6.0 ACTIONS PLANNED FOR FUTURE TANK WASTE REMEDIATION OPERATION AND UTILIZATION PLAN REVISIONS (Orme) 6-1
6.1 FIRST REVISION 6-1
6.2 FUTURE REVISIONS 6-2
6.3 INTEGRATION OF MODELING EFFORTS 6-3

7.0 REFERENCES (Kirkbride) 7-1

APPENDIXES

A - BASES AND ASSUMPTIONS (Penwell)

B - PROCESS TECHNICAL BASIS (Orme)

C - INVENTORY (Shelton and MacLean)

D - CHARACTERIZATION DATA NEEDS (Kirkbride)

E - MATERIAL BALANCE SHEETS FOR PHASE I STAGING OPERATIONS (Certa)

F - MATERIAL BALANCE SHEETS FOR PHASE II STAGING OPERATIONS (Orme)

G - ADDITIONAL/ALTERNATIVE PHASE I HIGH-LEVEL WASTE FEEDS (Manuel)

H - PHASE I SUPPLEMENTAL INFORMATION (Certa)

I - LOW-ACTIVITY WASTE SUPPORTING DOCUMENTATION (Certa)

J - SINGLE-SHELL TANK RETRIEVAL MID-LEVEL LOGIC DIAGRAMS (Penwell)

K - DOUBLE-SHELL TANK USAGE ALLOCATIONS FOR PHASE I PRIVATIZATION (Certa)

LIST OF FIGURES

1.0-1. U.S. Department of Energy Tank Waste Remediation System Cleanup Logic . . . 1-2

1.0-2. Phase I Processing Functions 1-3

1.0-3. Related Tank Waste Remediation System Efforts 1-6

3.1-1. Feed Staging Strategy. 3-1

3.1-2. Feed Delivery Protocol Timing and Logic. 3-3

3.1-3. Double-Shell Tank Requirements for the Disposal Planning Case. 3-9

3.1-4. Total Projected Double-Shell Tank Waste Volume. 3-9

3.1-5. Tank 241-AP-106 Projected Fill History. 3-11

3.1-6. Tank 241-AP-108 Projected Fill History. 3-11

3.1-7. Tank 241-AP-102 Projected Fill History. 3-12

3.1-8. Tank 241-AP-104 Projected Fill History. 3-12

3.2-1. Phase I High-Level Waste Feed Quantities After Pretreatment. 3-44

3.2-2. Proposed Phase I High-Level Waste Feed Transfer System 3-49

3.2-3. High-Level Waste Batch Transfer Volumes. 3-65

3.4-1a. High-Level Waste and Low-Activity Waste Processing 3-72

3.4-1b. Low-Activity Waste Only Processing. 3-73

3.4-2. Tank 241-AN-105 Dilution at 40 °C 3-81

3.4-3. Tank 241-AN-104 Dilution at 40 °C 3-82

3.4-4. Tank 241-AW-101 Dilution At 40 °C. 3-83

3.4-5. Tank 241-AN-103 Dilution At 40 °C 3-84

3.4-6. In-Tank Processing Equipment and Instruments 3-97

LIST OF FIGURES (CONTINUED)

3.4-7. Phase I High-Level Waste Pretreatment and Feed Staging. 3-108

4.3-1. Cumulative Number of Single-Shell Tanks Initiated for Retrieval. 4-7

LIST OF TABLES

2.1-1. Single-Shell Tank 1997 Mass-Weighted Wash and Leach Factors of Key Components 2-4

2.1-2. Feed Delivered to the Low-Activity Waste Private Contractors. 2-6

2.1-3. Summary of Feed Delivery Schedule. 2-6

2.1-4. Low-Activity Waste Feed Staging and Product Planning Summary. 2-9

2.1-5. Phase I Immobilized High-Level Waste Summary. 2-10

3.1-1. Summary Feed Staging Schedule 3-5

3.1-2. Estimates of Delivered Sodium. 3-6

3.1-3. Envelope Classification of Double-Shell Tanks as of June 1, 2000 3-15

3.1-4. Envelope Classification of Double-Shell Tanks As of June 1, 2011. 3-17

3.1-5. Envelope Classification of Delivered Low-Activity Waste feed Batches. 3-19

3.1-6. Envelope Classification of Double-Shell Tanks are of June 2000 for Proposed Envelope Limits. 3-22

3.1-7. Envelope Classification of Double-Shell Tanks are of June 2011 for Proposed Envelope Limits. 3-24

3.1-8. Low-Activity Waste Feed Processing Sequence. 3-28

3.1-9. Summary of Waste Compatibility Data Quality Objectives Evaluation 3-32

3.1-10. Cross-Reference of Existing Low-Activity Waste Feed Staging Issues 3-37

3.2-1. Phase I High-Level Waste Envelope D Comparison 3-46

LIST OF TABLES (CONTINUED)

3.2-2. Acceptable Physical Property Ranges for Selected Phase I High-Level Waste Feed Components (DOE 1996) 3-47

3.2-3. Pretreatment Processing Durations 3-52

3.2-4. Feed Staging Durations for Tanks 241-AZ-101, 241-AZ-102, and 241-AY-102/241-C-106. 3-53

3.2-5. Schedule for Phase I High-Level Waste Pretreatment and Feed Staging. 3-55

3.2-6. High-Level Waste Transfer System Design Comparison with Candidate Feeds Reynolds Number Set to 20,000 (Fowler 1995a). 3-59

3.2-7. In-Tank Processing Equipment Need Dates. 3-61

3.2-8. In-Tank Processing Equipment Need Dates--Alternate Sequencing. 3-62

3.4-1. Phase I Immobilized Low-Activity Waste and Intermediate Product Summary . . . 3-74

3.4-2. Phase I Immobilized High-Level Waste Summary. 3-75

3.4-3. Simulated Versus Measured Properties in 241-AN-105 Supernate. 3-79

3.4-4. Tank 241-AN-105 Dilution at 40 °C. 3-81

3.4-5. Tank 241-AN-104 Dilution At 40 °C. 3-82

3.4-6. Tank 241-AW-101 Dilution At 40 °C. 3-83

3.4-7. Tank 241-AN-103 Dilution At 40 °C. 3-84

3.4-8. Private Contractor 1 Batches 3-86

3.4-9. Private Contractor 2 Batches 3-91

3.4-10. Shear Strength of Phase I Sludges. 3-99

3.4-11. Effective Cleaning Radius and Mobilization Using Two Mixer Pumps. 3-99

3.4-12. Mean Particle Diameter 3-100

3.4-13. Leach Factors Derived from Environmental Simulation Program Modeling of Enhanced Sludge Washing 3-102

LIST OF TABLES (CONTINUED)

3.4-14. Enhanced Sludge Washing Results for Phase I Sludges 3-103

3.4-15. Tank 241-C-107 Sludge Settling and Thickening Results. 3-106

3.4-16. Simulation of C-107 Sludge Settling and Thickening. 3-107

3.4-17. Phase I Private Contractor Low-Activity Waste Feeds and Products. 3-111

3.4-18. Phase I Immobilized High-Level Waste Summary. 3-111

3.5-1. Need Dates for Supporting Projects 3-115

3.5-2. Potential Project Integration Issues 3-117

4.3-1. Initial Retrieval Sequence With As-Retrieved Volumes. 4-9

4.4-1. Old and New Single-Shell Tank Caustic Leach Factors. 4-19

4.4-2. Low-Level Waste Glass Formulation Constraints (Orme 1996). 4-21

4.4-3. High-Level Waste Glass Formulation Ranges (CVS AT 1150 °C). 4-24

LIST OF TERMS

BNFL	British Nuclear Fuels, Ltd.
CC	Complex concentrate
CIP	Cesium intermediate product
CP	Concentrated phosphate
DOE	U.S. Department of Energy
DQO	Data Quality Objectives
DSC	Differential scanning calorimetry
DSSF	Double-shell slurry feed
DST	Double-shell tank
DWPF	Defense Waste Processing Facility
ESIP	Entrained solids intermediate product
ESP	Environmental Simulation Program
ESW	Enhanced sludge wash
FY	Fiscal year
HDW	Hanford Defined Waste
HLW	High-level waste
HTWOS	Hanford Tank Waste Operation Simulator
ICD	Interface Control Document
IHLW	Immobilized high-level waste
ILAW	Immobilized low-activity waste
ITRT	Independent Technical Review Team
LANL	Los Alamos National Laboratory
LMAES	Lockheed Martin Advanced Environmental Systems
LAW	Low-activity waste
LLW	Low-level waste
MYWP	Multi-year work plan
NCAW	Neutralized current acid waste
NRC	U.S. Nuclear Regulatory Commission
OWVP	Operational waste volume projection
PHMC	Project Hanford Management Contractor
PUREX	Plutonium-uranium extraction
RFP	Request for Proposal
RL	U.S. Department of Energy-Richland Field Office
SORWT	Sort on Radioactive Waste Type
SST	Single-shell tank
TGA	Thermogravimetric analysis
TIP	Technetium intermediate product
TOC	Total organic carbon
TRAC	Track RAdioactive Components
TRU	Transuranic
TWRS	Tank Waste Remediation System
TWRSO&UP	Tank Waste Remediation System Operation and Utilization Plan
USQ	Unreviewed Safety Question

LIST OF TERMS (CONTINUED)

V&V	Verification and validation
WIT	Waste Integration Team
WRF	Waste Receiver Facility
WTD	Waste Transfer Date

TANK WASTE REMEDIATION SYSTEM OPERATION AND UTILIZATION PLAN

1.0 INTRODUCTION

The U.S. Department of Energy Richland Operations Office (RL) is in the first stages of contracting with private companies for the treatment and immobilization of tank wastes. The components of tank waste retrieval, treatment, and immobilization have been conceived in two phases (Figure 1.0-1). To meet RL's anticipated contractual requirements, the Project Hanford Management Contractor (PHMC) companies will be required to provide waste feeds to the private companies consistent with waste envelopes that define the feeds in terms of quantity, and concentration of both chemicals and radionuclides. The planning that supports delivery of the feed must be well thought out in four basic areas:

1. Low-activity waste (LAW)/high-level waste (HLW) feed staging plans. How is waste moved within the existing tanks to deliver waste that corresponds to the defined feed envelopes to support the Private Contractor's processing schedule and processing rate?

2. Single-shell tank (SST) retrieval sequence. How are *Hanford Federal Facility Agreement and Consent Order* (Tri-Party Agreement) (Ecology et al. 1994) milestones for SST retrieval integrated into the Phase I processing to set the stage for Phase II processing to complete the mission?

3. Tank Waste Remediation System (TWRS) process flowsheet. How do materials flow from existing tank inventories through: (1) blending and pretreatment functions in the double-shell tanks (DSTs), (2) contractor processing facilities, and (3) stored waste forms (Figure 1.0-2)

4. Storage and disposal of the immobilized low-activity waste (ILAW) and immobilized high-level waste (IHLW) product. How is the ILAW and IHLW product received from the private companies, the ILAW disposed onsite, and the IHLW stored onsite until final disposal?

Figure 1.0-1. U.S. Department of Energy Tank Waste Remediation System Cleanup Logic.

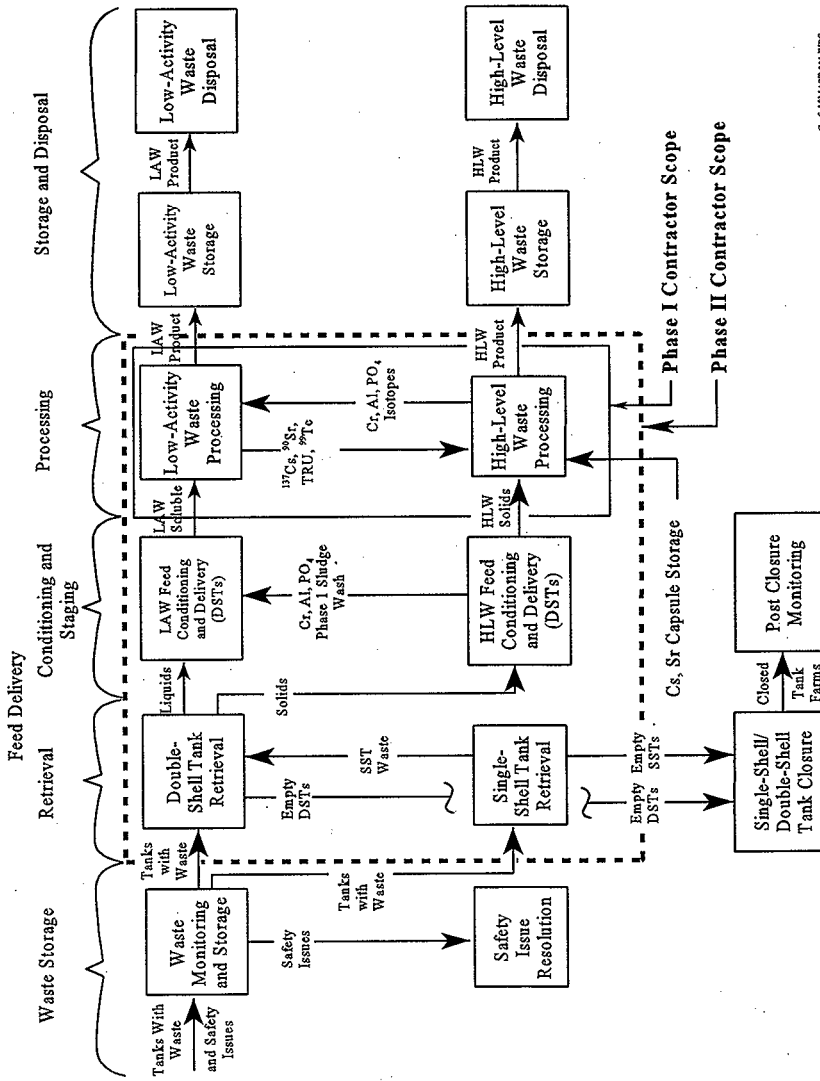
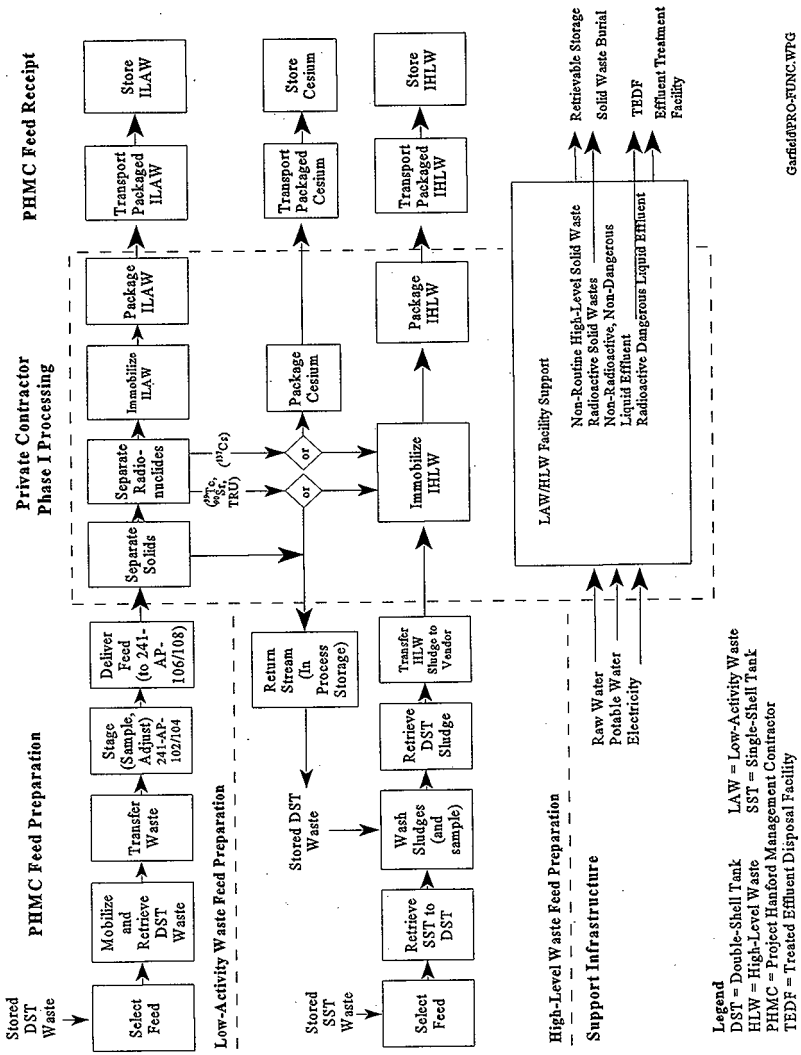


Figure 1.0-2. Phase I Processing Functions.



1.1 BACKGROUND

The Tank Waste Remediation System Operation and Utilization Plan (TWRSO&UP) addresses the four areas of LAW and HLW feed staging, SST retrieval sequence, TWRS process flowsheet, and storage and disposal, and consolidates multiple plans that were provided in fiscal year (FY) 1996 (e.g., *Phase I High-Level Waste Pretreatment and Feed Staging Plan* [Manuel et al. 1996], *Low-Level Waste Feed Staging Plan* [Certa et al. 1996], *Initial Retrieval Sequence and Blending Strategy* [Penwell et al. 1996], and the *TWRS Privatization Process Technical Baseline* [Orme et al. 1996]). These documents provided a foundation for understanding the disposal program in terms of the interface with Phase I processing (primarily DST waste) and the Tri-Party Agreement milestones associated with Phase II processing (primarily SST waste). In addition, these four efforts have been integrated in a single dynamic computer model called the *Hanford Tank Waste Operation Simulator* (HTWOS). This model tracks waste inventories in tanks as they are retrieved and transferred through the life cycle of the TWRS disposal mission.

These plans are based upon specifications for the U.S. Department of Energy's (DOE's) Phase IA contract with two Private Contractors. The assumptions made concerning envelope definition, total quantity, and rate of delivery are subject to change. The plans will be updated in the future in response to changes that occur.

1.2 PURPOSE

The intent of this work is to provide a fully integrated tool for assessing all aspects of feed delivery for the disposal program. The TWRSO&UP is a living document that will be updated in the future to support programmatic planning needs. It consolidates separate documents into one document and represents the best information to date on how source tanks can be used to satisfy Phase I envelopes. The TWRSO&UP also shows how Phase I feed delivery is integrated with SST retrieval and provides the SST retrieval sequence for Phase II. This work represents a significant advance in the use of a single model (HTWOS), which defines a baseline of transfers and mass balance for both the TWRS operations and disposal programs. HTWOS is integrated with the Operational Waste Volume Projection (OWVP) and will be the software validated in FY 1998 for application in both programs. Use of the same model for multiple efforts is a breakthrough in configuration control, integration, and efficiency. The TWRS life-cycle of waste movements from the present through Phase I and Phase II is now contained in a single, dynamic, flowsheet model and is managed as a "system." Future work and document revisions will refine the base case and add alternatives driven by various scenarios as defined by DOE/Contractor needs for Phase I and DOE/Washington State Department of Ecology (Ecology) needs to address Tri-Party Agreement milestones for Phase II.

1.3 DOCUMENT OVERVIEW

Key findings are categorized under highlights and recommendations in Section 2.0. The document is generally organized around Privatization Phase I (3.0) and Phase II (4.0). Key topics and sections where they may be found are as follows:

LAW Feed Staging--Section 3.1 and Appendix I
HLW Feed Staging--Section 3.2 and Appendix G
SST Retrieval Sequence--Section 4.3
Process Summary Basis--Sections 3.4 and 4.4 and Appendix B
HTWOS Model--Section 5.0
Constraints, Requirements, and Assumptions--Appendix A
Characterization--Inventory (Appendix C) and Data Quality Objectives (Appendix D).

1.4 RELATED TANK WASTE REMEDIATION SYSTEM EFFORTS

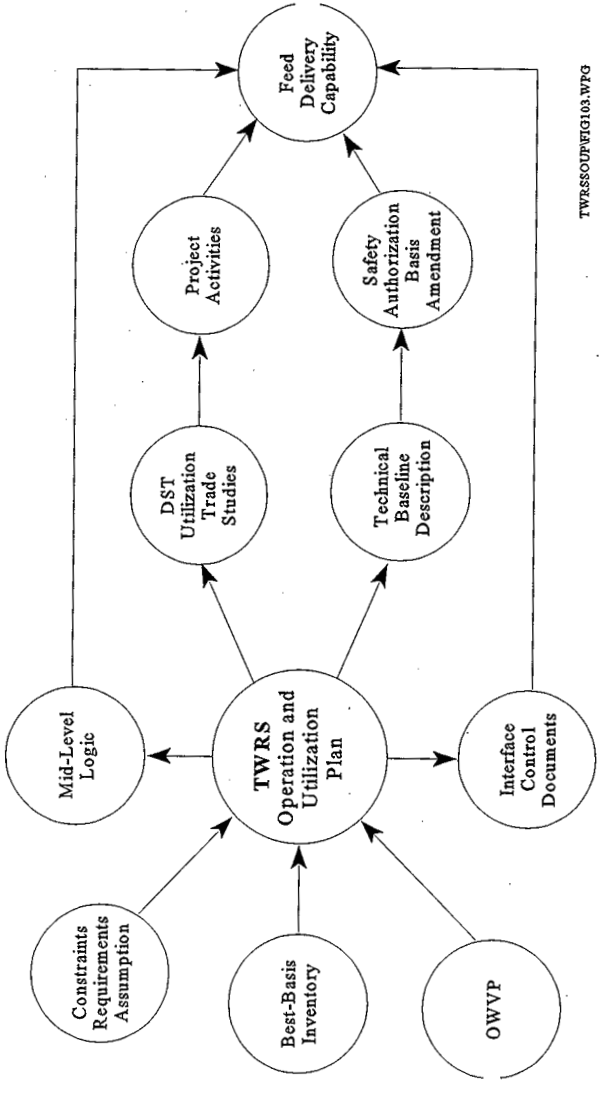
The TWRSO&UP is a central part of several related efforts depicted on Figure 1.0-3 that each describe an aspect of the TWRS feed delivery system. A synopsis of each is given below.

