54E+01	1.32E-04		6.54E+01
K2O	1.49E+00	5.45E-04		1.49E+00
La2O3	2.42E-01	5.77E-07		2.42E-01
Li2O			7.19E+00	7.19E+00
MgO	8.63E+00	2.36E-07		8.63E+00
MoO3		5.96E-08		5.96E-08
Na2O	1.10E+02	6.18E+01		1.72E+02
Ni2O3	1.30E+00	7.04E-05		1.30E+00
NpO2		8.13E-10		8.13E-10
P2O5	4.83E+00	5.58E-04		4.83E+00
PbO2	2.19E+00	2.34E-05		2.19E+00
PdO	1.46E-01			1.46E-01
PuO2	4.90E-02	4.11E-04		4.94E-02

Table D-4. Feed Oxide Quantities and Estimated Composition Variation Study Glass Compositions Immobilization of Tank 241-AY-102/241-C-106 (36 Percent/75 Percent Retrieval) (2 sheets)

Stream oxide components	HLW oxides	LAW oxides [a]	Formers [b]	Glass
Re2O7				
Rh2O3				
Ru2O3				
Sb2O5				
SeO3		3.86E-10		3.86E-10
SiO2	1.25E+02	5.25E-06	1.99E+02	3.24E+02
SO3	1.49E+00	2.11E-03		1.49E+00
SrO	1.60E-01	1.63E-03		1.61E-01
Tc2O7	1.61E-02	6.61E-02		8.22E-02
TeO3				
ThO2				
TiO2		3.93E-10		3.93E-10
Tl2O3				
UO3	1.35E+00	2.13E-05		1.35E+00
V2O5				
WO3		1.06E-07		1.06E-07
ZnO	4.58E-02	3.51E-07		4.58E-02
ZrO2	2.28E+00	2.89E-09		2.28E+00

HLW = High-level waste

LAW = Low-activity waste.

[a] The LAW oxides are an estimate of the Intermediate Waste Products from LAW services that the HLW/LAW private contractor is required to incorporate into the HLW product. A bulk composition is calculated, based on Certa et al. (1996), and the mass is partitioned equally between the 14 HLW feed batches.

[b] The composition of glass formers have not been optimized to consider the physical properties of the glass.

Table D-5. Feed Oxide Quantities and Estimated Composition Variation Study Glass Compositions Immobilization of Tank 241-AY-102/241-C-106. (36 Percent/99 Percent Retrieval) (2 sheets)

Stream oxide components	HLW oxides	LAW oxides [a]	Formers [b]	Glass
Total Mass (MT)	5.43E+02	6.19E+01	3.28E+02	9.33E+02
MnO2	3.82E+00	4.87E-05		3.82E+00
Ag2O	1.01E+00	3.98E-09		1.01E+00
Al2O3	8.48E+01	4.07E-03		8.48E+01
Am2O3	7.25E-04	1.50E-04		8.75E-04
As2O5		5.02E-09		5.02E-09
B2O3	5.92E-02	1.11E-07	4.66E+01	4.67E+01
BaO	5.84E+00	5.49E-08		5.84E+00
BeO		8.61E-16		8.61E-16
Bi2O3	5.91E-01	6.43E-09		5.91E-01
CaO	1.85E+01	8.79E-05		1.85E+01
CdO	4.63E-01	1.53E-08		4.63E-01
Ce2O3				
Cm2O3	7.06E-11			7.06E-11
Co2O3	7.10E-03			7.10E-03
Cr2O3	1.79E+00	5.22E-05		1.79E+00
Cs2O	2.05E-02	9.60E-02		1.17E-01
CuO	1.67E-01	6.28E-09		1.67E-01
Eu2O3		2.97E-10		2.97E-10
Fe2O3	8.43E+01	1.32E-04		8.43E+01
K2O	1.95E+00	5.45E-04		1.95E+00
La2O3	2.42E-01	5.77E-07		2.42E-01
Li2O			9.33E+00	9.33E+00
MgO	1.14E+01	2.36E-07		1.14E+01
MoO3		5.96E-08		5.96E-08
Na2O	1.46E+02	6.18E+01		2.08E+02
Ni2O3	1.64E+00	7.04E-05		1.64E+00
NpO2		8.13E-10		8.13E-10
P2O5	6.39E+00	5.58E-04		6.39E+00
PbO2	2.89E+00	2.34E-05		2.89E+00
PdO	1.93E-01			1.93E-01
PuO2	6.33E-02	4.11E-04		6.37E-02

Table D-5. Feed Oxide Quantities and Estimated Composition Variation Study Glass Compositions Immobilization of Tank 241-AY-102/241-C-106. (36 Percent/99 Percent Retrieval) (2 sheets)

Stream oxide components	HLW oxides	LAW oxides [a]	Formers [b]	Glass
Re2O7				
Rh2O3				
Ru2O3				
Sb2O5				
SeO3		3.86E-10		3.86E-10
SiO2	1.64E+02	5.25E-06	2.72E+02	4.36E+02
SO3	2.04E+00	2.11E-03		2.04E+00
SrO	1.96E-01	1.63E-03		1.97E-01
Tc2O7	2.13E-02	6.61E-02		8.74E-02
TeO3				
ThO2				
TiO2		3.93E-10		3.93E-10
Tl2O3				
UO3	1.71E+00	2.13E-05		1.71E+00
V2O5				
WO3		1.06E-07		1.06E-07
ZnO	6.05E-02	3.51E-07		6.05E-02
ZrO2	3.02E+00	2.89E-09		3.02E+00

HLW = High-level waste

LAW = Low-activity waste.

[a] The LAW oxides are an estimate of the Intermediate Waste Products from LAW services that the HLW/LAW private contractor is required to incorporate into the HLW product. A bulk composition is calculated, based on Certa et al. (1996), and the mass is partitioned equally between the 14 HLW feed batches.

[b] The composition of glass formers have not been optimized to consider the physical properties of the glass.

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