TWRSO&UP (HNF-SD-WM-SP-012 [this document]). This document provides the operating plan for LAW/HLW feed delivery and SST retrieval for the TWRS life cycle with a priority emphasis on Phase I.

Constraints, Requirements, and Assumptions (HNF-SD-WM-SP-012 [this document]). This document is attached as Appendix A of the TWRSO&UP. It provides a compilation of the requirements for feed delivery. Each requirement is categorized as a technical basis, an external constraint, an internal requirement, an enabling assumption (pending future information), or a simplifying/modeling assumption. Each requirement is also categorized with regard to which aspect of the work it impacts. The narrative for each requirement includes the source of information and a discussion of any issues that complicate the requirement.

Best-Basis Inventory (Tank Characterization Reports and HNF-SD-WM-TI-740 [Kupfer et al. 1997]). The best-basis inventory (Kupfer et al. 1997) provides data on the chemical composition for each of the 177 tanks as well as a composite inventory of all tanks. Inventories include values for each chemical and radionuclide component (e.g., metric tons of sodium, aluminum, nitrate, etc., and curies of $^{239/240}PU$, ^{137}Cs, ^{90}Sr, etc.) presently stored in each tank. Information used to establish these inventories originated from sample analysis, key historical records, (e.g., essential material purchase records), from various chemical flowsheets used in reprocessing fuel at Hanford, and from calculations of radionuclide isotope generation and decay. The tank waste inventory data are used for TWRS process flowsheet modeling, safety analyses, risk assessments, retrieval, treatment and disposal system design.

Figure 1.0-3. Related Tank Waste Remediation System Efforts.



Operational Waste Volume Projection (HNF-SD-WM-ER-029, Rev. 23 [Strode and Boyles 1997]). This document presents the basis for predicting DST usage through FY 2015. It provides the disposal program with a projection of the transfers between now and the start of waste treatment when waste movements are dictated primarily by the waste treatment.

Technical Baseline Description (HNF-SD-TWR-TM-001, Rev. 0). This document provides a description of the feed delivery system to guide safety analysis, environmental compliance, operation and maintenance planning, project planning, trade studies, and other work. This document addresses the operating constraints and philosophy, a description of the hardware utilized, and relates this information to the projects which provide new equipment to support feed delivery.

Safety Authorization Basis Amendment. The safety authorization basis amendment is the plan to provide an integrated safety overview of the project upgrades and operational activities which support Phase I feed staging. Feed staging activities outside the current authorization basis (the approved safe operating conditions) will be evaluated as Unreviewed Safety Questions (USQ) and further analyzed in Hazard Identification and Evaluation (HIE) so that an Authorization Basis Amendment may be prepared and approved. Modifications to equipment or procedures will be made as required to meet all safety requirements.

Mid-Level Logic (HNF-SD-TWR-TM-001, Rev. 1). Provides logic for LAW and HLW Phase I feed delivery to depict the essential activities required to successfully deliver feed to the contractors on the privatization contract schedule. Dates are included for each activity and a schedule version of the same activities shows a critical path.

Interface Control Documents (ICDs). The ICDs define the technical interface between the DOE, its PHMC Team, and the Phase I Private Contractors. ICDs serve as a basis for agreement between DOE, its PHMC Team, and the Private Contractors. ICDs describe the functional interface (what is being done and by whom) and describe physical interfaces (how things are done). Of the 22 ICDs prepared, three specifically address feed delivery. Presently, the ICDs are in draft form and will remain so until agreed upon between the DOE, the PHMC Team, and the Private Contractors.

Low-Activity Waste Feed ICD-19 (HNF-SP-1223)
High-Level Waste Feed ICD-20 (HNF-SP-1224)
Waste Feed Tanks ICD-21 (HNF-SP-1225)

Trade Studies. Two trade studies have been done or are in progress to resolve feed delivery issues. They are described below.

DST Utilization (HNF-SD-TWR-AGA-002). This trade study investigates the equipment alternatives for treating and retrieving LAW and HLW from the DSTs (e.g., mixer pumps, sluicing, sonic probes, etc.). This study provides the basis for scoping project W-211.

Enhanced Sludge Washing (HNF-SD-TWR-AGA-003). This trade study investigates the high-level waste (HLW) pretreatment alternatives. Either water or a dilute caustic solution can be used to wash nonradioactive chemicals from the HLW feed thus reducing the HLW glass volume.

The documents described above are prepared by various organizations and are updated annually in most cases, or when new information shows that an update is warranted.

Project Activities. The reader is referred to the Technical Baseline Description (Papp 1997) for a more detailed description of the TWRS project activities. The primary projects are listed below.

W-211 Initial Tank Retrieval Systems. This project provides the mixing and retrieval equipment upgrades to the DSTs that contain LAW and HLW feed for privatization. These upgrades must be provided on a schedule prioritized by the Phase I retrieval sequence.

W-314 Tank Farm Restoration and Safe Operations. This project provides a variety of DST upgrades to instrumentation, ventilation, piping, pits, and electrical systems.

W-320 Tank 241-C-106 Retrieval. The purpose of the Tank 241-C-106 Waste Retrieval Sluicing System is to simultaneously slurry the solid waste in 241-C-106 with a sluice stream of supernatant from tank 241-AY-102, and pump the slurry from 241-C-106 to 241-AY-102. In 241-AY-102, the solids will settle from the slurry and the supernatant will be pumped back to 241-C-106 as the sluice medium.

2.0 SUMMARY

The TWRSO&UP provides results and recommendations from several related TWRS feed delivery system efforts. These include integration with operational waste volume projections, establishment of a consistent waste inventory basis, development of refined sludge washing factors, plans for LAW and HLW feed staging, status of overall TWRS process flowsheets, development of SST retrieval sequences, and review of schedules for current projects that impact the feed delivery system.

The LAW and HLW feed staging analyses and results are presented at a detailed level for Phase I and at a summary level for Phase II. Phase II analysis is based on blending all waste not processed during Phase I. It is inappropriate to analyze Phase II processing in greater detail at this time.

2.1 HIGHLIGHTS

The following sections discuss major achievements of, or results from, the technical work performed to prepare this document.

2.1.1 Integration with Operational Waste Volume Projection

The Hanford tank farms operations support group has been making projections for more than 20 years to manage DST space to meet the needs of newly generated waste and to plan volume reductions in the evaporators. The tank waste treatment mission added complexity to the waste projections since the defense mission at Hanford was changed to a cleanup mission. This added complexity requires the integration of many activities at a detailed level to make sure that the tank waste is cleaned up in a timely and cost-effective manner. Until this year the disposal and operational modeling were conducted in parallel and only limited attempts were made to integrate them. This is the first year that software transfer files were exchanged such that waste movements in both models are well integrated. Starting in FY 1998, both disciplines (Disposal and Operations) will work toward using the same HTWOS software for waste volume and composition projections. This software integration represents a significant improvement in program integration and supports effective configuration control within TWRS.

While improvement has been made in program integration, a few discrepancies exist. These discrepancies are detailed in Section 5.2 and will be reconciled by the next revision of this document. Most of the discrepancies occur during the Phase II section of the modeling and the few that do occur during Phase I do not impact the results. Overall the integration of the HTWOS and OWVP models was successful since the primary objective was to ensure that the transfers/tank farm operations related to Phase I matched. The Phase II operations, including SST retrieval during Phase I, will be integrated at a later date.

2.1.2 Tank Waste Inventory

The inventory basis (henceforth referred to as the TWRS inventory) created for use in studies commissioned by the TWRSO&UP provides estimates for the composition of wastes in the 149 SSTs and 28 double-shell tanks (DSTs) as of September 30, 1996, the starting point for the OWVP. This TWRS inventory is a provisional inventory that will be replaced by the best-basis tank-by-tank inventory (Hodgson and LeClair 1996).

Inventories developed earlier for other studies are now inadequate for the TWRSO&UP because: (1) these inventories have either been invalidated by continued waste transfers or new information concerning tank contents has become available; (2) the inventory bases are not partitioned into water-soluble and water-insoluble phases which is necessary for TWRSO&UP studies; and (3) the number of analytes reported is not sufficient to satisfy the characterization data needs.

The methodology used to generate the TWRS inventory is similar to that used for earlier TWRS inventory development work (Orme 1996 and Certa 1996) and documented in Shelton 1996a and 1996b. The SST estimates are based on the results of the Hanford Defined Waste (HDW) model developed at the Los Alamos National Laboratory (LANL) and normalized so that the sum of component masses in the SSTs and DSTs agree with current global inventory assumptions (Kupfer et al. 1997). Estimates for DSTs were developed directly from sample data. Appendix C describes in detail how the TWRS inventory was developed and documents the inventory.

The HDW model uses historical transfer records, chemical purchase and usage records, flowsheet records, and other information to estimate the bulk contents of each waste tank. The first revision of the HDW model (Agnew 1995), provided the starting point for the derivation of the inventory used here.

The global inventory was developed as part of the best-basis inventory task (Hodgson and LeClair 1996). Only several of the completed best-basis estimates for individual DSTs were available for use in the development of the TWRS inventory.

The bulk inventory estimates for each tank were divided into water-soluble and water-insoluble fractions by applying wash factors, obtained from water-washing tests of core samples taken from over 30 tanks, to the bulk inventories. Generally, the water soluble fraction is the LAW stream and the water insoluble fraction is the HLW stream.

Data collection for these TWRS inventory estimates ended on May 1, 1997. The initial inventories for every tank were frozen as of that date in order to complete the LAW feed staging study. For internal calculations, radionuclide values are decayed to January 1, 1994, to match the decay date of the best-basis inventory task.

2.1.3 Sludge Wash Factors

The ability of the enhanced sludge wash (ESW) process to remove glass volume-controlling constituents has been the subject of ongoing studies because glass volumes directly relate to disposal costs, a major programmatic consideration. Last year's evaluation of ESW data raised a question about the capability of ESW to reduce glass volumes (Orme et al. 1996).

The Tri-Party Agreement (Ecology et al. 1994) established the need for a decision, due in March 1998, whether the ESW process produced a reasonable amount of HLW glass. The need for a "final decision" on the role of advanced separations processes is effectively deferred to coincide with preparation of the Phase II request for proposal. Although DOE is no longer working toward a fullscale HLW pretreatment conceptual design in March 1998, the current state of the ESW data is nevertheless very relevant to a variety of preliminary Phase II-related tasks scheduled to begin in 1999, including the definition of Phase II process and product requirements. These tasks are predecessors to the Phase II request for proposal.

In this fourth and final year of the M-50-03 task, DOE is in a position to report with reasonable confidence that advanced sludge separation processes (i.e., acidic processes) should not be required. This conclusion is based on the best and latest values for tank inventory and ESW data, and glass volumes calculated by two independent methodologies. ESW (augmented by oxidative leaching of selected wastes) is compatible with the Tri-Party Agreement's "reasonable" volume criterion for immobilized HLW product.

The total HLW glass volume can be managed at a reasonable level because (1) the blending that occurs as waste is retrieved and transferred through the tank farms makes sludge batches more uniform, and (2) ESW supplemented by selective oxidative pretreatment removes from sludges sufficient amounts of glass volume-controlling constituents. The flexibility afforded by out-of-tank pretreatment during Phase II should make it possible for Phase II contractors to improve on blending as a tool for glass volume control, and exercise more precise control over pretreatment process conditions.

There are also non-chemical approaches to controlling final glass volume, as opposed to pretreatment which focuses on chemistry. For example, bottom-draining melters could obviate the problems associated with solids formation in top-draining melter. Melting at higher temperature (i.e., staying well above the liquidus temperature) is an alternate approach to dealing with solids formation. A totally different approach to making fewer waste packages is to simply make more efficient use of space by altering the canister geometry. The Phase II Private Contractors should consider the advantages of non-chemical approaches to controlling glass volume.

The ESW test results that were available as of August 1997 (Lumetta and Rapko 1994, Rapko et al. 1995, Temer and Villarreal 1995, Lumetta et al. 1996, Temer and Villarreal 1996, Lumetta et al. 1996, Temer and Villarreal 1997) were considered in the evaluation of

sludge wash factors (Colton 1997). Useable ESW performance data for two DSTs and 31 SSTs are available.[1] Oxidative leach data are available for one DST and four SSTs.

The evaluation of mass-weighted factors for SSTs is documented in *Status Report: Pretreatment Chemistry Evaluation FY 1997--Wash and Leach Factors for the Single-shell Tank Waste Inventory* (Colton 1997). The available ESW data represents 75 percent of the SST sludge, but more importantly, 80 percent of the SST chromium. Interest is focused on chromium's behavior during ESW because the best-basis inventory dramatically increases the total chromium over the previous inventory. These sludge wash factors are not integrated into current HTWOS modeling. They are, however, used in current TWRS process flowsheets.

The mass-weighted wash and leach factors for three glass-impacting constituents are reported in Table 2.1-1. The total mass of these three constituents in the tank wastes have the biggest influence on the production of immobilized high-level waste for a total blend of the tank wastes. Mass-weighted wash factors represent the fraction of the inventory initially present (after retrieval) in the aqueous phase. The mass-weighted leach factors represent the fraction of washed solids that subsequently solubilize during caustic leaching and final washing.

Table 2.1-1. Single-Shell Tank 1997 Mass-Weighted Wash and Leach Factors of Key Components.

Component	Wash (% initially soluble)	Leach (% removed from washed solids)
Al	24	88
Cr	35	78
P	79	75

Beginning in 1994 and again in 1995, leach factors were estimated from the small ESW data base (5 and 15 ESW results, respectively) without mass weighting. The fraction of the waste represented by these tests was insufficient to justify deriving mass-weighted factors. In 1996, mass-weighted average leach factors were derived for the first time from the 22 ESW tests that were then available. For chromium, however, leaching data were not available for waste types containing most of the SST chromium, and the mass-weighted chromium leach factor was a poor 14 percent. With ESW data now accounting for 80 percent of the SST chromium, the mass-weighted chromium leach factor is a more favorable 78 percent.

[1]ESW results for one tank (241-BX-105) were omitted from the evaluation because the sample was unrepresentative of the waste in the tank.

2.1.4 Low-Activity Waste Feed Staging

The operating scenario for delivery of feed to the private LAW contractors was revised to reflect current contract requirements rather than requirements from the Phase I Request for Proposal. The scenario reflects updated inventory estimates and projections, proposed requirements from the ICD for LAW Feed, waste management and tank space considerations from Revision 23 of the OWVP (Strode and Boyles 1997), Mid-Level Logic Diagrams, and updates to many of the enabling and simplifying assumptions.

The base case estimates of the feed delivered to the two LAW Private Contractors are shown in Table 2.1-2. Table 2.1-3 summarizes the feed delivery schedule for the base case operating scenario (for more details see Table 3.1.1). There is insufficient waste under the base case meeting Envelope A specification limits to satisfy the minimum order quantity without blending or shimming. However, several fall-back positions have been identified that may reduce the overall cost to the taxpayers.

- Revise the Envelope A limits as recommended in the Envelope Assessment (Section 3.1.1.4). The DOE/WIT are currently working on refined LAW feed envelopes with the intention of shifting the majority of wastes that now fit Envelope C into Envelope A.

- Blend existing Envelope A feed with near-Envelope A feed so that the Envelope A specifications are satisfied.

- Shim near-Envelope A feed with sodium hydroxide, sodium nitrate and/or sodium nitrite to bring within specification.

- Make up the shortage of Envelope A feed by adding sodium hydroxide, sodium nitrate and/or sodium nitrite.

- Reduce the minimum order quantity of Envelope A and deliver additional Envelope C feed to make up the difference.

The feed staging plans are being revised to take advantage of the blending and shimming capability provided by the use of intermediate staging tanks.

Table 2.1-2. Feed Delivered to the Low-Activity Waste Private Contractors.

Envelope	Totals for both contractors, MT sodium		
	Delivered quantity	Minimum order quantity	Maximum order quantity
A	4,122[a]	5,200	9,800
B	234	200	2,000
C	4,578	200	4,800
TOTAL	8,934		10,200

[a]The PHMC Contractor will revise the feed staging plans to include the staging and delivery of the additional Envelope A feed needed to meet the minimum order quantities by either blending of existing Envelope A feed with near-Envelope A feed or by shimming near-Envelope A feed with caustic to adjust the analyte:sodium ratios. Additionally, the DOE/WIT are working on refined LAW feed envelopes that will reclassify a significant quantity of Envelope C waste as Envelope A. If this is done, the delivered quantity of Envelope A may be as large as 9,200 MT Na.

Table 2.1-3. Summary of Feed Delivery Schedule.

Envelope	Feed source (static date)	Pre-stage tank (static date)	Batch	Batch ready date
A	241-AN-105 (Static)[a]		1	7/2001
	241-AN-104 (Static)		2	12/2001
	241-AW-101 (Static)		3	5/2003
	241-AN-103 (Static)		4	1/2004
B	241-AZ-101	241-AY-101 (1/2002)	5	9/2004
	241-AZ-102			
C	241-AN-107 (11/1997)		6-7	7/2005
	241-AN-102 (Static)		8	12/2005
	241-AN-106 (7/1999)		9	4/2006
	241-SY-101 (Static)	241-AN-102 241-AN-107 (4/2006)	10	12/2006
	241-SY-101 (Static) 241-SY-103 (Static)	241-AN-102 241-AN-107 (9/2006)	11	7/2007

[a]"Static" means that the feed presently exists in the referenced double-shell tank and its composition is not expected to change.

The OWVPs show that there is sufficient DST space for staging feed to the Private Contractors. However, essentially all tank space is fully allocated. No contingency space is available for changes in assumptions, potential out-of-specification feed batches or uncertainty in the projections. Significant reductions of the demand on DST storage space before and during Phase I processing could provide a measure of assurance that feed staging can be performed within available DST space or may help (subject to re-evaluation of tank space demands) relax the need to use 241-AP-106 and -108 for waste management activities during their upgrade and turn-over activities. The need to complete interim stabilization (salt-well pumping) of SSTs by the end of FY 2000 and the need for early retrieval of SST waste should be re-considered as a means to reduce the demand on the DST storage space.

2.1.5 High-Level Waste Feed Staging

A sufficient quantity of HLW feed can be prepared for delivery to the Private Contractor by June 2002 to satisfy the minimum order quantity of Waste Envelope D specified in the Phase I Privatization contracts (DOE-RL 1996c,d). With the planned DST retrieval system (i.e., two 300-hp mixer pumps), the total quantity of pretreated HLW feed (approximately 350 MT of waste oxides excluding sodium and silicon) is at least 140 percent of the minimum order quantity (245 MT). However, additional sources of feed are required to support HLW immobilization during the optional extension of Phase I. The maximum amount of pretreated HLW feed available from 241-AZ-101, 241-AZ-102, and 241-AY-102/241-C-106 (450 MT) is less than the maximum order quantity (465 MT), assuming 100 percent retrieval. Based on the minimum anticipated efficiencies of the DST retrieval systems, the amount of waste available for feed would be 75 percent of the maximum order quantity. Potential sources of additional HLW feed that can be used to satisfy maximum order quantity are: 241-AY-101, 241-C-101, 241-C-102, 241-C-103, 241-C-104, and 241-C-105 (see Appendix G). Further analyses are needed to determine the preferred tanks and methods of retrieval.

To prepare the HLW feeds for delivery to the Private Contractor, the pretreatment of the high-heat and aging waste sludges should consist of between one and four 1:1 washes with dilute caustic solution (0.1*M* NaOH). Following pretreatment, the compositions of the HLW feeds will be chemically adjusted with sodium hydroxide and silicates to satisfy the Waste Envelope D specifications for aluminum, sodium, and silver. (Alternatively, as discussed in Section 2.2.2, the Waste Envelope D specifications can be slightly modified.) These steps represent an appropriate set of processes required to satisfy the composition requirements defined by Waste Envelope D, and to produce a HLW feed which would allow the Private Contractor the greatest flexibility toward maximizing the HLW product loading. Enhanced sludge washing is the baseline planning case (Kinzer 1996), and is evaluated in a separate alternatives study (Manuel 1997). The HLW feed preparation strategy modeled in HTWOS (water washing) is summarized in Section 3.4.3.4.

This "Base Case" HLW Pretreatment and Feed Staging Plan processes the three feeds in this order: 241-AZ-101, 241-AZ-102, 241-AY-102/241-C-106. However, it may be

advantageous to prepare HLW feed from 241-AY-102/241-C-106 before 241-AZ-102. The benefits of processing 241-AY-102/241-C-106 second and 241-AZ-102 third in the sequence are as follows:

- The estimated quantity of feed retrievable from 241-AY-102 (containing 241-C-106 sludge) is more certain than for 241-AZ-102, and therefore it would be easier to estimate when the equipment in the next tank (i.e., 241-AZ-102) would have to be installed.

- The quantity of feed available from 241-AY-102 (containing 241-C-106 sludge) is greater than 241-AZ-102, and processing it sooner would reduce the composition variability in the early part of Phase I.

- Emptying 241-AY-102 sooner, opens the opportunity to fill it with additional feeds from C Farm (Appendix G) while 241-AZ-102 is being processed. Transfer lines will exist as a result of sludge retrieval from 241-C-106. The pretreated solids in 241-AY-102 could then serve as a potential HLW feed tank if additional feeds are desired.

2.1.6 Tank Waste Remediation System Flowsheet

The following section summarizes the feed staging activities.

2.1.6.1 Phase I.

Low-Activity Waste Feed Delivery. The PHMC Team prepares LAW feed in tanks 241-AP-102 and 241-AP-104, and stages about 4,500 MT of sodium to each Private Contractor's feed tank (241-AP-106 or 241-AP-108) over the duration of Phase I. During retrieval, water is added (if necessary) to facilitate retrieval, meet tank farm operating specifications, and satisfy feed specifications. The chemistry of some Phase I LAW feeds has been modeled thermodynamically to identify when the dilution of ionic strength precipitates aluminum to avoid over-dilution.

Feed delivery begins when the Private Contractors' tank has about 30 days worth of feed remaining. This strategy of receiving into and feeding from the same tank enables the Private Contractors to operate their facilities continuously. The Private Contractors avoid the inefficiency and inconvenience of plant shutdowns and restarts between discrete batches of feed. However, the feed tank is emptied when switching between envelopes.

Low-Activity Waste Feed Processing. The Private Contractors separate solids and remove (as needed to satisfy Phase I immobilized low-activity waste [ILAW] specifications) strontium/transuranic (TRU), cesium, and technetium from the LAW supernate. The Private Contractors immobilize pretreated LAW in an unspecified waste form (assumed to be glass containing 20 wt% Na_2O). ILAW packages occupy 2.6 m^3 of storage space.

Table 2.1-4 summarizes the LAW feed to and production of ILAW (volume and package count) from each Private Contractor.

Table 2.1-4. Low-Activity Waste Feed Staging and Product Planning Summary.

		Envelope			Total
		A	B	C	
Private Contractor 1	MT Na	2,060	120	2,320	4,500
	m^3 ILAW	6,560[a]	940[b]	7,390[a]	14,890
	Packages[c]	2,530	360	2,850	5,740
Private Contractor 2	MT Na	2,060	120	2,230	4,410
	m^3 ILAW	6,560	940	7,100	14,600
	Packages	2,530	360	2,740	5,630
Total	MT Na	4,120[d]	240	4,550	8,900
	m^3 ILAW	13,120	1,880	14,490	29,490
	Packages	5,060	720	5,590	11,370

ILAW = Immobilized low-activity waste
LAW = Low-activity waste
[a]Envelopes A and C ILAW displaces 3.18 m^3 per MT Na
[b]Envelope B ILAW displaces 7.95 m^3 per MT Na
[c]Packages displace 2.6 m^3
[d]The PHMC Contractor will revise the feed staging plans to include the staging and delivery of the additional Envelope A feed needed to meet the minimum order quantities by either blending of existing Envelope A feed with near-Envelope A feed or by shimming near-Envelope A feed with caustic to adjust the analyte:sodium ratios. Additionally, the DOE/WIT are working on refined LAW feed envelopes that will reclassify a significant quantity of Envelope C waste as Envelope A. If this is done, the delivered quantity of Envelope A may be as large as 9,200 MT Na.

High-Level Waste Pretreatment and Feed Delivery. The PHMC Team pretreats HLW sludges in 241-AZ-101, 241-AZ-102, and 241-AY-102 (including retrieved 241-C-106 sludge) by multiple water washes to provide feed to the HLW contractor that is within feed specifications. Washing separates water-soluble waste constituents from the solids and prepares up to 450 MT (oxide equivalent, not including Na and Si) of washed solids for the HLW Private Contractor.

High-Level Waste Processing. The HLW contractor combines separated radionuclides with the washed solids and vitrifies at no less than 25 wt% waste oxide loading (not including sodium and silicon). The HLW package is a DWPF canister containing 0.62 m^3 (1.65 MT) of IHLW.

Table 2.1-5 summarizes the washing scenario for each tank and the mass/canister count of IHLW returning from the HLW Private Contractor.

Table 2.1-5. Phase I Immobilized High-Level Waste Summary.

Tank	Washes[a]	Washed oxide (MT)	Glass (MT[a] 25 wt% waste oxide)	Canisters (1.65 MT) (0.62 m^3)
241-AZ-101	3	96	390	230
241-AZ-102	4	160	650	390
241-AY-102 (w/241-C-106)	2	190	780	470
Total		450	1,810	1,100

[a]Dilute caustic wash at a 1:1 liquid-to-sludge ratio.

2.1.6.2 Phase II. DOE will procure all retrieval and treatment services from Private Contractors during Phase II. There are programmatic planning assumptions available for Phase II, but no document comparable the Phase I Request for Proposal (RFP) (DOE-RL 1996) has been prepared to provide specific guidance on feed envelopes, separation requirements, and product specifications. DST waste that was not processed during Phase I and all of the remaining SST waste will be treated during Phase II.

Phase II operations can be broken into three categories:

1. Retrieval of the SSTs (by sluicing as a reference, although some tanks may require alternate methods)

2. Operation of the DST system as a receiving facility for retrieved SST waste and a staging facility for pretreatment and treatment operations

3. Pretreatment and treatment operations in contractor provided facilities.

Retrieval of 149 SSTs and managing that waste in the DSTs is an inherently batch-type operation which is better suited to the dynamic modeling capabilities of HTWOS (see Section 4.3). The flowsheet feed stream basis is a hypothetical composite of the total tank inventory remaining in the system at the beginning of Phase II.

Phase II's Private Contractors will develop their own process flowsheets, but the TWRS Process Flowsheet (Orme 1995) provides a reasonable processing architecture for current evaluations. The sludges in the composite feed stream are subjected to enhanced sludge washing (ESW). From the perspective of this flowsheet (i.e., treatment of a composite feed stream), the main purpose of ESW is to remove chromium to minimize the chromium-controlled glass volume. The vitrification of ESW treated sludge and radionuclides separated from the liquid phase will produce about 37,000 MT (13,900 m^3) of chromium-controlled IHLW.

Supernate created during retrieval and ESW leachates/wash liquors are treated to remove soluble radionuclides so that ILAW will satisfy concentration and performance assessment requirements. These liquids are likewise vitrified. Sodium is the assumed glass-controlling constituent in the liquid wastes. Assuming ILAW contains a minimum 20 wt% Na_2O, Phase II will produce 29,490 m^3 of ILAW.

2.1.7 Single-Shell Tank Retrieval Sequence

This section of the report documents highlights for the selected SST retrieval sequence for the TWRS. The main discussion is found in Section 4.3. The disposal program retrieval sequence is a listing of the SSTs showing the proposed retrieval order (sequence), and the proposed retrieval dates. The retrieval sequence study assumes sluicing as the baseline retrieval method. A preferred retrieval method has not been selected or provided as input to the retrieval studies at this time. Assuming sluicing versus other retrieval methods affects retrieval timing, but not the dilution for transfer and storage, which is determined by transfer restrictions.

The objective of this work for FY 1997 is to update the TWRS baseline retrieval sequence, and to report the sequence to satisfy the requirements of Tri-Party Agreement milestone M-45-02B. The work performed during FY 1997 is based upon the results of the retrieval sequence studies performed during FY 1995 (Certa 1995) and FY 1996 (Penwell 1996). It is also based upon the results of the FY 1997 LAW and HLW feed staging studies described in this report, and the other major bases and assumptions described in Appendix A of this report.

The sequence is developed for several other reasons. The studies associated with development of a retrieval sequence determine the following:

- The impact of program and system assumptions on the feasibility of meeting retrieval, LAW processing, and HLW processing goals and milestones

- The effects of the blending associated with various retrieval sequences upon the HLW glass volume

- The effects of various sequences upon the quantity of retrieval equipment which will be needed for retrieval

- The impact of the sequence for retrieval of SSTs upon the ability to meet retrieval and processing milestones.

There are several significant findings and conclusions from the retrieval sequence study. They are discussed briefly below.

1. Using the assumed SST retrieval infrastructure, it may not be possible to meet the 2018 retrieval interim milestone for SST retrieval completion (M-45-05). The assumed SST retrieval infrastructure is based upon realistic funding projections and can meet the environmental regulations for leak detection. Further studies will need to be performed to determine what is needed to allow the milestone to be met.

2. If the entire AX tank farm is retrieved before 2011, there will not be enough DST space available to meet Tri-Party Agreement target milestone M-45-05-T08. To meet the milestone, 35 tanks must be retrieved before the start of Phase II LAW processing. However, only a few million gallons of DST space are freed by Phase I privatized processing. Retrieval of 241-AX-101 will require 8,330 m^3 (2.2 Mgal) of the available storage space. Therefore, even if the AX farm is not retrieved, it is estimated that there will not be enough space available to allow the milestone to be met without retrieving waste from northern quadrant tanks, such as the 200 series tanks, which contain small quantities of waste. Because of the space constraints, this document assumes retrieval is initiated for only 32 SSTs before September 30, 2010.

3. To maximize the effectiveness of DST utilization, processing of DSTs containing large quantities of sludge should be delayed until later in the Phase II processing time period. This minimizes the space needed to store washed solids and maximizes the effectiveness of DST utilization.

4. The retrieval system for TX tank farm should be designed to allow retrieval from two tanks simultaneously because retrieval of TX farm one tank at a time (sequentially) would take approximately 12 years.

5. The new cross-site transfer line and the associated cross-site receiver will be in almost constant use during Phase II. Some transfers from the 200 West area are delayed up to three weeks waiting for the cross-site transfer line to become available because several tanks are in the queue waiting to transfer. It may be helpful to use two tanks from the 200 East area as cross-site receivers during Phase II retrieval and processing. This option should be evaluated as part of future studies to determine what equipment is needed during Phase II retrieval.

2.1.8 Project Support Schedules

The late need dates from the base case operating scenario were compared to the existing project schedules in an effort to make sure needed equipment and facilities are available to support feed delivery. Twenty-six "project tasks"[1] were identified. The major results of the review follow (see Section 3.5 for more details):

- Twelve are scheduled to complete in time to support the base case operating scenario. In a few cases, the operating scenario may require noise-level (one month or less) adjustments to be in full agreement with the baseline schedules for these project tasks.

- Eight are scheduled to complete within two to eight months after the late need date from the base case operating scenario. The baseline schedules for these project tasks were established before privatization and re-alignment to support privatization has not been fully completed.

- Five are needed in fiscal years 2004 through 2006. The acquisition strategy of these project tasks has not been determined yet.

- The baseline for one project task was not available due to on-going project re-alignment activities.

Additionally:

- Six project integration issues were identified for resolution.

- A method for the Disposal Program to allocate and manage schedule slack was proposed to help address the scheduling issues.

[1]As used in this section, a "project task" can be an existing capital project, a portion of an existing capital project, an expense funded activity, or a yet to-be-determined acquisition strategy. Each project task provides the facilities, equipment or systems needed to support a specific operational activity from the base case operating scenario. Of the 26 project tasks, 11 are part of Project W-211 (Double-Shell Tank Retrieval Systems).

2.2 RECOMMENDATIONS

The following section summarizes recommendations identified in the analysis performed to prepare this document.

2.2.1 Low-Activity Waste Plan Changes

The PHMC Team has identified two refinements to the low-activity waste feed staging plans that are required to bring the plans into compliance with the privatization contracts as currently written. See Section 3.1.3, Recommendations, for the full text.

- The PHMC Team will refine the feed staging plans to include staging and delivery of additional Envelope A feed by either blending of existing Envelope A feed with near-Envelope A feed or by shimming near-Envelope A feed to adjust the analyte:sodium ratios. The blending and shimming capability provided by the intermediate feed staging tanks (241-AP-102 and -104) may be used for this purpose.

- The additional feed needed to deliver the combined maximum order quantity of Envelope A, B, and C will be included in the operating scenario. This last feed batch was not included in this version of the operating scenario in order to maintain consistency with the Disposal Planning Case in the Operational Waste Volume Projection. This case was established before the feed classification work in this report was completed.

The PHMC Team has identified areas that require further analysis in order to further refine the feed staging plans:

- Perform the analysis to establish a basis for negotiating the minimum duration between delivery of successive feed batches. The 114-day value used in this report is an enabling assumption.

- Develop and implement process control schemes that reduce the probability of preparing an out-of-specification feed batch.

- Develop and implement fall-back positions to correct or mitigate the consequences of an out-of-specification feed batch.

- Develop fall-back positions for retrieval of feed in the event that there are problems with the mixer-pumps (or whatever equipment is actually deployed).

- Confirm that performing the mixer-pump test in 241-AZ-101 and pre-staging the NCAW supernate from 241-AZ-101 and -102 into 241-AY-101 will not adversely affect the composition of the delivered Envelope B feed.

The following contract changes have been recommended to potentially reduce cost. They address issues identified in this report, the LAW Feed ICD (ICD 19) (Berry 1997), or the previous *Low-Activity Waste Feed Staging Report* (Certa et al. 1996). These recommendations should increase the robustness of the feed delivery system and plans, while remaining fair to both the PHMC Team and the Private Contractors. In addition, they may provide additional flexibility to the PHMC Team in selecting the first few feed batches and in relaxing the continued use of 241-AP-106 and 241-AP-108. However, it recognized that these recommendations may require negotiation between DOE and the Private Contractors. See Section 3.1.3, Recommendations, for the full text.

- Reduce the minimum size of the first feed batch.
- Reduce the minimum order quantity of Envelope A.
- Include a new combined minimum order quantity for Envelopes A, B and C.
- Explicitly permit the DOE/PHMC Team to complete delivery of the feed batch that reaches a minimum order quantity even if this means that the minimum order quantity will be exceeded.
- Refine the Envelope limits for aluminum, sulfate, total organic carbon, transuranic and ^{90}Sr.
- Develop a compensatory model for processing of off-specification feed.
- Impose a minimum duration between the completion of the delivery of one feed batch and the waste transfer date for the following batch.

2.2.2 High-Level Waste Feed Staging Plan Changes

In the next revision of the TWRSO&UP, the HLW pretreatment and feed staging plan will evaluate a feasible operating scenario in which the additional Envelope D feeds, identified in Appendix G, are pretreated and staged to the Private Contractor. This strategy will improve the ability to satisfy both the minimum and maximum order quantities, regardless of uncertainties in retrieval efficiencies or in the pretreatment process. Additionally, more detailed operational scenarios for blending and/or chemical adjustment (by additional pretreatment or "shimming") of the HLW feeds will be developed, which can be used to satisfy the Envelope D composition specifications.

Similar to the recommendations for LAW feed staging, the following contract changes are recommended as potential means for reducing cost and improving flexibility for feed delivery. It is recognized that these recommendations will require negotiation between the DOE and the Private Contractors.

- Modify the current definition of Waste Envelope D (and the Expanded Design Basis for Waste Envelope D), specifically for the maximum concentrations of aluminum and silver.

- Minimize the number of analytes in Waste Envelope D to include only those components which are considered significant to the performance of the immobilization process.

2.2.3 Waste Feed Delivery Characterization Data Needs

The following actions need to be performed to define Disposal Program Characterization data needs or to obtain necessary characterization and process data. See Appendix D for further discussion on these actions.

- Perform statistical analyses on available data for the candidate Phase I feeds to identify what data are needed to support feed delivery activities.

- Perform dilution and dissolution tests on the candidate Phase I LAW feed tanks to determine how much can be dissolved and what it will take to dissolve the waste.

- Perform an analysis (using Monte-Carlo techniques) to determine the probability that the feed delivered to the Private Contractors meets the envelope specifications given the uncertainties in estimating the composition, the solid/liquid equilibrium, the initial retrieval sequence, and the mixing of heels in the interim staging tanks..

- Complete the 241-AZ-101 Mixer Pump Test.

- Provide any required data or bases missing from the best-basis inventory that are needed to determine conformance to contract feed envelope specifications.

2.2.4 Phase II Laboratory Testing

The following actions are recommended to provide data to support planning for Privatization Phase II.

- Continue Enhanced Sludge Wash (ESW) tests on SST sludges to obtain data representing >90 percent of the SST sludge volume and to confirm the data for Sort on Radioactive Waste Type (SORWT) groups containing large volumes of sludge.

- Focus oxidative leaching tests on selected waste types that offer the highest potential to reduce residual chromium. SY tank farm waste is an example.

- Compare Colton's inventory estimate (Colton 1997) to best-basis inventory totals to provide insight for further sampling and testing. Other individual component inventories (e.g., sulfate) may have increased to the point of controlling IHLW volumes for individual HLW batches during Phase II.

2.2.5 Future Engineering Trade Studies

Engineering and trade studies will be needed during future years to support SST retrieval, and to improve sequence generation and process development. The needed studies that are currently known are shown on the retrieval mid-level logic diagrams (see Appendix J).

2.2.5.1 Sequential Processing. The current planning baseline for Phase II assumes that the LAW and HLW immobilization facilities will operate in parallel, with LAW immobilization starting on October 1, 2011, and HLW immobilization starting on December 31, 2012. However, it is recommended that future evaluations be performed to assess the potential benefits of deferring HLW immobilization until later in Phase II. Among the benefits of this "Sequential Processing" alternative (Slaathaug et al. 1996) are as follows:

- Consolidation of all of the pretreated HLW solids in the DST system would allow the "Total Blend" (Penwell et al. 1996) to be produced, generating the minimum volume of immobilized HLW product.

- The "Total Blend" minimizes the number of feed compositions, for which the HLW immobilization facility would have to be designed and HLW product composition qualified.

- If HLW immobilization is deferred until the completion of LAW processing, the same facility may be used to perform both functions.

- Deferring HLW immobilization reduces the capital expenditure at the beginning of Phase II, possibly without a schedule impact on SST retrieval and closure.

The HTWOS model can be used to assess whether the implementation of the "Sequential Processing" alternative is feasible. The capability of storing pretreated HLW solids within the DST system can be determined, and any additional tank capacity requirements can be quantified. Estimates of HLW disposal costs and any other expenses incurred can be made. It can also be determined whether this alternative has a negative impact, if any, on the completion dates for SST retrieval.

2.2.5.2 Phase II Infrastructure. A Phase II infrastructure study is needed. This study would include several sub-studies. The sub-studies include determination of the recommended basic Waste Retrieval Facility (WRF) configuration for the three WRFs for the northeast and northwest quadrants and for U farm, and determination of the basic recommended retrieval

infrastructure configuration for each of the four tank farm quadrants and each of the farms within those quadrants.

Future TWRSO&UP studies should evaluate alternatives for maximizing use of the DSTs. The HTWOS model will need to be updated to allow the DSTs to switch functions during the midst of retrieval. This will allow studies to be performed to maximize utilization of the available DST space.

2.2.6 Tank Waste Remediation System Operation and Utilization Plan Next Revision

The following actions need to be completed to prepare the next revision of the TWRSO&UP. See Section 5.0 for further discussion of future work on the TWRSO&UP.

- Complete the partitioning of the best-basis inventory into soluble and insoluble fractions and place results under configuration control.
- Incorporate FY 1997 SST ESW wash and leach factors.
- Add additional detail to the way that HTWOS models 241-C-106 sluicing.
- Review the appropriate ICDs for changes that affect the feed staging analysis and incorporate those changes into the HTWOS model.
- Complete the HLW Pretreatment Process AGA (Manuel et al. 1997) and incorporate the results into the HTWOS model.
- Expand the HTWOS model to include storage and disposal facilities.

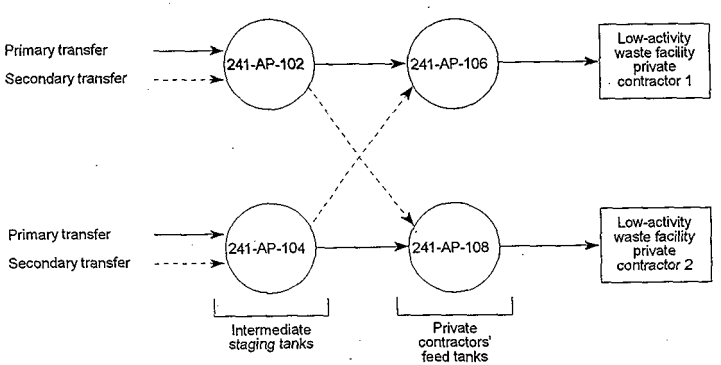
3.0 PRIVATIZATION PHASE I

The DOE/PHMC team is anticipating Phase I contractual obligations that will be finalized some time in FY 1998, and other tank management obligations occurring during Phase I. These obligations include the staging of LAW feed to up to two Private Contractors, the staging of HLW feed to up to one of those Private Contractors, the receiving of various final and intermediate waste products from the contractors, and the receiving of miscellaneous waste streams. This section documents DOE/PHMC team studies on the usage of tank farm facilities to meet privatization contract obligations, proposed SST retrieval activities, and to the extent possible, a process summary. Proprietary considerations preclude describing Private Contractor processing except to estimate the return of major product stream volumes.

3.1 LOW-ACTIVITY WASTE FEED STAGING

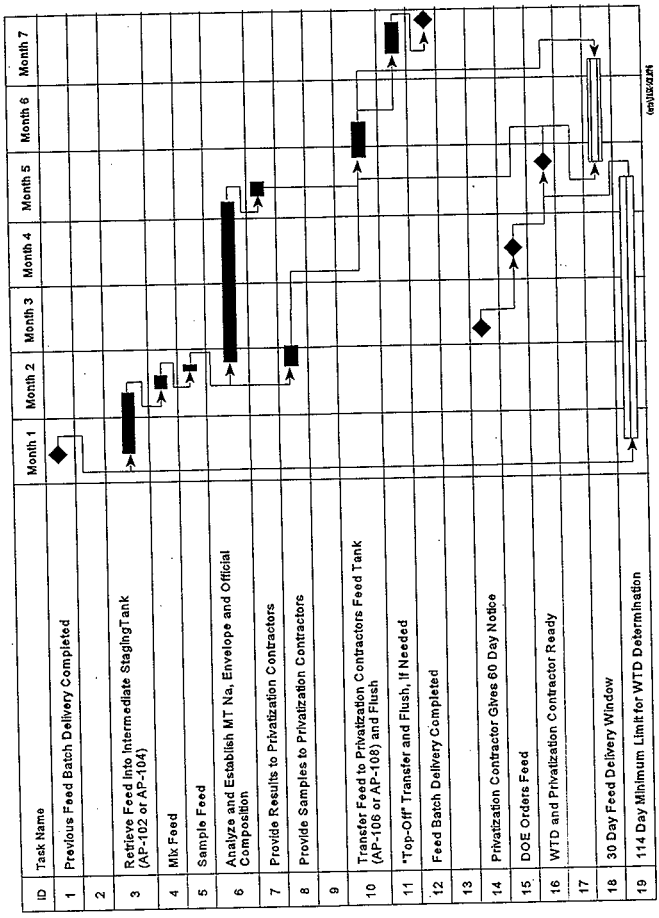
The DOE/PHMC Team is required to provide the two Phase I LAW Private Contractors with the appropriate quantities of feed of a specified composition at the proper times. To do this, the PHMC Team plans to use tanks 241-AP-102 and 241-AP-104 as intermediate feed staging tanks as shown in Figure 3.1-1. Waste retrieved from other DSTs will be transferred to the staging tanks and qualified before delivery to the Private Contractors' feed tanks (241-AP-106 or 241-AP-108).

Figure 3.1-1. Feed Staging Strategy.



Fresh feed is retrieved and transferred to the intermediate feed staging tanks as soon as the intermediate feed staging tank is emptied of its previous batch. In certain cases, feed may be "pre-staged" in another DST before transfer to the intermediate feed staging tanks. The waste is mixed, sampled, analyzed and adjustments are made if needed. The qualified feed is transferred from the intermediate staging tank to the feed tank according to the feed transfer protocol in the draft ICD for LAW Feed (Berry 1997). The overall operating logic and timing for the qualification and delivery of a single batch of feed is shown in Figure 3.1-2 (Berry 1997).

Figure 3.1-2. Feed Delivery Protocol Timing and Logic.



3.1.1 RESULTS AND CONCLUSIONS

The following section presents the results and conclusions for the LAW feed staging plans.

3.1.1.1 Operating Scenario. The LAW portion of the operating scenario refers to the waste transfers and other operational activities needed to deliver LAW feed to the Private Contractors. Major assumptions governing this operating scenario are discussed in Appendix A. A new enabling assumption, not included in Appendix A, was added: A nominal two month controlled mixer-pump startup has been added before retrieving waste from each watch list tank in order to degas the waste per the Mid-Level Logic Diagrams.

The operating scenario is summarized by Table 3.1-1. Estimates of the sodium delivered to each of the Private Contractors' feed tanks broken down by time (proof-of-concept or extension) and envelope are shown in Table 3.1-2. The composition of each feed batch is included in Section 3.4, Tables 3.4-9 and 3.4-10.

Table 3.1-1. Summary Feed Staging Schedule.

Env	Batch	Feed source (static date)	Pre-stage tank (static date)	Approximate timing[a]					Total feed delivered for both contractors (MT Sodium)
				Start boot-strap transfers	Start retrieval[b]	Begin staging[c]	Batch ready[d]	Batch delivered	
A[e]	1	241-AN-105 (Static)	-	9/1999	1/2001	3/2001	7/2001	7/2001	1,027
	2	241-AN-104 (Static)	-	-	7/2001	10/2001	12/2001	1/2003	1,070
	3	241-AW-101 (Static)	-	-	11/2002	1/2003	5/2003	9/2003	856
	4	241-AN-103 (Static)	-	-	8/2003	10/2003	1/2004	5/2004	1,170
B	5	241-AZ-101 241-AZ-102	241-AY-101 (1/2002)	8/2000		5/2004	9/2004	3/2005	234
C	6	241-AN-107 (11/1997)	-	-	3/2005	3/2005	7/2005	7/2005	238
	7							8/2005	544
	8	241-AN-102 (Static)	-	-	8/2005	8/2005	12/2005	12/2005	954
	9	241-AN-106 (7/1999)	-	-	12/2005	12/2005	4/2006	8/2006	822
	10	241-SY-101 (Static)	241-AN-102 241-AN-107 (4/2006)	1/2006	1/2006	8/2006	12/2006	3/2007	1,230
	11	241-SY-101 (Static) 241-SY-103 (Static)	241-AN-102 241-AN-107 (9/2006)	4/2006	4/2006 6/2006	3/2007	7/2007	1/2008	789

[a]All dates are based on the operating scenario and are subject to change within the contract and ICD limits.
[b]The Start Retrieval date applies to the source tank and includes the 60 days allocated for controlled degassing of waste in the watch-list tanks.
[c]The Begin Staging is when feed for this batch is first transferred into the intermediate feed staging tanks.
[d]The Batch Ready date includes the 114-day limit in the proposed feed delivery protocol, where applicable.
[e]The PHMC Contractor will revise the feed staging plans to include the staging and delivery of the additional Envelope A feed needed to meet the minimum order quantities by either blending of existing Envelope A feed with near-Envelope A feed or by shimming near-Envelope A feed with caustic to adjust the analyte:sodium ratios. Additionally, the DOE/WIT are working on refined LAW feed envelopes that will reclassify a significant quantity of Envelope C waste as Envelope A. If this is done, the delivered quantity of Envelope A may be as large as 9,200 MT Na.

Table 3.1-2. Estimates of Delivered Sodium.

	Envelope	Contractor 1	Contractor 2	Minimum order quantity	Maximum order quantity	Total for both contractors
Proof-of-concept	A[a]	2,062	2,061	2,600		4,122
	B	118	116	100		234
	C	119	119	100		239
	Subtotal	2,299	2,296			4,595
Extension	C	2,228	2,112			4,340
	A	-	-			-
	B	-	-			-
	Subtotal	2,228	2,112			4,340
	Total	4,526	4,408		5,100	8,934
By envelope	A[a]	2,062	2,061	2,600	4,900	4,122
	B	118	116	100	1,000	234
	C	2,347	2,231	100	2,400	4,578

[a]The PHMC Contractor will revise the feed staging plans to include the staging and delivery of the additional Envelope A feed needed to meet the minimum order quantities by either blending of existing Envelope A feed with near-Envelope A feed or by shimming near-Envelope A feed with caustic to adjust the analyte:sodium ratios. Additionally, the DOE/WIT are working on refined LAW feed envelopes that will reclassify a significant quantity of Envelope C waste as Envelope A. If this is done, the delivered quantity of Envelope A may be as large as 9,200 MT Na.

The DST processing sequence is shown in Section 3.1.1.5. The waste transfers and certain precedence relationships directly needed to implement the LAW portion of the operating scenario are shown on the schedule in Figure I-1 (Appendix I). "Bubble-diagrams" of these transfers are shown in Appendix E, Figures E-1, E-2, and E-3. The full set of transfers are included in Appendix H, Transfers Through October 2011. The retrieval and transfer equipment needed to support the operating scenario is discussed in Section 3.4.2.1.

The timing for the staging of the first two batches is determined by project schedules (equipment availability), waste management activities, transfer logistics and the need to operate within existing tank space. This portion of the operating scenario will be adjusted as the Project W-211 Baseline and Mid-Level Logic Diagrams are "locked-in" and the tank use coordination issues in Section 3.1.1.2 are resolved.

The overall timing of the staging of remaining feed batches is determined by the assumed LAW processing rates and the quantity of sodium in the feed. Knowledge of actual processing rates, including the planned ramp-up, is important for establishing the final timing for these feed batches.

The current allocation[1] of the proposed 114 day minimum limit between completion of delivery of one feed batch and the waste transfer date (WTD) for the next feed batch is as follows:

- 25 days--Set up transfer; correct problems, such as failed pumps, jumpers and other equipment
- 5 days--Retrieve and transfer feed to the intermediate feed staging tanks
- 14 days--Mix feed; take and analyze process control samples
- 5 days--Take feed qualification and contractor samples; transport samples to the PHMC Team's laboratory
- 60 days--Analyze samples and report results
- 5 days--Interpret and evaluate results (establish official composition and envelope classification).

This allocation does not include the time necessary to correct an out-of-specification feed batch. See Appendix A, Item 6.11, for more discussion.

For the larger feed batches, there may be schedule slack between qualification of a feed batch and delivery to the Private Contractor. This slack is available to absorb variability and delays in the feed staging activities, minor increases in processing rate and to correct out-of-specification feed batches. For example, a waste transfer scheduled for 3 days based on setup time and pumping rates could take significantly longer if there are equipment failures or operational/administrative delays.

[1]Based on enabling assumptions in Table E-10 (Certa et al. 1996).

Figure 3.1-3 shows overall DST requirements for the joint[1] TWRSO&UP/OWVP planning case (Strode and Boyles 1997). This figure accounts for space that is not available for used (such as head space in watch list tanks, spare tanks, etc.). Almost all DST space is allocated from fiscal year 1998 through 2008. Figure 3.1-4 shows the total volume of waste stored in DST system as a function of time as determined by the HTWOS computer model. Tank space required to empty and flush 241-AP-102, -104, -106 and -108, to hold the increased feed volume after dilution during retrieval, and to receive returns from the Private Contractors has been included in these figures. However, additional tank space that may be required for correction of out-of-specification feed batches has not been included.

Together, it is clear that aggressive management of tank space is critical to having sufficient space to support Phase I privatization. Appendix J, Double-Shell Tank Usage Allocation for Phase I Privatization, provides a summary plot of tank usage assumptions.

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[1]Programmatic and technical assumptions are in good agreement between both models from 1997 through 2003, the critical period for supporting Phase I Privatization. There are some minor differences in tank usage between 2004 and 2007. From 2008 through 2011 there are differences in tank usage. From 2011 on, both the SST Retrieval Sequence and amount of new waste received by the DST system vary. These differences do not affect overall model results or major conclusions.

Figure 3.1-3. Double-Shell Tank Requirements for the Disposal Planning Case.

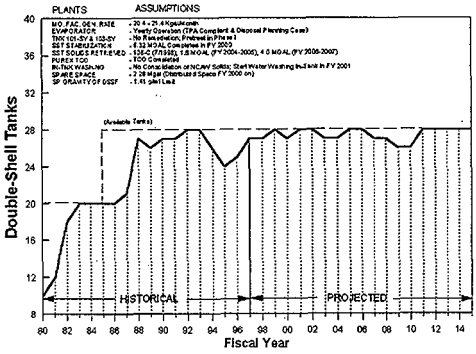
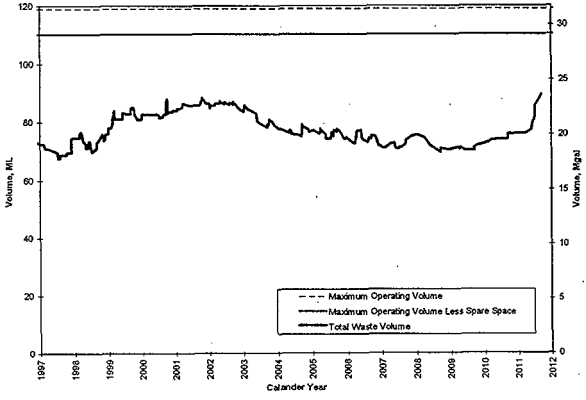


Figure 3.1-4. Total Projected Double-Shell Tank Waste Volume.



Near-term (before December 31, 2003) tank space demands are primarily governed by the amount of salt-well liquor pumped during the interim stabilization of the SSTs. The OWVP shows that 1.9 E+07 L (4.9 Mgal) of salt-well liquor is schedule to be pumped during fiscal years 1998-2000. After concentration through the 242-A Evaporator, the liquor will occupy a final volume of 1.2 E+7 ML (3.2 Mgal). Reduction or elimination of additional salt-well pumping can reduce demand on tank space during the period and provide a measure of assurance that adequate tank space will be available to support Phase I Privatization.

Long-term (between January 1, 2004 and June 1, 2011) tank space demands are primarily governed by the degree of back-filling of the DSTs made available by Phase I LAW processing with waste retrieved from the SSTs. Almost all DST space is back-filled with retrieved SST waste. Delay of SST retrieval can provide contingency space for correcting out-of-specification feed batches and to account for modeling and assumption uncertainty.

3.1.1.2 Coordination of Double-Shell Tank Use and Construction Activities. The Privatization contracts state that each Private Contractor will modify their assigned feed tank (241-AP-106 or 241-AP-108) and supporting systems. Due to DST tank space limitations, the current feed staging plans and Operational Waste Volume Projections continue to use these tanks for waste management during the same time frame that tank modifications and turnover are expected to occur. The PHMC Team and Private Contractors need to coordinate the PHMC Teams's continued use of these tanks with the permitting, tank upgrade and turnover activities. Figures 3.1-5 and 3.1-6 show the projected use of these tanks through the end of Phase I. These figures provide a rough indication of the activity taking place in these tanks; the details will change depending upon evolving waste management needs and turnover activities. The first batch of feed will be delivered no earlier than October 1, 2000 and no later than June 1, 2002. These coordination issues are being addressed as part of the feed tank (ICD 21) and LAW feed (ICD 19) ICDs (Berry 1997).

Similarly, the PHMC Team will need to use tanks 241-AP-102 and 241-AP-104 for waste management during the same time frame that Project W-211 is preparing them for use as intermediate feed staging tanks. Figures 3.1-7 and 3.1-8 show the projected use of these tanks through the end of Phase I. Again, the details will change depending upon evolving waste management needs and construction activities. The Project Manager for W-211 is aware of the need to coordinate these activities and believes that a detailed construction schedule can be prepared that will accommodate the waste management activities.

Figure 3.1-5. Tank 241-AP-106 Projected Fill History.

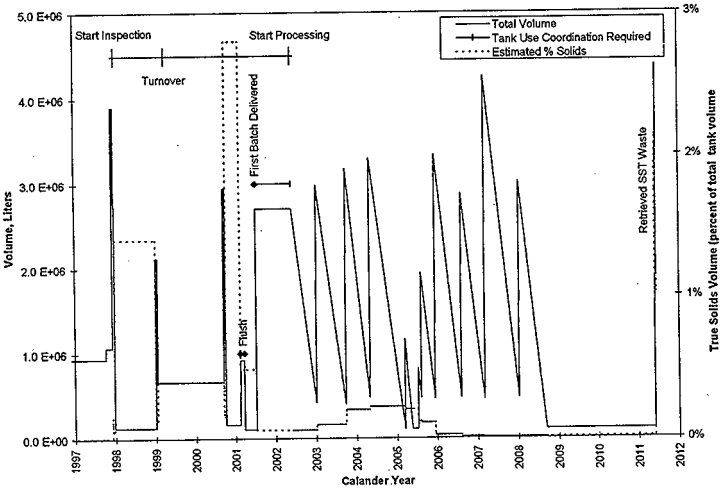


Figure 3.1-6. Tank 241-AP-108 Projected Fill History.

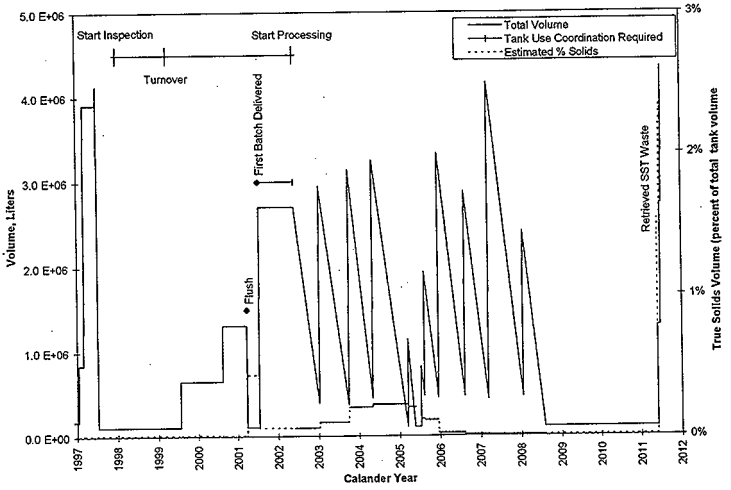


Figure 3.1-7. Tank 241-AP-102 Projected Fill History.

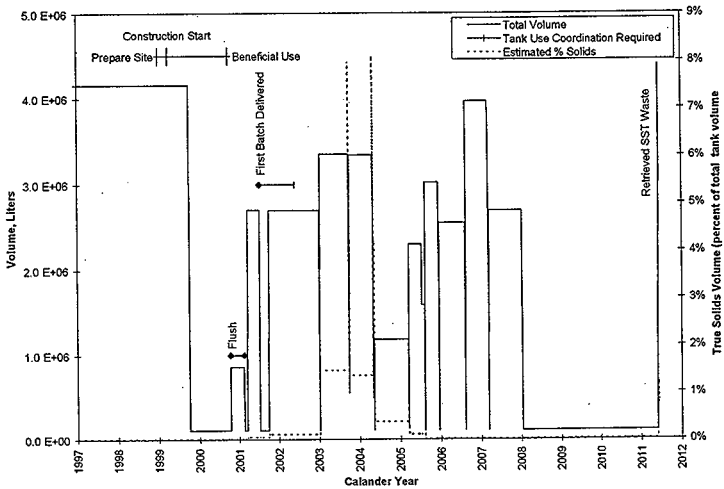
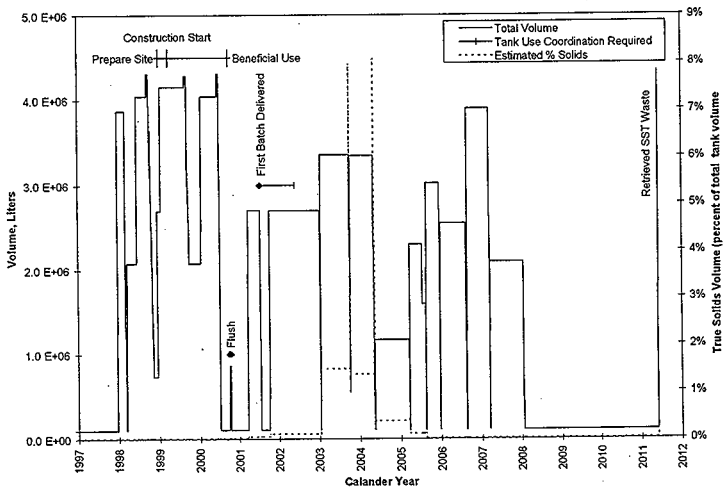


Figure 3.1-8. Tank 241-AP-104 Projected Fill History.



3.1.1.3 Feed Classification. Three feed envelopes, entitled Envelope A, B, and C, are established by the Privatization Contracts (DOE-RL 1996c, d). Each envelope provides a different technical challenge for the Private Contractors. Envelope A waste represents "waste that will test the production capacity and fission-product removal efficiency of the plants and will produce a final product in which waste loading will be limited by sodium. Envelope B waste is similar to Envelope A, except that it was defined so that the waste loading in the final product will be limited by minor component concentrations... The Private Contractor, will however, be challenged by working in a high-activity/high-heat environment. Envelope C represents waste with complexing agents that may interfere with strontium-90 or TRU decontamination and therefore require demonstration of organic destruction or another acceptable mitigation technology" (Patello et al. 1996).

In addition to the envelope specifications in the contracts, several major enabling assumptions were made:

The concentration ratio limits specified by the feed envelopes were assumed to refer to the liquid phase concentrations only.

At least one of the Envelope A maximum limits for Cl, Cr, F, PO_4, or SO_4 must be exceeded for waste to be delivered as Envelope B.

The Envelope A maximum limits for TOC must be exceeded for waste to be delivered as Envelope C[1].

As discussed in the following sections, three sets of waste compositions were compared to these limits and classified according to envelope (or classified as excluded if no envelope was satisfied). Waste with compositions that fell within 20 percent of any limit were further classified as borderline.

3.1.1.3.1 Initial Snapshot. The first set of compositions represent an initial snapshot of the targeted, as-retrieved fraction of waste projected to be present in the DSTs on June 1, 2000. For tanks with little or no metal oxide sludge, the entire tank's contents were targeted for retrieval. For tanks with significant amounts of sludge, the sludge was excluded from retrieval.

The amount of dilution water needed to retrieve the targeted waste fraction was determined as the greater of the amount of water needed to result in a maximum as-retrieved bulk SpG of 1.40 or to reach a maximum liquid phase sodium concentration. The maximum sodium concentration for the four DSTs containing Envelope A feed were selected to be roughly mid-way between the concentration at which no more solids dissolve and the

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[1]After the pending increase in the TOC to Sodium ratio for Envelope A and B to that of C, this enabling assumption will be revised to read: "At least one of the Envelope C maximum limits for ^{90}Sr and TRU must be exceeded for waste to be delivered as Envelope C."

concentration at which gibbsite begins to precipitate. This was determined by computer modeling using the Environmental Simulation Program (ESP)[1] package (see Section 3.4.2.3 for a discussion of solid-liquid equilibria and ESP modeling). A matrix of "wash-factors" that represents the end result of the solid-liquid equilibria calculations performed by ESP were used to repartition the liquid and solid components after retrieval (this accounts for the dissolution of sodium salts and the potential precipitation of other solids, except that wash factors were not available for 241-AW-101). The maximum sodium concentration for all other wastes was the proxy limit of 7.0*M*; no other adjustments were made for solid-liquid equilibria; no "wash-factors" were applied.

Table 3.1-3 shows the envelope classification of each DST along with the quantity of sodium in the liquid phase after retrieval. This table does not account for that fraction of the waste that will remain behind in the source tank after retrieval and therefore overestimates the amount of sodium by 3 to 10 percent. For example, after retrieval of the supernate from 241-AN-107 (which contains supernate above a sludge layer) there will be sodium remaining in the 0.10 ML of supernate heel above the sludge and in the interstitial liquid in the sludge. The majority of the waste (42 percent) is classified as Envelope C; 30 percent satisfies Envelope A limits, 25 percent is excluded, and 2 percent satisfies Envelope B limits. There is not enough Envelope A feed to meet the minimum order quantity for both contractors (5,200 MT Na) without blending or shimming[2]. However, several fall-back positions have been identified:

- Make up the shortage of Envelope A feed with by adding sodium hydroxide, sodium nitrate and/or sodium nitrite.
- Shim near-Envelope A feed with sodium hydroxide, sodium nitrate and/or sodium nitrite to bring within specification
- Revise the Envelope A limits as recommended in the Envelope Assessment (Section 3.1.1.4).
- Reduce the minimum order quantity of Envelope A and deliver additional Envelope C feed to make up the difference.

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

[2]The PHMC Contractor will revise the feed staging plans to include the staging and delivery of the additional Envelope A feed needed to meet the minimum order quantities by either blending of existing Envelope A feed with near-Envelope A feed or by shimming near-Envelope A feed with caustic to adjust the analyte:sodium ratios. Additionally, the DOE/WIT are working on refined LAW feed envelopes that will reclassify a significant quantity of Envelope C waste as Envelope A. If this is done, the delivered quantity of Envelope A may be as large as 9,200 MT Na.

Table 3.1-3. Envelope Classification of Double-Shell Tanks as of June 1, 2000.

Available	Tank	MT Na in Target Feed				
		Envelope A	Envelope B	Envelope C	Excluded	
Dec-99	AN-101				937	
Jan-93	AN-102			1,060		
Jan-93	AN-103	1,234				
Jan-93	AN-104	1,100				
Jan-93	AN-105	1,090				
Jul-99	AN-106			846		
Oct-97	AN-107			913		
Apr-99	AP-101				745	
Oct-99	AP-102			11		
Oct-99	AP-103			435		
Jan-00	AP-104			552		
Jun-98	AP-105				805	
Jan-99	AP-106				33	
Nov-99	AP-107			14		
Jul-99	AP-108			117		
Jan-93	AW-101	991				
Nov-99	AW-102			104		
Aug-98	AW-103				388	
Oct-99	AW-104				491	
Jun-96	AW-105				15	
Dec-99	AW-106				104	
Mar-97	AY-101				21	
Nov-98	AY-102				72	
Jan-93	AZ-101		359			
Jan-93	AZ-102				197	
Jan-93	SY-101			1,390		
Jan-00	SY-102			155		
Jan-93	SY-103			718		
						Non-Target
	Sub-Totals	4,415[a]	359	6,316	3,808	1,391
	A+B+C	11,090				

TARGET FEED ONLY BASIS

Separate	30%	2%	42%	25%
A+B+C	74%			
Total	14,898			

TOTAL DOUBLE-SHELL TANK INVENTORY BASIS					Non-Target
Separate	27%	2%	39%	23%	9%
A+B+C	68%				
Total	16,288				

[a]See Table 2.1-2 note on Envelope A feeds.

Appendix I, Table I-1 compares the estimated composition of the retrieved liquid phase against the envelope limits on an analyte by analyte basis. The table shows which compositions satisfy the envelope limits and which are borderline.

The initial snapshot was used to establish the processing sequence described in Section 3.1.1.5.

3.1.1.3.2 Final Snapshot. The second set of compositions represent a final snapshot of the targeted, as-retrieved fraction of waste projected to be present in the DSTs on June 1, 2011. This projection reflects the waste in the system after the base case processing of LAW (including the extension period), HLW (only the currently identified feed), and the retrieval of waste from SSTs. The majority of the waste (78 percent) is classified as excluded, 20 percent satisfies Envelope C limits, 2 percent satisfies Envelope B limits, and none satisfied Envelope A limits (Table 3.1-4). As with Table 3.1-3, this table does not account for that fraction of the waste that will remain behind in the source tank after retrieval. A large fraction of the Excluded feed is supplied from retrieved SST waste. Therefore, both the estimated SST compositions and the applicability of the Phase I envelopes to Phase II should be carefully examined.

Appendix I, Table I-2 compares the estimated composition of the retrieved liquid phase against the envelope limits on an analyte by analyte basis. The table shows which compositions satisfy the envelope limits and which are borderline.

Table 3.1-4. Envelope Classification of Double-Shell Tanks As of June 1, 2011.

Available	Tank	MT Na in Target Feed				
		Envelope A	Envelope B	Envelope C	Excluded	
Jan-05	AN-101				943	
Jun-07	AN-102			298		
Oct-09	AN-103				423	
Jan-05	AN-104				772	
Mar-11	AN-105				10	
May-07	AN-106				278	
Jun-07	AN-107			501		
Jan-05	AP-101				753	
Jan-08	AP-102			17		
Jan-05	AP-103			444		
Jan-08	AP-104			18		
Jan-05	AP-105				815	
Sep-08	AP-106			17		
Oct-08	AP-107				494	
Aug-08	AP-108			18		
Jan-11	AW-101				935	
Apr-11	AW-102				42	
Jan-05	AW-103				389	
Jan-05	AW-104				495	
Apr-06	AW-105				122	
Jan-11	AW-106				101	
May-04	AY-101		167			
Apr-09	AY-102				1	
Oct-08	AZ-101				187	
Aug-05	AZ-102				1	
Jun-07	SY-101			503		
Apr-11	SY-102				272	
Jan-08	SY-103				283	
						Non-Target
	Sub-Totals	0	167	1,817	7,312	1,392
	A+B+C		1,983			

TARGET FEED ONLY BASIS

Separate	0%	2%	19%	79%
A+B+C		21%		
Total		9,296		

TOTAL DOUBLE-SHELL TANK INVENTORY BASIS

					Non-Target
Separate	0%	2%	17%	68%	13%
A+B+C		19%			
Total		10,688			

3.1.1.3.3 Delivered Feed. The third set of compositions represents point-estimates of the individual feed batches delivered to each Private Contractor. Table 3.1-5 shows the quantity of sodium in each feed batch, the envelope classification, and the nominal date on which the feed has been staged and qualified in the intermediate feed staging tanks (not the delivery date).

All feed batches satisfied their intended envelope, based on point composition estimates.

Appendix I, Table I-3 compares the estimated composition of the liquid phase of the delivered feed against the envelope limits on an analyte-by-analyte basis. The table shows which compositions satisfy the envelope limits and which are borderline.

Detailed mass balances for each feed batch are presented in Appendix E.

Table 3.1-5. Envelope Classification of Delivered Low-Activity Waste feed Batches.

Available	Batch[b]	MT Na in Delivered Feed			
		Envelope A	Envelope B	Envelope C	Excluded
Jul-01	C1-1	514			
Jan-02	C1-2	535			
May-03	C1-3	428			
Jan-04	C1-4	585			
Sep-04	C1-5		118		
Jul-05	C1-6			119	
Jul-05	C1-7			272	
Dec-05	C1-8			477	
Apr-06	C1-9			411	
Dec-06	C1-10			615	
Jul-07	C1-11			452	
Sub-Totals		2,062[a]	118	2,346	
Jul-01	C2-1	513			
Jan-02	C2-2	535			
May-03	C2-3	428			
Jan-04	C2-4	585			
Sep-04	C2-5		116		
Jul-05	C2-6			119	
Jul-05	C2-7			272	
Dec-05	C2-8			477	
Apr-06	C2-9			411	
Dec-06	C2-10			615	
Jul-07	C2-11			337	
Sub-Totals		2061[a]	116	2,231	

Totals[c]	4,122[a]	234	4,578	0
A+B+C	8,934			

[a]See Table 2.1-2 note on Envelope A feeds.
[b]The *Batch* column is read as follows: Cx-y means Contractor x, Batch y.
[c]There may be error due to round-off in the least significant digit

3.1.1.4 Envelope Assessment. The purpose of this section is to identify proposed changes to the low-activity waste feed envelopes. The changes identified in this assessment are those that will significantly increase the amount of waste classified as Envelope A and provide additional assurance that tanks with a borderline classification will remain within their intended envelope. This assessment is being performed in advance of the statistical evaluations of the contents of the static feed tanks and in advance of the application of the DQO for Determining that Feed T is appropriate for Batch X (See Appendix D).

Critical assumptions used for this assessment are as follows:

- The process limits given in Patello et al. (1996) accurately reflect the processing concerns and constraints for both LAW Private Contractors.
- The total uncertainty[1] on each analyte:sodium ratio of the waste to be classified is no more than ±20 percent. This is the same value used to screen for borderline classifications.
- *Less-Than* values in raw data sources are treated as missing data and not further evaluated.

The methodology used for the envelope assessment is discussed below; the assessment is provided in Appendix I, Table I-4.

The analyte:sodium ratios in Tables I-1 and -2 (Appendix I) were reviewed for maximum projected values and percent of entries with missing data (zeros entries). The projected values for tanks with transfers between the sample date and the snapshot date (tanks that are dynamic) may be biased low since missing data are handled as zeros. The percent of entries with missing data may also be biased low since mixing waste with missing data with other waste with non-zero values for an analyte will result in a non-zero result. The results of this review are documented in the column labeled *Maximum Value In This Study [% Missing]* in Table I-4 (Appendix I).

The analyte:sodium ratios in Tables I-1, -2 and -3 (Appendix I) were reviewed to identify the desired envelope classification of each tank or feed batch. The desired envelope classification of each batch was based upon a subjective evaluation of the envelope limit changes needed to accommodate the feed, nearness to the process limits and the descriptive evaluation of each analyte as presented in Patello et al. (1996). The results of this review are documented in the group of columns labeled *Problem Areas* in Table I-4 (Appendix I). Tanks

[1]As used here, the total uncertainty includes contributions from sampling in the source tank, sample preparation, sample analysis, solid-liquid equilibria, blending with other tank heels, feed qualification sampling and feed qualification sample analysis. The ±20 percent value probably underestimates this uncertainly.

containing less than 100 MT Na were excluded from this review, as was the evaporator feed tank (241-AW-102) and product tank (241-AW-106).

Proposed Limits were then selected for those analytes that influence the classification of significant quantities of feed based on the problem areas identified above. When possible, the proposed limit was at least ±25 percent away from both the process limit and the value needed to reclassify the feed into the desired envelope.

Analytes with significant quantities of missing data (>30 percent) or that are missing for tanks that provide Phase I feed were designated as having insufficient data for drawing conclusions in this assessment. This is not a determination that additional sample data are needed; consideration of less-than values, statistical evaluations of waste composition, or other studies may be required before drawing conclusions with respect to these analytes.

The proposed limits and explanatory notes are shown in the group of columns labeled Recommendation in Table I-4 (Appendix I) and summarized below:

Analyte	Envelope	Contract limit[a]	Proposed limit[a]	Units
Al	A, B, C	1.90 E-01	3.5 E-01	g-mole Al/g-mole sodium
SO4	A	9.7 E-03	2.0 E-02	g-mole SO4/g-mole sodium
TOC	A, B	6.0 E-02	5.0 E-01	g-mole C/g-mole sodium
U	A, B, C	1.2 E-03	1.4 E-02	g-mole U/g-mole sodium
TRU	C	3.0 E+06	3.7 E+06	Bq TRU/g-mole sodium
Sr-90	A, B	4.4 E+07	5.6 E+07	Bq Sr-90/g-mole sodium

[a]All limits are maximum analyte:sodium ratios.

The projected tank compositions for the initial snapshot were reclassified using the proposed envelope limits and the results of the reclassification are summarized in Table 3.1-6. The amount of Envelope A feed is potentially increased from 4,415 MT Na (Table 3.1-3) to 9,248 MT Na. This is over double the amount available under the current contract limits. There is a corresponding reduction in the amount of Envelope C. The amount of waste classified as Envelope B and as Excluded change slightly.

Table 3.1-6. Envelope Classification of Double-Shell Tanks are of June 2000 for Proposed Envelope Limits.

Available	Tank	MT Na in Target Feed				
		Envelope A	Envelope B	Envelope C	Excluded	
Dec-99	AN-101				937	
Jan-93	AN-102			1,060		
Jan-93	AN-103	1,234				
Jan-93	AN-104	1,100				
Jan-93	AN-105	1,090				
Jul-99	AN-106	846				
Oct-97	AN-107			913		
Apr-99	AP-101				745	
Oct-99	AP-102	11				
Oct-99	AP-103	435				
Jan-00	AP-104	552				
Jun-98	AP-105				805	
Jan-99	AP-106				33	
Nov-99	AP-107	14				
Jul-99	AP-108	117				
Jan-93	AW-101	991				
Nov-99	AW-102	104				
Aug-98	AW-103		388			
Oct-99	AW-104	491				
Jun-96	AW-105				15	
Dec-99	AW-106		104			
Mar-97	AY-101		21			
Nov-98	AY-102				72	
Jan-93	AZ-101		359			
Jan-93	AZ-102				197	
Jan-93	SY-101	1,390				
Jan-00	SY-102	155				
Jan-93	SY-103	718				
						Non-Target
	Sub-Totals	9,248	872	1,973	2,804	1,391
	A+B+C	12,093				

TARGET FEED ONLY BASIS

Separate	62%	6%	13%	19%
A+B+C	81%			
Total	14,898			

TOTAL DOUBLE-SHELL TANK INVENTORY BASIS

					Non-Target
Separate	57%	5%	12%	17%	9%
A+B+C	74%				
Total	16,288				

The projected tank compositions for the final snapshot were also reclassified using the proposed envelope limits (Table 3.1-7). The amount of waste classified as Excluded is reduced slightly (79 percent [Table 3.1-4] versus 64 percent for the proposed limits). A large fraction of the Excluded feed is supplied from retrieved SST waste. Therefore, both the estimated SST compositions and the applicability of the Phase I envelopes to Phase II should be carefully examined.

Table 3.1-7. Envelope Classification of Double-Shell Tanks are of June 2011 for Proposed Envelope Limits.

Available	Tank	MT Na in Target Feed				
		Envelope A	Envelope B	Envelope C	Excluded	
Jan-05	AN-101				943	
Jun-07	AN-102	298				
Oct-09	AN-103				423	
Jan-05	AN-104				772	
Mar-11	AN-105				10	
May-07	AN-106				278	
Jun-07	AN-107			501		
Jan-05	AP-101				753	
Jan-08	AP-102	17				
Jan-05	AP-103	444				
Jan-08	AP-104	18				
Jan-05	AP-105				815	
Sep-08	AP-106	17				
Oct-08	AP-107		494			
Aug-08	AP-108	18				
Jan-11	AW-101				935	
Apr-11	AW-102				42	
Jan-05	AW-103		389			
Jan-05	AW-104	495				
Apr-06	AW-105				122	
Jan-11	AW-106				101	
May-04	AY-101		167			
Apr-09	AY-102				1	
Oct-08	AZ-101				187	
Aug-05	AZ-102				1	
Jun-07	SY-101	503				
Apr-11	SY-102				272	
Jan-08	SY-103				283	
						Non-Target
	Sub-Totals	1,810	1,049	501	5,935	1,392
	A+B+C		3,361			

TARGET FEED ONLY BASIS

Separate	19%	11%	5%	64%
A+B+C		36%		
Total		9,296		

TOTAL DOUBLE-SHELL TANK INVENTORY BASIS

					Non-Target
Separate	17%	10%	5%	56%	13%
A+B+C		31%			
Total		10,688			

3.1.1.5 Low-Activity Waste Processing Sequence. The following criteria were used to establish the order that DST supernate is provided to the Private Contractors. The first group of criteria was considered non-tradeable (musts), the second group tradeable (wants).

Non-Tradeable

- ● The waste must belong to the proper envelope.
- ● The minimum order quantities must be satisfied.
- ● The minimum batch sizes must be satisfied.
- ● A DST must be emptied for receipt of returned ^{90}Sr/TRU and Entrained Solids by June 1, 2002.
- ○ A DST in AN Farm must be emptied for receipt of retrieved SST waste by December 31, 2003, to be used as a sluicing receiver by the Initial SST Retrieval System (ISSTRS).

Tradeable

- ○ Avoid staging tanks with low quality projections (including waste that is not static) early.
- ○ Stage tanks that are easier to retrieve early.
- ● Avoid "tank-hopping." Finish emptying each DST promptly.
- ● Avoid staging tanks that contain significant quantities of insoluble solids (sludge) early.
- ● Process dilute waste (lower specific gravity) early.
- ● Simplify Project W-211 design and construction activities by grouping tanks from the same farm together.
- ■ Group tanks that may require blending to correct out-of-specification feed near tanks that provide suitable blending stock.

Legend

- ● These criteria influenced the staging sequence.
- ○ These criteria did not influence the staging sequence (non-discriminator).
- ■ Recommended future criteria (not used).

Table 3.1-8 shows how these criteria were applied to develop the processing sequence using the composition data from the initial snap-shot in Table 3.1-2. The list of tanks was sorted by Envelope, Early Retrieval Desirability[1] (more desirable first), and then increasing specific gravity. The list was reviewed for consistency with the non-tradeable and tradeable criteria and deviations from the sorted order made when appropriate. These deviations are discussed below along with the transfers needed to "bootstrap" or pre-stage certain feed batches. See Appendix I, Figure I-1, for the LAW feed staging and delivery schedule. Appendix E, Figures E-1, E-2, and E-3, contains "bubble diagrams" of these feed batches.

As shown in Section 3.1.1.3, Table 3.1-2, four tanks (241-AW-101, 241-AN-103, -104 and -105) contain Envelope A feed and all of this feed must be used towards the minimum order quantity. Therefore, the first four feed batches must be obtained from these tanks, all of which are on the watch list for flammable gas concerns. Transfer of waste *out of* a hydrogen/flammable gas tank requires written approval by Nuclear Safety and DOE. Transfer of waste *into* a watch-list tank requires written approval by the Secretary of Energy (OSD-T-151-00030, OSD 1997). It is important that all actions needed to obtain these approvals be completed well in advance of the planned transfer dates (these actions are identified on the mid-level logic diagrams (Boston 1997).

The first tank was selected to be 241-AN-105. Tank 241-AW-101 was skipped because the point estimate of 991 MT Na is not sufficient to supply the minimum 1,000 MT Na (500 MT per contractor) for the first feed batch. Tank 241-AN-105 is a borderline tank (it is estimated to be within 17 percent of the maximum total organic carbon [TOC] limit), however it is assumed that the pending increase in the Envelope A TOC limit to 0.5 mole TOC per mole Na will be made. Once retrieved, this tank is immediately backfilled with flush solution from 241-AP-102, -104, -106 and -108 and then used as a dilute receiver for the remainder of the mission (including Phase II).

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[1]A measure, called "Early Retrieval Desirability," was constructed from three of the tradeable criteria to facilitate spreadsheet manipulation of the processing sequence. This measure is read from the matrix (see Table 3.1-8) of retrieval difficulty scores and projection quality (tanks with borderline envelope classification were treated as low quality projections for this purpose).

The retrieval difficulty score is based upon the relative difficulty associated with each of the various retrieval considerations. A binary number was constructed by reading the patterns of "x"s and blanks as "1"s and "0"s, respectively. "Incremental insertion" was considered the most difficult and assigned to the most significant bit (16); "Supernate\Slurry Transfer or Decant Pump" was considered the least difficult and assigned to the least significant bit (1). The other considerations were assigned to bits 8, 4, and 2. The retrieval difficulty score is the natural logarithm of one plus the base 10 value of the binary number. This score should only be used for ranking (a larger number means more difficult). It is not meant to represent the proportional or relative increases in difficulty.

Table 3.1-8. Low-Activity Waste Feed Processing Sequence.

Projections							Targeted Feed						Retrieved Feed				Projections			Retrieval Equipment					Sequencing			
Tank	Waste Type	Waste Envelope	Projection Quality	Borderline Classification?	% Margin, Limiting Species	Feed Available (Static Date or Date of Projection)	(Na), (M) Soluble	SpG Bulk	Volume, (L) Bulk	Dilution Ratio Final:Original Volume	Liquid Phase Fraction Included In Target	Solid Phase Fraction Included In Target	Liquid Phase (Na), (M)	Bulk SpG	Solids, wt% (Estimate)	Volume, (L)	Na, (MT)	Description of Retrieved Feed	Description of Waste Excluded from Retrieval	Incremental Insertion	Mixer Pump(s)	Mobilize with Slurry Distributors In Recirc. Loop	In-Line Dilution	Supernate/Slurry Transfer or Decant Pump	Retrieval Difficulty Score	Early Retrieval Desirability	Desired Processing Sequence	Tank
AZ-102	NCAW-->B		H			01-93	2.5	1.11	3.40E+06	1.00	1.0	-	2.52	1.11		3.40E+06	197	Supernate	0.35 - .88 ML Fluffed Sludge.					x	1.00	0	5	AZ-102
AY-101			M			03-97	2.3	1.11	4.01E+05	1.00	1.0	-	2.26	1.11		4.01E+05	21	Supernate	0.31 ML Sludge					x	1.00	3		AY-101
AW-105	NCRW		L			06-96	0.4	1.03	1.53E+06	1.00	1.0	-	0.44	1.03		1.53E+06	15	Supernate	1.12 ML Sludge					x	1.00	6		AW-105
AY-102			L			11-98	0.9	1.06	3.65E+06	1.00	1.0	-	0.86	1.06		3.65E+06	72	Supernate	.71 - 1.78 ML Fluffed Sludge					x	1.00	6		AY-102
AP-106			L			01-99	2.2	1.11	6.63E+05	1.00	1.0	1.0	2.19	1.11	1.08%	6.63E+05	33	Supernate - Entire tank	-					x	1.00	6		AP-106
AW-103	NCRW		L			08-98	4.3	1.23	3.88E+06	1.00	1.0	-	4.34	1.23		3.88E+06	388	Supernate	1.37 ML Sludge					x	1.00	6		AW-103
AW-104			L			10-99	5.6	1.27	3.83E+06	1.00	1.0	-	5.58	1.27		3.83E+06	491	Supernate	0.68 ML Sludge & 0.42 ML salts					x	1.00	6		AW-104
AP-101			L			04-99	7.7	1.35	4.18E+06	1.11	1.0	-	7.00	1.31		4.63E+06	745	Supernate - Entire Tank	-				x	x	2.00	6		AP-101
AN-101	DSSF		L			12-99	9.6	1.38	4.23E+06	1.37	1.0	1.0	7.00	1.27	0.01%	5.82E+06	937	Slurry - Entire Tank	-		x		x	x	3.58	6		AN-101
AP-105			L			06-98	9.1	1.50	3.85E+06	1.30	1.0	-	7.00	1.38		5.00E+06	805	Slurry - Entire Tank	-		x		x	x	3.58	6		AP-105
AW-106			L			12-99	6.1	1.3	7.43E+05	1.00	1.0	-	6.07	1.26		7.43E+05	104	-	-	-	-	-	-	-	-	9		AW-106
AW-101	DSSF	A	H			01-93	10.2	1.50	4.27E+06	1.58	1.0	1.0	6.50	1.32	3.41%	6.73E+06	991	Slurry - Entire Tank	-		x		x	x	3.58	3	3	AW-101
AN-105	DSSF	A	H	Y	18% TOC_{max}	01-93	11.5	1.50	4.13E+06	1.35	1.0	1.0	8.50	1.37	0.09%	5.58E+06	1090	Slurry - Entire tank	-		x		x	x	3.58	6	1	AN-105
AN-104	DSSF	A	H	Y	8% $SO4_{max}$	01-93	12.7	1.58	3.77E+06	1.51	1.0	1.0	8.40	1.39	0.21%	5.70E+06	1100	Slurry - Entire tank	-		x		x	x	3.58	6	2	AN-104
AN-103	DSS	A	H	Y	17% Al_{max}	01-93	14.5	1.59	3.69E+06	1.82	1.0	1.0	8.00	1.32	0.14%	6.71E+06	1234	Slurry - Entire tank	-	x	x		x	x	4.81	6	4	AN-103
AZ-101	NCAW	B	H			01-93	4.9	1.22	3.19E+06	1.00	1.0	-	4.90	1.22		3.19E+06	359	Supernate	0.25 - 0.62 ML Fluffed Sludge					x	1.00	0	5	AZ-101
AN-102	CC	C	H			01-93	11.3	1.42	4.07E+06	1.62	1.0	-	7.00	1.26		6.59E+06	1060	Supernate	0.34 ML Sludge				x	x	2.00	1	8	AN-102
AN-106		C	M			07-99	8.5	1.33	4.32E+06	1.22	1.0	1.0	7.00	1.27	0.49%	5.27E+06	846	Supernate	0.05 ML Sludge				x	x	2.00	3	9	AN-106
SY-101	CC	C	H			01-93	14.1	1.65	4.28E+06	2.02	1.0	1.0	7.00	1.32	0.12%	8.64E+06	1390	Soluble Portion - Entire Tank	Insoluble portion.		x		x	x	3.58	3	10	SY-101
AP-102		C	H	Y	3% TOC_{min}	10-99	4.4	1.19	1.04E+05	1.00	1.0	1.0	4.44	1.19		1.04E+05	11	Supernate - Entire tank	-					x	1.00	6		AP-102
AP-103	CP	C	H	Y	19% TOC_{min}	10-99	4.5	1.19	4.16E+06	1.00	1.0	1.0	4.55	1.19	0.04%	4.16E+06	435	Supernate - Entire tank	-					x	1.00	6		AP-103
SY-102		C	L			01-00	5.3	1.20	1.27E+06	1.00	1.0	-	5.29	1.20		1.27E+06	155	Supernate	0.27 ML Sludge					x	1.00	6		SY-102
AP-107		C	L			11-99	5.8	1.23	1.06E+05	1.00	1.0	1.0	5.83	1.23	0.01%	1.06E+05	14	Supernate - Entire tank	-				x	x	2.00	6		AP-107
AP-104	DC	C	L	Y	7% $^{99}Tc_{max}$	01-00	5.9	1.23	4.05E+06	1.00	1.0	1.0	5.93	1.23	0.01%	4.05E+06	552	Supernate - Entire tank	-					x	1.00	6		AP-104
AP-108		C	L			07-99	7.8	1.27	6.50E+05	1.11	1.0	1.0	7.00	1.24	0.01%	7.25E+05	117	Supernate - Entire tank	-					x	1.00	6		AP-108
AN-107	CC	C	H	Y	19% TRU_{max}	10-97	9.3	1.37	4.26E+06	1.33	1.0	-	7.00	1.28		5.68E+06	913	Supernate	0.51 ML Sludge				x	x	2.00	6	6-7	AN-107
SY-103	CC	C	H	Y	7% Al_{max}	01-93	11.2	1.49	2.79E+06	1.60	1.0	1.0	7.00	1.31	0.58%	4.48E+06	718	Soluble Portion - Entire Tank	Insoluble portion.		x		x	x	3.58	6	11	SY-103
AW-102		C	L			11-99	5.4	1.2	8.41E+05	1.00	1.0	-	5.39	1.22		8.41E+05	104	-	-	-	-	-	-	-	-	9		AW-102

Early Retrieval Desirability Matrix

Look-up table breakpoints for Retrieval Difficulty	Projection Quality* H	M	L	-	
0	9	9	9	9	Waste not retrieved
0.5	0	3	6	9	Pump only
1.5	1	3	6	9	Pump w/dilution water
2.5	2	4	6	9	Pump w/dilution water and slurry dist.
3.1	3	4	6	9	Mixer w/anything but incremental
4.05	5	5	6	9	Incremental w/anything but mixer
4.6	5	5	6	9	Incremental & mixer w/anything.

*Tanks with Borderline Envelope Classification are treated as having L Projection Quality

SORT ORDER: This list is sorted by Envelope, Early Retrieval Desirability (more desirable first), and then Target Bulk SpG (increasing).

Retrieval Difficulty Score: Larger values are more difficult.
Early Retrieval Desirability: Smaller values are more desirable.

DATA SET IDENTIFICATION		
HTWOS RUN NUMBER:		data
HTWOS RUN DATE:		9/5/97 3:42:24 p.m.
SNAPSHOT DATE:		6/2/00
9/5/97	Case 09	Base Case For Phase 1

Desired Processing Sequence: This sequence differs from the sort order to reflect constraints such as minimum and maximum order quantity, ISSTRS receiver tank in AN-Farm, DST space considerations, necessity of bootstrap transfers, etc.

Notes:

1) This is a snapshot of the projected DST contents on 6/2000 for the purposes of establishing the LAW Feed Delivery Sequence.

2) Mass balances that include heels remaining in the cross-site transfer origin tank, pre-staging tanks and intermediate staging tanks and the private contractors feed tanks are not reflected in this table.

3) The PHMC Team is refining the operating scenario to satisfy the minimum order quantities of Envelope A feed and the maximum combined order quantities for Envelopes A, B and C. Additionally, the DOE/WIT are working on refining the Envelopes to reclassify a significant amount of Envelope C waste as Envelope A waste.

The second tank was selected to be 241-AN-104. This time, tank 241-AW-101 was skipped to permit Project W-211 to enjoy design and construction efficiencies by upgrading 241-AN-105 and 241-AN-104 on a similar schedule. Tank 241-AN-104 is also a borderline tank (it is estimated to be within 8 percent of the maximum SO_4 limit). Staging 241-AN-104 early (before processing begins) will provide additional time to recover from an out-of-specification feed batch. Additionally, it may be possible to selectively blend waste from both 241-AN-104 and 241-AN-105 and potentially avoid an out-of-specification condition at the cost of added operational complexity. Once retrieved, this tank is backfilled with the double-shell slurry feed (DSSF) that is projected to be stored in 241-AP-107. Tank 241-AP-107 can then be used for receipt of the Entrained Solids that are expected to be returned from both Private Contractors and the ^{90}Sr/TRU that is expected to be returned from one Private Contractor.

The third tank was selected to be 241-AW-101.

The fourth tank was selected to be 241-AN-103, a borderline tank (it is estimated to be within 17 percent of the maximum Al limit). It may also be the most difficult to retrieve since it is the most concentrated of the four Envelope A tanks (it contains DSS; the others contain only DSSF). The crust may potentially complicate retrieval operations. Once retrieved, it is designated to be used as the SE quadrant sluicing receiver for ISSTRS.

The fifth batch of feed must satisfy Envelope B limits. Tank 241-AZ-101 contains Envelope B waste (the NCAW supernate); tank 241-AZ-102 contains waste that can be used as Envelope B blend stock. This batch is pre-staged in 241-AY-101 after decanting the supernate in 241-AY-101 in FY 1997. Pre-staging is necessary to avoid interference with the pretreatment of the HLW sludge in 241-AZ-101 and -102. After the mixer pump test in 241-AZ-101, the NCAW supernate is transferred on top of the sludge in 241-AY-101. As much supernate from 241-AZ-102 as can fit is used to top-off 241-AY-101. There are three issues with this feed batch:

1. Confirming that the mixer pump test will not adversely impact the composition of the NCAW supernate.

2. Confirming that the sludge in 241-AY-101 will not adversely affect the composition of the pre-staged feed.

3. The pre-staged feed contains about 400 MT of Na of which only 234 MT is delivered (total for two contractors). This feed can be processed in approximately 60 days. Per the draft ICD for LAW Feed, the next batch may not be delivered for about 54 days. It is recommended that future plans deliver all available Envelope B feed (200 MT to each contractor) to reduce the estimated outage (See Appendix A, Item 5.11).

The sixth and seventh batches will be provided by waste from 241-AN-107. Caustic addition is required to bring this waste to within the tank farm corrosion specifications. If not

performed prior to feed staging as currently planned, the adjustment may be made in the intermediate feed staging tanks. Tank 241-AN-107 is a borderline tank (it is estimated to be within 14 percent of the maximum TRU limit). None-the-less, it is planned as the first batch of Envelope C feed to maintain consistency with the OWVP Disposal Planning case and draft Multi-Year Work Plan (MYWP) submittal which were established before the feed classification work was completed (this will be corrected during the next revision of the TWRSO&UP). The staged feed is delivered to the Private Contractors in two batches. The sixth batch is kept small for the same reasons as batch 5 (See Appendix A, Item 5.11); the seventh batch delivers the remainder of the feed. Again it is recommended that future plans deliver this feed in a single batch (although, since the seventh batch is already staged and qualified, the desired goal is delivery of practical size feed batches rather than an outage).

The eight batch of feed is supplied from 241-AN-102.

The ninth batch of feed is supplied from 241-AN-106. This waste is available near CY 1999; its projected composition is subject to change along with its Envelope Classification since the TWRSO&UP/OWVP projections show that this tank will be receiving 242-A Evaporator bottoms until July 1997.

The tenth feed batch is supplied from 241-SY-101. Tank 241-SY-103 was skipped because 241-SY-101 already has a mixer pump that may be suitable for retrieval. This batch is pre-staged in 241-AN-102 and -107. First, the solids in 241-SY-102 are removed and transferred to 241-AW-105 to avoid potential adulteration of the feed[1]. Waste from 241-SY-101 is transferred to 241-SY-102 and then transferred via the cross-site system to 241-AN-102 and 241-AN-107. If the pending modification of the maximum TOC limit for Envelope A results in re-classification of this feed as Envelope A, this feed may be delivered earlier in the sequence.

The eleventh batch of feed is supplied from 241-SY-103 and the remaining waste from 241-SY-101. This batch is also pre-staged in 241-AN-102 and -107. Like 241-SY-101, if the pending modification of the maximum TOC limit for Envelope A results in re-classification of this feed as Envelope A, this feed may be delivered earlier in the sequence.

[1]The risk of not meeting the feed envelopes due to leaving these solids in 241-SY-102 has not been evaluated. The timing of this activity is consistent with Project W-211's schedule for the installation of the already-designed retrieval system in 241-SY-102.

A twelfth feed batch was not included in the operating scenario due to large uncertainties concerning available feed and composition and to maintain consistency with the OWVP Disposal Planning case which was established before the feed classification work was completed (this will be corrected during the next revision of the TWRSO&UP). The final snapshot (Table 3.1-3) shows that at the end of the Phase I extension most of the available feed is excluded (7,312 MT Na). Most of the remaining feed (167 MT Na Envelope B and 1,817 MT Na Envelope C) consists of retrieved SST waste which was not originally intended to be delivered during Phase I and is of low projection quality.

3.1.1.6 Waste Compatibility Assessment. Before transfer of waste within the DST system, a series of decision rules must be reviewed. These rules are documented in Fowler 1995a and 1995b and consolidate requirements from many sources. These rules, or their successors will need to be verified before each staging transfer. The discussions in the following sections are a cursory review that attempt to identify potential problems that may interfere with the staging of feed. Table 3.1-9 summarizes the results of the waste compatibility assessment for the transfers that deliver feed to the Private Contractors feed tanks (241-AP-102 or -104 to 241-AP-106 or -108). Any waste compatibility problems that occur with mixing of heels with the delivered batch and the waste heel in contractor feed tanks are identified in the following discussion.

Criticality Decision Rule. The rule for when the plutonium inventory[1] in the destination tank is less than 10 Kg will be satisfied if the total plutonium in the transfer is less than 15 g or the [Pu] in the source waste is less than 0.013 g/L (there are other ways to satisfy the criticality rule that are not being addressed here).

A review of the projected inventories for each contractor feed batch show the estimated plutonium inventory to be near zero. A review of the projected supernate/slurry inventories for each batch show that the maximum estimated equivalent [Pu] to be 5.46E-04 g Pu/L and the maximum equivalent quantity of plutonium in any single transfer (not including entrained solids) is about 1,850 g plutonium. Table 3.1-9 lists the projected equivalent [Pu].

Another source of Pu that has not been evaluated is the entrainment of Pu bearing solids during retrieval and transfer (decant) of supernate sitting above a sludge layer. Also, the radionuclide inventory estimates upon which this assessment has been based are incomplete.

The criticality decision rule should not interfere with or otherwise influence staging of Phase I DST supernate unless entrained solids during a decant transfer (which were not projected) contain significant quantities of plutonium. However, a modification to the Criticality Safety Evaluation Report may be required as a result of the USQ screening activities. The USQ screening is part of the authorization basis work scope identified on the mid-level logic diagrams (Boston 1997).

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[1]Plutonium inventory is calculated using plutonium equivalents as defined in WHC 1994.

Table 3.1-9. Summary of Waste Compatibility Data Quality Objectives Evaluation.

Rule Batch name	Criticality[a] equiv Pu (g/L)	Flammable gas SpG	Energetics	Corrosion	TRU segregation[b] TRU nCi/g	Heat generation BTU/h	Pumpability	Waste type	High PO_4
C1-1	1.64E-06	1.26	Not Evaluated.	OK	0.669	7,820	Not evaluated.	In General, all envelope switches may be problematic unless tanks that have been pumped down to the heels are considered empty.	The concentrated phosphate waste in tank 241-AP-102 is not a source of feed during Phase I.
C2-1	2.01E-05	1.31	Many DSTs have received organic wash waste from PUREX. This means that there could be soluble tributyl phosphate or separate phase PUREX-type solvent in the supernate in some DSTs.	OK	2.70	7,870	Insufficient waste characterization data (such as physical properties as a function of water or caustic dilution). It is assumed that the diluted waste will satisfy Pumpability requirements.		
C1-2	2.54E-07	1.26		OK	0.0759	10,100			
C2-2	1.92E-07	1.26		OK	0.0626	10,100			
C1-3	8.38E-06	1.28		OK	0.967	10,700			
C2-3	6.04E-06	1.28		OK	0.687	10,600			
C1-4	2.23E-07	1.25		OK	0.383	11,500			
C2-4	2.01E-07	1.23		OK	0.354	11,400			
C1-5	0.	1.27		OK	0.0361	25,400			
C2-5	0.	1.27		OK	0.0359	25,000			
C1-6	6.38E-05	1.34		OK	331.	4,920			
C2-6	1.97E-05	1.34		OK	331.	4,910			
C1-7	2.13E-05	1.35		OK	357.	8,280			
C2-7	2.16E-05	1.35		OK	357.	8,300			
C1-8	5.46E-04	1.29		NO	110.	7,640			
C2-8	5.45E-04	1.29		NO	109.	7,590			
C1-9	1.35E-04	1.37		OK	21.7	6,290			
C2-9	1.27E-04	1.31		OK	20.5	6,280			
C1-10	05.91E-05	1.28		OK	13.7	5,470			
C2-10	3.23E-05	1.29		OK	17.2	5,520			
C1-11	1.79E-05	1.27		OK	6.48	3,840			
C2-11	1.34E-05	1.27		OK	7.87	3,170			

[a]Entrained solids were not considered in evaluating this rule. Entrained solids are likely to be the major contributors to Pu and TRU in the waste.
Shaded cells require further evaluation. See the accompanying text for a description of the concerns.

Flammable Gas Accumulation Decision Rule. If the specific gravity of a source tank is less than 1.3 or the weighted mean specific gravity of the resulting blend is less than or equal to 1.41, then the transfer may proceed. A detailed technical evaluation is required to transfer waste exceeding the specific gravity limit. The operative rule will require that the specific gravity of the source tank, plus any in-line dilution, be less than or equal to 1.41 since most staging transfers will transfer the waste into a nearly empty tank.

None of the batches of feed to be delivered to the Private Contractors are projected to exceed the 1.41 SpG limit. However, the estimated supernate/slurry specific gravity of wastes currently in seven of the tanks providing Phase I feed exceed the 1.41 SpG limit; these tanks (241-AN-102, 241-AN-103, 241-AN-104, 241-AN-105, 241-AW-101, 241-SY-101, and 241-SY-103) will be diluted with water to satisfy the flammable gas rule (see Table 3.1-8 for estimated dilution water requirements).

The specific gravity of the staged feed batches is projected to range from 1.25 to 1.37 (Table 3.1-9). These values are acceptable.

Energetics. The waste must have no separable organic and the source and destination tanks must have endotherms in excess of exotherms. The energetics of the system are dependent on the organic speciation. The TWRSO&UP does not model organic speciation therefore differential scanning calorimetry (DSC) and thermogravimetric analysis (TGA) behavior could not be predicted from the projected inventories; this rule requires further evaluation as part of the authorization basis work scope on the mid-level logic diagrams (Boston 1997).

An emerging issue is that 22 DSTs received PUREX organic wash waste based on transaction records through January 1, 1994 (Agnew 1996). This means that there could be soluble tributyl phosphate or separate phase PUREX-type solvent in the supernate in some DSTs. Additionally, in 1985 B. M. Mauss observed that a surface sample from 241-AW-105 contained an organic phase (Herting 1990). The DSTs identified in Agnew's report include 241-AN-101 through 241-AN-107, 241-AP-101 through 241-AP-103, 241-AP-105, 241-AP-106, 241-AP-108, 241-AW-101, 241-AW-102, 241-AW-105, 241-AW-106, 241-AY-101, 241-AZ-101, 241-AZ-102, 241-SY-101, and 241-SY-103. Some of these are candidate tanks for private Phase I feed.

Corrosion Decision Rule. The decision rule provides three sets of relationships between $[NO_2^-]$, $[NO_3^-]$ and $[OH^-]$ that must be satisfied (the $[OH^-]$ is relaxed when the temperature is less than 167 °F). The set in use depends upon the $[NO_3^-]$. Batches C1-8 and C2-8 violate the rule that says for $[NO_3]$ between 1.0 M and 3.0 M, the $[OH^-]$ must be between $0.1*[NO_3^-]$ and 10 M (this waste is caustic deficient as it sits in 241-AN-102). The entries in Table 3.1-9 for these two batches are shaded.

This rule should not interfere with feed staging plans, but will influence chemical additions to the feed staging tanks. For example, approximately 3,500 L of 50 wt% NaOH would be needed to bring batch C1-8 into specification. Process Engineering recommended

that 72,000 L of 19 M (50 wt%) NaOH be added to 241-AN-102 to raise the hydroxide concentration to 0.5M (Sloughter and Miller 1996). This adjustment will be added to the next revision of the TWRSO&UP, either as an adjustment of the waste in 241-AN-102, or in the intermediate feed staging tanks.

Watch List Tanks Decision Rule. This rule restricts the transfer of waste into a watch list tank by requiring Secretary of DOE approval. Staging of LAW feed requires transfer of waste into current watch list tanks immediately after emptying due to DST space constraints.

Currently, six DSTs are on the watch list (Hanlon 1996). They are 241-AN-103, 241-AN-104, 241-AN-105, 241-AW-101, 241-SY-101, and 241-SY-103. Waste from all are used for feed during Phase I.

Currently, eight DSTs are associated with a flammable gas unreviewed safety question (USQ). These tanks are 241-SY-101, 241-SY-103, 241-AW-101, 241-AW-104, 241-AN-103, 241-AN-104, 241-AN-105, and 241-AY-101. For all practical purposes, these tanks are treated as if they were on the watch list. Waste from tanks 241-AW-101, 241-AN-103, 241-AN-104, and 241-AN-105 is used for Envelope A feed.

The safety and administrative issues associated with the watch list designation or USQ should be reviewed to understand (and plan to avoid) potential impacts on feed staging activities. This has been identified on the mid-level logic diagrams (Boston 1997).

Transuranic Segregation Rules. This rule requires that waste with a [TRU] $\geq$100 nCi/g be transferred to a TRU storage tank. Otherwise the waste must be transferred to a non-TRU tank unless an analysis demonstrates that TRU segregation will not be jeopardized. The definition of TRU is "without regard to source or form, waste that is contaminated with alpha-emitting transuranium radionuclides with half-lives greater than 20 years and concentrations greater than 100 nCi/g at the time of assay" (DOE 1988). This is a different definition than that used by the envelope specifications. Decay mode and half-lives were obtained from Walker 1977.

The estimated [TRU] exceeded the rule limit for batches 6, 7, and 8. These batches contain the waste formerly stored in high TRU tanks 241-AN-102 and 241-AN-107. For batch 8, the feed only becomes TRU after the waste from the intermediate staging tank is mixed with the heel in the contractor feed tank. The Private Contractor may need to manipulate the existing high TRU heel to prevent the new feed batch that is being transferred into the tank from being affected by the high TRU heel. Table 3.1-9 shows the estimated [TRU] concentrations for each batch; values exceeding 100 nCi/g are shaded.

As with the criticality rule, there is potential for higher [TRU] due to inadvertent or intentional entrainment of sludge during retrieval and transfer. The radionuclide inventory estimates upon which this assessment has been based are not definitive.

Heat Generation Rate Rule. This rule requires that the heat generation rate in each AP-Farm tank must be less than or equal to 70,000 BTU/h. The heat generation rates for all projected contractor batches were less than 70,000 BTU/hr. However, the Tank Farm Operation Specification Document (OSD-7) (PHMC 1997) contains additional limits on [^{90}Sr] and [^{137}Cs] that are too restrictive and need to be deleted (They are overly conservative limits). Batches C1-5 and C2-5 have a [^{137}Cs] of 5. E+10 Bq/L, which exceeds the OSD-7 [^{137}Cs] limit of 2.12 E+10 Bq/L. The entries in Table 3.1-9 for these two batches are shaded.

Complexant Waste Segregation Rule. This rule requires transfer of complexant waste to a complexant waste receiver tank. Complexant waste is defined as waste with a mean [TOC] > 10 g/L at the double-shell slurry feed composition (Fowler 1995b). Waste classified as Envelope C is expected to meet the definition of complexant waste since the minimum [TOC]/[Na] limit for Envelope C was estimated from this rule.

Envelope C supernate can not be staged unless the intermediate feed staging tanks and the Private Contractor's feed tanks are temporarily designated as complexant waste receiver tanks. Batches 6-11 provide envelope C feed to the contractors.

Waste Pumpability Rule. The rule requires that Reynold's number (N_{Re}) for the transfer line be greater than or equal to 20,000 and the volume percent solids less than or equal to 30. The N_{Re} limit has been used as one of the measures in the transfer systems upgrades analysis (Galbraith et al. 1996).

This rule has not been evaluated on a case-by-case basis for the feed staging transfers since physical properties as a function of water (or dilute caustic) dilution are not known. It was assumed that the dilution of the waste to 7*M* [Na] or the value determined by ESP will satisfy this rule (Appendix A, Item 7.7).

Tank Waste Type. The rule provides a compatibility matrix for mixing of wastes of different types. The matrix must be followed to the extent practicable. To successfully stage DST supernate, this rule must permit mixing a heel of "incompatible" waste with the feed being staged. A heel of Envelope C waste (CC) cannot be mixed with Envelope A waste (most often DSSF/DSS). A heel of Envelope B waste (mostly NCAW) cannot be mixed with CC or DSSF/DSS. A heel of CP (CP is currently in 241-AP-102) cannot be mixed with DSSF/DSS or CC.

Generally, this rule prevents switching waste envelopes unless "to the extent practicable" permits mixing of an "incompatible" heel. Current practice is to treat tanks that have been pumped down to the heels as empty for the purposes of this rule. The interpretation and intent of this rule should be documented well in advance of feed staging activities. If technically justified, an exception or deminimus limit should be explicitly provided.

High Phosphate Waste. This rule prevents mixing waste with $[PO_4^{-3}] > 0.1M$ with waste containing a $[Na^+] > 8M$. The projected supernate composition of the waste currently stored in 241-AP-102 contains a $[PO_4^{-3}]$ of 0.122*M*. This waste is initially moved out of the

way and does not get sent to the contractor feed tanks during Phase I. Additionally, tank 241-AP-102 is flushed before receipt of the first feed batch.

The concentrated phosphate waste in 241-AP-102 was transferred from 241-AN-106. There was a significant layer of crystals remaining on the 241-AN-106 tank walls. The crystals were discovered during the transfer between 241-AN-106 and 241-AP-102 when the transfer exceeded material balance limits. Crystal formation was confirmed using in tank photography. It is prudent to empty 241-AP-102 as soon as possible so that the tank can be inspected for the presence of solids and flushed if needed.

3.1.2 Issues And Caveats

New issues and caveats identified during the preparation of this report that are not documented elsewhere as potentially affecting feed staging and delivery are listed in the following sections. Those that have been previously documented are summarized in Table 3.1-10.

Table 3.1-10. Cross-Reference of Existing Low-Activity Waste Feed Staging Issues. (2 Sheets)

Internal number	Issue title	External citations[a]	Internal citations
1	Physical interface locations	ICD 19	-
2	Schedule, documentation, and procedures for waste feed transfer.	ICD 19	Appendix A: Items 5.6, 5.7, 5.17, 5.19, 5.20
3	Pipeline flushing requirements.	ICD 19	-
4	Methods and procedures to establish feed composition.	ICD 19	Appendix A: Item 5.7, 5.17, 5.19, 5.20, 8.6
5	Final Interface Control Document.	ICD 19	-
6	Agreement of Proposed Requirements Issue	ICD 19	-
7	Available LAW Feed Issue	ICD 19, RPT-224	§ 3.1.1.3.1
8	Compensation Model for Processing Off-Specification Feed Issue	ICD 19	§ 3.1.3
9	Establish Exclusive Feed Envelopes Issue	ICD 19, RPT-224	§ 3.1.1.3 Appendix A: Items 4.1, 4.2
10	Feed Tank Fill Status Issue	ICD 19, RPT-224	§ 3.1.1.2 Appendix A: Items 5.14, 5.15
11	Heat Generation Rate Limit Issue	ICD 19	§ 3.1.1.6
12	LAW Feed Delivery Procedure Issue	ICD 19	-
13	LAW Feed Envelope Issue (Expanded)	ICD 19, RPT-224	§ 3.1.3, § 3.1.1.4 Appendix A: Items 4.1, 4.4, 7.2
14	LAW Feed Impurity Clause Issue	ICD 19	-
15	Maximum Implied Radionuclide Concentration Issue	ICD 19	-
16	Maximum Sodium Quantity in First Feed Batch of Envelope B and C Issue	ICD 19, RPT-224	§ 3.13, Appendix A: Item 5.11
17	Minimum Size of First Feed Batch Issue	ICD 19, RPT-224	§ 3.13
18	Pipeline Flush Requirements for Feed or Liquid Waste Products Issue	ICD 19	-

Table 3.1-10. Cross-Reference of Existing Low-Activity Waste Feed Staging Issues. (2 Sheets)

Internal number	Issue title	External citations[a]	Internal citations
19	Process Design Sample Quantity and Schedule Issue	ICD 19	-
20	Solids Measurement Issue	ICD 19, RPT-224	Appendix A, Items 4.1, 4.3
21	Throughput Rate Issue (Includes "114-day limit" as a sub-issue)	ICD 19, RPT-224	Appendix A, Items 5.4, 6.1, 6.2, 6.10, 6.11, 11.1
22	Top-Off Transfer Issue	ICD 19	Appendix A, Items 3.11, 5.3, 5.4
23	Functional Flow Block Diagrams	RPT-224	Appendix A, Item 1.1
24	Contractor Specific Base-line not available		Appendix A, Item 1.2
25	Safety Issue Resolution	RPT-224	Appendix A, Item 1.4
26	Waste Compatibility Issues	RPT-224	§ 3.1.1.6 Appendix A, Item 3.2
27	Must Feed Remain Within Specification After Delivery	RPT-224	Appendix A, Items 3.10, 5.17
28	Soluble Tributyl Phosphate or Separate Phase Organic	RPT-224	Appendix A, Item 4.1, Item 7.24
29	Solid-Liquid Equilibria Issues	RPT-224	§ 3.1.1.3.1 § 3.4.2.3 Appendix A, Item 7.7
30	Solids Tracking, Control & Quantity Issues	RPT-224	Appendix A, Items 7.8, 7.9
31	Project Support Schedules	RPT-224	§ 3.5, Appendix A, Item 11.6

[a]ICD 19: ICD 19, LAW Feed (Berry 1997); RPT-224 (Certa et al. 1996).

3.1.2.1 New Issues. New issues (or existing not documented elsewhere as potentially affecting feed staging and delivery) identified during the preparation of this report are listed below:

- The feed envelopes require modification to accommodate the point-estimates of the available feed sources (see Section 3.1.1.4 and 3.1.3) without routine blending or shimming of feed. One of the original premises of the envelope concept was that they would be sufficiently broad to envelope existing feed without blending.

- It is necessary to confirm that performing the mixer-pump text in 241-AZ-101 and pre-staging the NCAW supernate from 241-AZ-101 and -102 into 241-AY-101 will not adversely affect the composition of the delivered Envelope B feed.

- The waste in 241-AN-102 requires addition of caustic to satisfy the tank corrosion specifications. This existing issue has been documented elsewhere (Sloughter and Miller 1996) but only recently identified as affecting feed staging since the joint TWRSO&UP/OWVP planning case does not include adjustment of this waste.

- Solids from the concentrated phosphate waste stored in 241-AP-102 may have plated-out on the side of the tank. If so, the plans to flush this tank may require modification.

3.1.2.2 Caveats. The following caveats apply:

- Many of the assumptions documented in Appendix A are beyond the control of the PHMC Team (such as processing rates, order quantities and envelope limits).

- The proposed 114 day minimum limit between completion of delivery of one feed batch and the waste transfer date (WTD) for the next provides little or no contingency for the PHMC Team.

- The ability of the PHMC Teams laboratory to support the 60-day allocated sample turnaround time has not been confirmed.

- Although the Operational Waste Volume Projections show that there is sufficient DST space for staging feed to the Private Contractors, essentially all tank space is fully allocated. No contingency space is available for changes in assumptions, potential out-of-specification feed batches or uncertainties in the projections.

- Late need dates for facilities, equipment and systems do not include an allowance for schedule slippage or changes to assumptions.

- Process control schemes for avoiding and fall-back positions for correcting out-of-specification feed batches have not been developed.

- Fall-back positions for retrieving feed have not been developed in case the deployed equipment fails to perform up to expectations.

- The solid/liquid equilibria of waste during retrieval, transfer and blending has not been confirmed with laboratory studies. Both computer modeling and a 7*M* [Na] proxy limit have been used in lieu of laboratory data.

- The classification of feed according to envelope and the assessment of the envelope limits have been performed using point-estimates and an assumed value for total uncertainty of ±20 percent. Statistical evaluations of the static (or near static) feed have not been completed. Statistical evaluations of the probability that staged feed will be determined to be out-of-specification have not been performed.

3.1.3 Recommendations

The following recommendation assumes that the Envelope Limits and Order Quantities will not be changed:

- The PHMC Team will revise the feed staging plans to include staging and delivery of additional Envelope A feed by either blending of existing Envelope A feed with near-Envelope A feed or by shimming near-Envelope A feed with caustic (or sodium salts) to adjust the analyte:sodium ratios.

The following recommendations will increase the robustness of the feed delivery system and plans while remaining fair to both the PHMC Team and the Privatization Contractors. In addition, they may provide additional flexibility to the PHMC Team in selecting the first few feed batches and in relaxing the continued use of 241-AP-106 and 241-AP-108. However, it is recognized that these recommendations may require negotiation between DOE and the Privatization Contractors. Most of these recommendations and underlying issues have already been identified in *ICD 19, Low-Activity Waste Feed* (Berry 1997) or the *Low-Activity Waste Feed Staging Plan* (Certa et al. 1996).

- Reduce the minimum size of the first feed batch from 500 MT sodium to 300 MT sodium per Privatization Contractor. This provides a measure of assurance that the first batch of feed can be obtained from a single DST and provides some flexibility in selecting that DST.

- Reduce the minimum order quantity of Envelope A from 2,600 MT sodium to 1,500 MT sodium per Privatization Contractor. This provides a measure of assurance that the minimum order quantity of Envelope A can be provided under the current feed envelopes even if suitable waste is not available from one of the four DSTs containing Envelope A feed or less sodium can be retrieved than currently estimated.

- Include a new combined minimum order quantity for Envelopes A, B and C of 2,800 MT sodium per Privatization Contractor to ensure that their cost basis remains fairly constant. The sum of the minimum order quantities for Envelope A, B, and C is currently 2,800 MT sodium per Privatization Contractor.

- Explicitly permit the DOE/PHMC Team to complete delivery of the feed batch that reaches the minimum order quantity even if this means that the minimum order quantity will be exceeded. This is consistent with the PHMC Team's interpretation of the phase "in optimum practical quantities" used in the Privatization Contracts.

- Consider the envelope limit changes proposed in Section 3.1.1.5, Envelope Assessment. These changes may be influenced by the terms of the compensatory model (discussed below), the statistical evaluation of the static or near static feed source tanks, and other studies.

Analyte	Envelope	Contract limit[a]	Proposed limit[a]	Units
Al	A, B, C	1.90 E-01	3.5 E-01	g-mole Al/g-mole sodium
SO4	A	9.7 E-03	2.0 E-02	g-mole SO4/g-mole sodium
TOC	A, B	6.0 E-02	5.0 E-01	g-mole C/g-mole sodium
U	A, B, C	1.2 E-03	1.4 E-02	g-mole U/g-mole sodium
TRU	C	3.0 E+06	3.7 E+06	Bq TRU/g-mole sodium
Sr-90	A, B	4.4 E+07	5.9 E+07	Bq Sr-90/g-mole sodium

[a]All limits are maximum analyte:sodium ratios.

- Develop a compensatory model for processing of off-specification feed. This model would simplify the contractual implications for processing off-specification feed and reduce the likelihood of downtime for the contractors facilities due to lack of qualified feed. Such a model could be based on the following approach:

  1. Determine the percentage that the worst analyte:sodium ratio exceeds the appropriate envelope limit.

  2. Relax the final immobilized low-activity waste external package volume to sodium in the feed ratio by the same percentage. This allows a reduction in target waste oxide loading in the glass to off-set the higher concentration.

3. Increase the fixed unit price for processing this batch of feed by the same percentage. This accounts for the additional materials and processing time required to produce the additional amount of glass.

- Negotiate a 114-day minimum duration (or greater) between the completion of the delivery of one feed batch and the waste transfer date for the following batch. The 114-day duration may be influenced by the following recommendation.

- Re-consider both the need to complete interim stabilization (salt-well pumping) of SSTs by the end of FY 2000 and the need for early retrieval of SST waste. Reduction of the demand on DST storage space before and during Phase I processing could provide a measure of assurance that feed staging can be performed within available DST space or may help (subject to re-evaluation of tank space demands) relax the need to use 241-AP-106 and -108 for waste management activities during their upgrade and turn-over activities.

The following recommendations are completely within the PHMC Team's area of responsibility. See Section 2.2.4 for recommendations concerning characterization needs.

- The 114-day duration between the completion of the delivery of one feed batch and the waste transfer date for the following batch should be allocated to the appropriate activities on the mid-level logic diagrams (Boston 1997). Those responsible for the planning and execution of these activities will either confirm that the activity can be performed within the allocated duration, identify changes needed to fit within this duration, recommend a new allocation, or recommend an increase in the 114-day duration. The 114-day duration is an enabling assumption (see Appendix A, Item A6.11, for more details).

- Develop alternative process control schemes that reduce the probability of preparing an out-of-specification feed batch. Elements of this scheme may include (a) process control samples taken at various times during the feed staging process to identify potential problems early enough for correction and (b) planning to provide suitable blending stock for tanks with borderline compositions. The latter (b) may require that installation of retrieval systems be accelerated so that there are at least two suitable waste sources available for blending purposes. Evaluation of these alternatives will require understanding the costs associated with the Compensatory Model for Processing Off-Specification Feed. The selected alternative may influence the length of the 114-day duration between the completion of the delivery of one feed batch and the waste transfer date for the following batch.

- Develop fall-back positions to correct or mitigate the consequences of an out-of-specification feed batch. Elements of this may include (a) use of the compensatory model, (b) chemical adjustment of the feed batch, (c) removal of a part of the feed batch and blending the remainder of the batch with other waste and (d) setting the entire feed batch aside and staging a completely new batch. The latter two (c&d)

may require that the installation of retrieval systems be accelerated so that there are at least two suitable waste sources available for blending purposes and maintaining empty DSTs to receive the out-of-specification feed (above and beyond the required space tank space). Evaluation of these alternatives will require understanding the costs associated with the Compensatory Model for Processing Off-Specification Feed. The selected alternative may influence the length of the 114-day duration between the completion of the delivery of one feed batch and the waste transfer date for the following batch.

- Develop fall-back positions for retrieval of feed in the event that there are problems with the mixer-pumps (or whatever equipment is actually deployed). Elements may include alternative mobilization/retrieval schemes and equipment. For example, supernate from several tanks may be decanted and blended to provide additional time for correcting potential problems.

- Confirm that performing the mixer-pump test in 241-AZ-101 and pre-staging the NCAW supernate from 241-AZ-101 and -102 into 241-AY-101 will not adversely affect the composition of the delivered Envelope B feed. This will need to be based on either a qualitative argument or modeling since representative sludge samples will not be available due to sample truck shielding considerations.

3.2 HIGH-LEVEL WASTE PRETREATMENT AND FEED STAGING

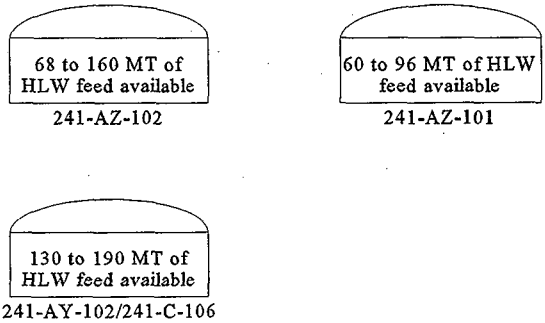
The Phase IA Privatization contracts establish specific requirements for the HLW feeds to be delivered to the Privatization Contractor. These requirements provide the objectives for the preparation of the sludges contained in DSTs, 241-AZ-101, 241-AZ-102, and 241-AY-102 (containing the sludge from SST, 241-C-106) for delivery to the Privatization Contractor by June 2002. The Phase I HLW pretreatment process summary in Section 3.4 describes the processing steps necessary to satisfy these contract requirements.

Enhanced sludge washing is the baseline planning case, based on DOE-RL direction (Kinzer 1996). Sludge washing (also referred to as water washing) was identified as the "Base Case" Phase I pretreatment process in this document, due to the increased demands on DST space from enhanced sludge washing. Since the enhanced sludge washing process generates more wash solution at higher concentrations of sodium hydroxide, less evaporation of the decanted liquids is possible, and therefore more DST storage space is required. In a time frame when DST space is already at a premium (i.e., the first SSTs are being retrieved), pretreatment by simple sludge washing is more compatible with the available tank space. A trade study (Manuel 1997) is being prepared to evaluate which pretreatment alternative is preferred. The HTWOS model will be used to develop waste volume management scenarios in the DST system that can accommodate Phase I enhanced sludge washing without having to sacrifice early SST retrieval objectives.

Tank Inventories

The "Base Case" pretreatment process (sludge washing) outlines the preparation of 450 MT of Waste Envelope D feed, based on 100 percent retrieval. The quantity of pretreated HLW feed will actually range from 260 to 450 MT of waste oxides excluding sodium and silicon, depending on which pretreatment process is selected (sludge washing or enhanced sludge washing) and the retrieval efficiency actually achieved. Based on Grams (1995), the minimum DST retrieval efficiencies are assumed to be 90, 60, and 85 percent for 241-AZ-101, 241-AZ-102, and 241-AY-102 (containing 241-C-106 sludge), respectively. (The minimum retrieval efficiency for 241-AY-102/241-C-106 is an approximation using a weighted average, assuming 100 percent for 241-C-106 and 36 percent for 241-AY-102). Based on the predicted caustic leach efficiencies for these tanks (Section 3.4), the feed quantity can decrease (from the "Base Case") by as much as 30 percent. Figure 3.2-1 and Table 3.2-2 summarize these feed quantity ranges.

Figure 3.2-1. Phase I High-Level Waste Feed Quantities After Pretreatment. (Based on MT of waste oxides excluding sodium and silicon)



Phase I High-Level Waste Feed Compositions

Table 3.2-1 shows the estimated Phase I HLW feed compositions versus the minimum and maximum concentrations specified for Waste Envelope D for several chemical constituents of the three HLW feeds. These compositions are based on sludge washing (also referred to as dilute caustic washing or water washing). This evaluation assumes that the wastes are staged to the Private Contractor sequentially from separate tanks, as discussed in Bacon (1996).

Table 3.2-1. Phase I High-Level Waste Envelope D Comparison for Selected Water-Washed Waste Constituents. (Based on 31 g/L Non-Volatile Oxides)

Component	Minimum concentration (g/L)	Estimated concentration after water washing (g/L)			Maximum concentration (g/L)
		AZ-101	AZ-102	AY-102/C-106	
Aluminum	1.30 (0.33)	4.42	4.77	4.25	4.30 (5.30)
Bismuth	0.00	0.009	0.006	0.0008	0.86
Chlorine	0.00	0.005	0.0002	0.01	0.10
Chromium	0.00	0.10	0.12	0.11	0.21 (0.42)
Fluorine	0.00	0.18	0.19	0.003	1.10
Iron	2.60 (1.70)	6.16	8.17	6.23	8.90 (13.00)
Manganese	0.00	1.37	0.18	0.30	2.00
Nickel	0.05 (0.00)	0.36	0.55	0.09	0.73 (1.00)
Palladium	0.00	NE	NE	NE	0.04
Phosphorus	0.00	0.06	0.06	0.44	0.54
Potassium	0.00	NE	NE	0.03	0.41
Rhodium	0.00	NE	NE	NE	0.04
Ruthenium	0.00	NE	NE	NE	0.11
Silicon	0.00	0.36	0.58	2.14	5.80
Silver	0.00	NE	NE	0.26	0.17
Sodium	2.30 (1.00)	3.45	1.65	4.22	6.00 (9.20)
Sulfur	0.00	0.15	0.11	0.03	0.20
Titanium	0.00	NE	NE	NE	0.40
Uranium	0.00	0.64	1.61	0.04	4.20
Zirconium	0.00	2.16	1.13	0.06	4.60

NE = Not estimated

Values enclosed in parentheses are for the *Expanded Design Basis for HLW Processing* as defined in the Phase I TWRS Privatization contracts (DOE 1996a and DOE 1996b).

Shaded rows indicate component concentrations which are close to or outside of the HLW feed specifications.

Analytes not shown are within the HLW feed specifications and/or have no significant impact on the immobilized HLW product.

As indicated in Table 3.2-1, the concentrations of some waste components of the HLW feeds may be outside of the Waste Envelope D limits. The concentrations of these components, however, can be brought within the Waste Envelope D limits by chemical adjustment after pretreatment. For example, the aluminum concentrations in 241-AZ-101 and 241-AZ-102 can be reduced by dissolving some of the aluminum with a small amount of caustic solution (i.e., 50 wt% sodium hydroxide). This dissolution process would be followed by decantation of the supernatant to remove the aluminum from the HLW feed. The effects of caustic leaching are evaluated in a separate trade study (Manuel 1997). This chemical adjustment will also increase the sodium concentration in 241-AZ-102, so that it will be within the specifications. Lastly, the silver concentration for the 241-AY-102/241-C-106 blend can be reduced by "chemically shimming" the feed by adding SiO_2. Because the Privatization Contractor will be adding a significant amount of these chemicals to formulate the immobilized HLW product, chemical adjustment with these "glass forming" materials is not expected to increase the HLW product volume. An economically optimized process to provide the necessary chemical adjustments has not yet been established. Optionally, as discussed in Section 2.2.2, the contract specifications for the HLW feed composition can be slightly modified.

Physical Properties

Table 3.2-2 shows the estimated physical properties of the pretreated HLW feeds versus the Waste Envelope D feed specification ranges. Much of the physical property data for the washed HLW feed are not available. However, the pretreated HLW to be transferred to the Privatization Contractor will be conditioned to meet the transfer system requirements for physical properties, as defined in the *TWRS Functions and Requirements* (WHC 1995a).

Table 3.2-2. Acceptable Physical Property Ranges for Selected Phase I High-Level Waste Feed Components (DOE 1996).

Physical property	Minimum	Estimate or specification		Maximum
Total mass of waste oxides excluding sodium and silicon	245 MT	Water wash	Caustic wash	465 MT
		350 to 450 MT	260 to 330 MT[a]	
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 a function of the actual DST sludge retrieval efficiency achieved. Minimum retrieval efficiencies of 90, 60, and 85 percent are assumed for 241-AZ-101, 241-AZ-102, and 241-AY-102/241-C-106, respectively. The maximum retrieval efficiency is assumed to be 100 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.

Waste Transfer System

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:

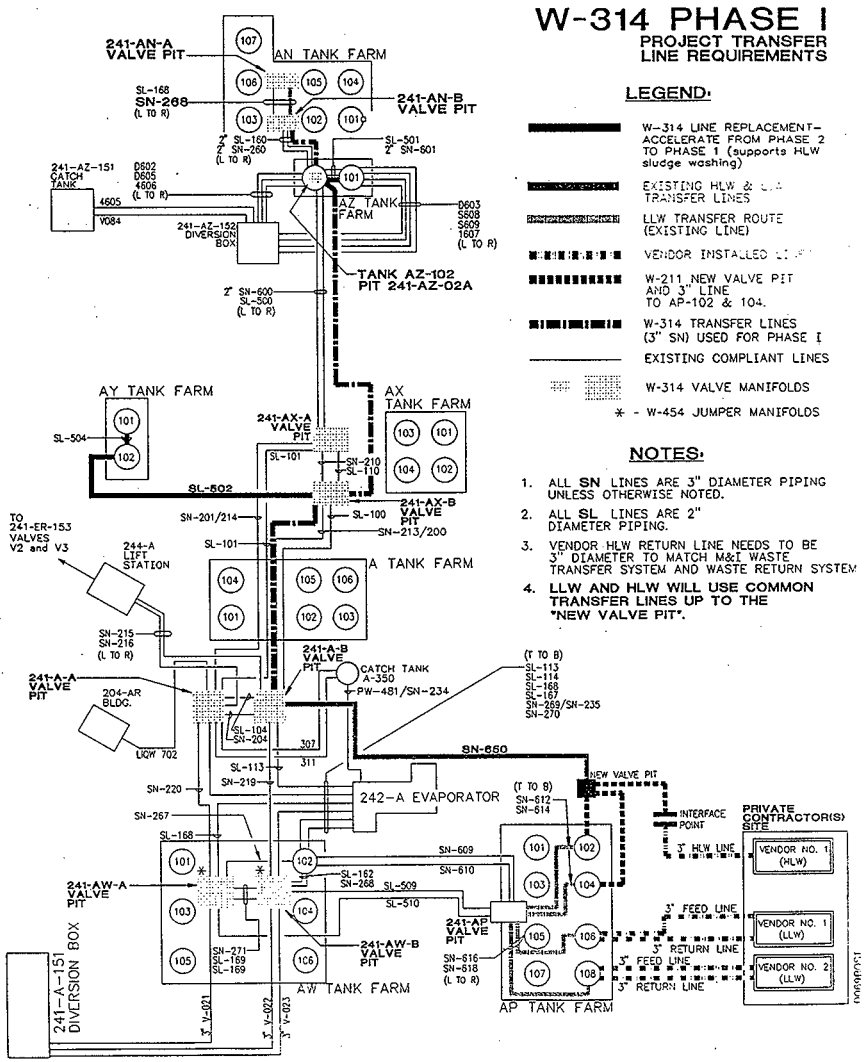
- Cost
- Hydraulic performance (i.e., head loss, pressure drop, and critical velocity)
- Schedule
- Flexibility
- Design limitations of the current transfer system and proposed upgrades
- Potential for conflicts (delays) in feed staging due to interactions with supernatant feed staging and other concurrent 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 3.2-2 is a schematic of the recommended feed transfer system from that study.

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.

A schedule of the Phase I waste transfers pertaining to HLW pretreatment and feed staging has been developed for the process summarized in Section 3.4. The operating scenario modeled for the pretreatment and staging of the HLW feeds to the Privatization Contractor represents the "Base Case" schedule of waste transfers. Future analyses, information regarding the Privatization Contractor's facility, resolution of open issues, and the establishment of PHMC/Privatization Contractor interface requirements may result in a significantly different "Base Case" to be presented in Revision 1 of the TWRSO&UP.

Figure 3.2-2. Proposed Phase I High-Level Waste Feed Transfer System.



3.2.1 Assumptions

This analysis utilizes an integrated approach to the planning of tank farm operations during Phase I. It develops the "Base Case" HLW pretreatment and feed delivery schedule, based on water washing and the minimum HLW immobilization processing rate. Open issues and uncertainties that affect the final selection of the pretreatment strategy are addressed in Section 3.2.3.4. The baseline will be updated as more information becomes available.

Because of the limited amount of tank space and the large number of waste transfers in the tank farms during Phase I, the movement of wash solutions and decanted supernatants resulting from in-tank sludge processing can have significant impacts on tank space usage and on the potential for transfer line conflicts with other waste transfers. The impacts of enhanced sludge washing are yet to be evaluated using the HTWOS model, during the development of Revision 1 of the TWRSO&UP. The implications on DST space availability for different HLW pretreatment scenarios will be an important evaluation, particularly from the standpoint of evaluating the feasibility of performing more aggressive pretreatment operations, such as caustic leaching. An evaluation of tank space implications will also determine the likelihood and degree of difficulty of pretreating the HLW feeds for delivery to the Privatization Contractor on time. Satisfying the feed delivery schedule is crucial to minimizing immobilization facility downtime.

As stated above, the dates in the schedule reflect a HLW immobilization facility operating at the minimum capacity specified in the TWRS Privatization contracts (DOE 1996a and DOE 1996b). The Private Contractor may operate at a higher processing rate, but the actual proposed processing rate is not yet available nor has a conservative planning assumption been established. In a future revision of this plan, a higher HLW immobilization processing rate may be used when information is available regarding the Privatization Contractor's processing rate or a recommended processing rate higher than the minimum is developed. The ability to deliver the feeds to support higher processing rates will be the subject of a separate trade study.

Under the assumptions above, the base case HLW pretreatment strategy, described in Section 3.4, based on water washing, has been input into the HTWOS model to determine a feasible operating scenario, which considers the interactions between HLW pretreatment, LAW feed staging, evaporator waste staging, facility waste inputs, and other waste transfers that occur during Phase I HLW pretreatment. Transfer line conflicts between all waste transfers during pretreatment are not fully modeled, but will be part of the Revision 1 of the TWRSO&UP.

3.2.1.1 Pretreatment Durations. To satisfy the HLW feed delivery schedule, which is currently based on the minimum immobilization processing rate, the duration of sludge pretreatment processing will impact the dates that the in-tank processing equipment will be needed. To develop the "Base Case" waste transfer schedule, the following durations for the required pretreatment operations are used (Table 3.2-3). The total time required for the pretreatment operations is shown at the bottom of the table, and will vary depending upon the number of wash repetitions.

The total allocated time (i.e., maximum total time) from Table 3.2-3 is used for preliminary planning purposes. This amount of time (i.e., 300 days for 241-AZ-101, 390 days for 241-AZ-102, and 210 days for 241-AY-102/241-C-106), plus the amount of time for feed staging in Table 3.2-4 (i.e., an additional 318 to 339 days) is the number of days in advance of the waste transfer date to the Privatization Contractor that in-tank processing equipment must be installed and operational in the DST. The "Base Case" schedule is based upon the maximum total time shown in Table 3.2-3.

As shown in Tables 3.2-3 and 3.2-4, the time required for pretreatment is significant. Thus, the lead time for performing design, construction, and startup of the in-tank processing equipment must be sufficient to meet the feed delivery schedule, when established. Section 3.2.3.2 discusses this issue in greater detail.

Table 3.2-3. Pretreatment Processing Durations.

Operation	Minimum duration per repetition	Maximum duration per repetition	Repetitions		
			241-AZ-101	241-AZ-102	241-AY-102/ 241-C-106
Decant Initial Supernatant[a]	1-2 days	30 days	1	1	1
Add wash solution[a]	1-2 days	30 days total	3	4	2
Mix waste with mixer pumps[b]	5 days (estimated)		3	4	2
Leach waste by mixing[b,c]	10 days (estimated)		1	1	1
Allow waste to settle	30 days	30 days	3	4	2
Sample and analyze solids and supernatant[f]	14 days	30 days total	3	4	2
Decant supernatant/ wash solution[a]	1-2 days		3	4	2
Minimum total time[d]			161 days	214 days	108 days
Total allocated time (maximum total time)[d,e]			300 days	390 days	210 days

[a]The minimum durations for waste transfers are based on a 0.73 ML/day pump rate. The maximum durations for waste transfers are a conservatively high estimate to account for equipment failures, transfer conflicts, etc. (Certa et al. 1996).

[b]Actual mixing time will vary depending upon the results of the W-151 mixer pump test.

[c]This step is performed only if caustic leaching is required, and is not used for the "Base Case" schedule.

[d]The total minimum and maximum times include the initial decant step.

[e]The total allocated time should be used for planning purposes.

[f]This sampling and analysis required here is to verify the progress of the pretreatment process for a few critical waste components (e.g., aluminum, sulfate, sodium).

3.2.1.2 High-Level Waste Feed Staging Durations. The staging of the HLW feeds will be preceded by the addition of transfer solution, to meet the feed concentration requirement of 25 to 100 g equivalent non-volatile oxides/L slurry feed. The actual volume and composition of the transfer solution will depend on the specific dilution requirements for waste transfers through the transfer lines (after the upgrades by Project W-314), any changes to the specification which are negotiated in Phase IA, and the sludge dissolution chemistry. For modeling purposes, it is assumed that the transfer will be performed by adding inhibited water to reach a feed concentration of 100 g equivalent non-volatile oxides/L, to conserve tank space, reduce the number of HLW feed batches, and reduce the evaporation requirements. The sodium in the inhibited water was neglected, in order to simplify the calculation, but is not expected to significantly increase the volume of transfer solution required.

After the transfer solution is added to the HLW source tank, the tank contents will be mixed. Samples will be taken, delivered to the HLW Privatization Contractor, and separately evaluated by the PHMC to certify that the feed will satisfy Waste Envelope D. A total of 315 days, which includes the estimated time for mixing, obtaining samples, analyzing the samples, and waste form qualification by the Privatization Contractor, is allocated for this activity. The durations for these activities are summarized in Table 3.2-4.

Table 3.2-4. Feed Staging Durations for Tanks 241-AZ-101, 241-AZ-102, and 241-AY-102/241-C-106.

Operation	Minimum duration	Allocated time
Add transfer solution[a]	1-2 days	10 days
Mix/sample/evaluate feed source, qualify waste form	315 days (estimated)	315 days
Transfer high-level waste batch to Privatization Contractor[a]	1 day	14 days
Total[b]	318 days	339 days

[a]Based on a 0.73 ML/day pump rate.

[b]See Section 3.2.1.1 for discussion on how pretreatment and feed staging durations combine to determine a total duration.

3.2.2 Results and Conclusions

Table 3.2-5 shows the schedules for the sludge pretreatment and transfer (staging) of the HLW feeds to the Privatization Contractor's facility. These preliminary schedules identify the timing required to conduct engineering analyses of the proposed HLW pretreatment and feed staging systems (e.g., waste transfer system, mixer pump testing, decant pump testing), and to define sampling requirements for the washed sludges in preparation for supplying feed to the Privatization Contractor. The dates in the schedule are adjusted based on the availability of tank space and conflicts with other waste transfers which will occur during that time period. For Revision 1 of the TWRSO&UP, the schedule may need to be further adjusted to correspond with a higher Privatization Contractor immobilization processing rate.

Using the "Base Case" assumptions, from a tank space utilization perspective, a feasible operating scenario has been developed. This schedule will allow the PHMC to deliver the first batch of HLW feed by June 1, 2002, and provide subsequent feed batches in time to support the minimum immobilization processing rate with zero idle time (60 MT of waste oxides excluding sodium and silicon over a 12-month period). The dates shown in Table 3.2-5 represent "late start dates," and provide little or no schedule slack.

The previous schedule in Manuel et al. (1996) indicated that the "Bootstrap Transfers" supporting the pretreatment of the 241-AZ-101 sludge (i.e., 241-AY-101 supernatant to 241-AP-106 and 241-AZ-101 supernatant to 241-AY-101) are to take place in FY 1998. These dates were based on an assumed scope and schedule for Projects W-151 and W-314. Project W-151, "Tank 241-AZ-101 Waste Retrieval System," was originally expected to include the installation of all of the required pretreatment processing equipment, but now includes only the mixer pump system. The additional equipment needs for 241-AZ-101 will be covered by expense funds, as discussed in Section 3.5. The FY 1996 report also assumed that the "Bootstrap Transfers" could be performed before the upgrades of transfer lines SL-502 and SL-504 (by Project W-314). Therefore, the pretreatment schedule has been changed to a "late date" schedule, and the project schedules (W-151, W-314, expense) are being changed.

Table 3.2-5. Schedule for Phase I High-Level Waste Pretreatment and Feed Staging. (Sheet 1 of 3)

Activity description	Transfer volume (L)	Late start date	Duration (days)
"Bootstrap" Transfer Supporting AZ-101 Pretreatment			
1. Transfer AY-101 Supernatant to AP-106	3,200,000	8/30/00	30
Other Operations Supporting AZ-101 Pretreatment			
** Perform AZ-101 Mixer Pump Test		4/21/98	30
** Obtain Grab Samples of Sludge from AZ-101 for PHMC		5/21/98	14
2a. Complete AZ-101 In-Tank Evaporation to 5*M* Na	0	8/30/00	0
"Bootstrap" Transfer Supporting AZ-101 Pretreatment			
3. Transfer AZ-101 Supernatant to AY-101	2,400,000	8/30/00	30
AZ-101 Sludge Washing Operations			
4a. Add Wash Solution to AZ-101 and Mix Sludge	550,000	9/29/00	30
5a. Wait for Sludge to Settle in AZ-101		10/29/00	30
6a. Sample Sludge and Decant AZ-101 Supernatant to AW-105	600,000	11/28/00	30
4b. Add Wash Solution to AZ-101 and Mix Sludge	550,000	12/28/00	30
5b. Wait for Sludge to Settle in AZ-101		1/27/01	30
6b. Sample Sludge and Decant AZ-101 Supernatant to AW-105	520,000	2/26/01	30
4c. Add Wash Solution to AZ-101 and Mix Sludge	550,000	3/28/01	30
5c. Wait for Sludge to Settle in AZ-101		4/27/01	30
6c. Sample Sludge and Decant AZ-101 Supernatant to AW-105	540,000	5/27/01	30
AZ-101 Feed Staging Operations			
7. Add Transfer Solution to AZ-101	550,000	6/26/01	10
** Mix/Sample/Evaluate AZ-101 Sludge		7/6/01	70
** Take Representative Samples from AZ-101, Provide Them to the Privatization Contractor, and Wait for Waste Form Qualification		9/14/01	245
8a. Transfer AZ-101 Slurry to Privatization Contractor (Batch #1 - 48 MT NVOL, 59 MT NVO)	590,000	5/17/02	15
** Immobilize High-Level Waste Feed Batch #1		6/1/02	293
8b. Transfer AZ-101 Slurry to Privatization Contractor (Batch #2 - 48 MT NVOL, 59 MT NVO)	590,000	3/6/03	15
** Immobilize High-Level Waste Feed Batch #2		3/21/03	293

Table 3.2-5. Schedule for Phase I High-Level Waste Pretreatment and Feed Staging. (Sheet 2 of 3)

Activity description	Transfer volume (L)	Late start date	Duration (days)
Other Operations Supporting AZ-102 Pretreatment			
** Obtain Core Samples from AZ-102 for PHMC		TBD	150
2b. Complete AZ-102 In-Tank Evaporation to *5M* Na	1,700,000	1/8/02	0
"Bootstrap" Transfer Supporting AZ-102 Pretreatment			
9. Transfer AZ-102 Supernatant to AY-101 and AN-104	1,300,000	1/8/02	30
AZ-102 Sludge Washing Operations			
10a. Add Wash Solution to AZ-102 and Mix Sludge	810,000	2/7/02	30
11a. Wait for Sludge to Settle in AZ-102		3/9/02	30
12a. Sample Sludge and Decant AZ-102 Supernatant to AN-105	250,000	4/8/02	30
10b. Add Wash Solution to AZ-102 and Mix Sludge	810,000	5/8/02	30
11b. Wait for Sludge to Settle in AZ-102		6/7/02	30
12b. Sample Sludge and Decant AZ-102 Supernatant to AN-105	780,000	7/7/02	30
10c. Add Wash Solution to AZ-102 and Mix Sludge	810,000	8/6/02	30
11c. Wait for Sludge to Settle in AZ-102		9/5/02	30
12c. Sample Sludge and Decant AZ-102 Supernatant to AN-105	790,000	10/5/02	30
10d. Add Wash Solution to AZ-102 and Mix Sludge	810,000	11/4/02	30
11d. Wait for Sludge to Settle in AZ-102		12/4/02	30
12d. Sample Sludge and Decant AZ-102 Supernatant to AN-105	800,000	1/3/03	30
AZ-102 Feed Staging Operations			
13. Add Transfer Solution to AZ-102	820,000	2/2/03	10
** Mix/Sample/Evaluate AZ-102 Sludge		2/12/03	70
** Take Representative Samples from AZ-102, Provide Them to the Privatization Contractor, and Wait for Waste Form Qualification		4/23/03	245
14a. Transfer AZ-102 Slurry to Privatization Contractor (Batch #3 - 40 MT NVOL, 45 MT NVO)	450,000	12/24/03	15
** Immobilize High-Level Waste Feed Batch #3		1/8/04	246
14b. Transfer AZ-102 Slurry to Privatization Contractor (Batch #4 - 40 MT NVOL, 45 MT NVO)	450,000	8/26/04	15
** Immobilize High-Level Waste Feed Batch #4		9/10/04	246
14c. Transfer AZ-102 Slurry to Privatization Contractor (Batch #5 - 40 MT NVOL, 45 MT NVO)	450,000	4/29/05	15
** Immobilize High-Level Waste Feed Batch #5		5/14/05	246
14d. Transfer AZ-102 Slurry to Privatization Contractor (Batch #6 - 40 MT NVOL, 45 MT NVO)	450,000	12/31/05	15
** Immobilize High-Level Waste Feed Batch #6		1/15/06	246

Table 3-2-5. Schedule for Phase I High-Level Waste Pretreatment and Feed Staging. (Sheet 3 of 3)

Activity description	Transfer volume (L)	Late start date	Duration (days)
Other Operations Supporting AY-102 Pretreatment			
** Obtain Core Samples from AY-102 for PHMC		TBD	150
AY-102 Sludge Washing Operations			
15. Sample Sludge and Decant AY-102 Supernatant to AN-105	2,000,000	3/16/05	30
16a. Add Wash Solution to AY-102 and Mix Sludge	1,200,000	4/15/05	30
17a. Wait for Sludge to Settle in AY-102		5/15/05	30
18a. Sample Sludge and Decant AY-102 Supernatant to AN-105	1,400,000	6/14/05	30
16b. Add Wash Solution to AY-102 and Mix Sludge	1,200,000	7/14/05	30
17b. Wait for Sludge to Settle in AY-102		8/13/05	30
18b. Sample Sludge and Decant AY-102 Supernatant to AN-105	1,200,000	9/12/05	30
AY-102 Feed Staging Operations			
19. Add Transfer Solution to AY-102	1,600,000	10/12/05	10
** Mix/Sample/Evaluate AY-102 Sludge		10/22/05	70
** Take Representative Samples from AY-102, Provide Them to the Privatization Contractor, and Wait for Waste Form Qualification		12/31/05	245
20a. Transfer AY-102 Slurry to Privatization Contractor (Batch #7 - 39 MT NVOL, 58 MT NVO)	580,000	9/2/06	15
** Immobilize High-Level Waste Feed Batch #7		9/17/06	236
20b. Transfer AY-102 Slurry to Privatization Contractor (Batch #8 - 39 MT NVOL, 58 MT NVO)	580,000	4/26/07	15
** Immobilize High-Level Waste Feed Batch #8		5/11/07	236
20c. Transfer AY-102 Slurry to Privatization Contractor (Batch #9 - 39 MT NVOL, 58 MT NVO)	580,000	12/18/07	15
** Immobilize High-Level Waste Feed Batch #9		1/2/08	236
20d. Transfer AY-102 Slurry to Privatization Contractor (Batch #10 - 39 MT NVOL, 58 MT NVO)	580,000	8/10/08	15
** Immobilize High-Level Waste Feed Batch #10		8/25/08	236
20e. Transfer AY-102 Slurry to Privatization Contractor (Batch #11 - 39 MT NVOL, 58 MT NVO)	580,000	4/3/09	15
** Immobilize High-Level Waste Feed Batch #11		4/18/09	236
** Complete High-Level Waste Immobilization (450 MT NVOL, 590 MT NVO)		12/10/09	0

NVOL = Non-Volatile Oxides Excluding Sodium and Silicon
NVO = Non-Volatile Oxides

General Notes:

- The activity numbers correspond to the illustration in Figure 3.4-11.
- Activities with no numbers (**) are not represented in Figure 3.4-11.
- The waste transfers shown in this schedule are based on conservative maximum durations, and may not correspond to the modeled schedule provided in Appendix H.

3.2.3 Issues and Caveats

This section describes the issues and caveats identified in the Phase I HLW pretreatment and feed staging "Base Case" evaluation. Issues are identified that directly impact the operating scenario and schedule for HLW pretreatment and feed staging. The list of issues is limited to those that affect the planning of the technical baseline for Tank Farm activities which will occur in support of Phase I immobilization processing.

Other issues that may be outside the scope of this analysis will fall into one or more of the following categories (which may overlap):

- Feed Delivery Mid-Level Logic Issues (Boston 1997) (e.g., risk reduction, inter-organizational schedule and baseline integration, schedule/scope of construction projects, safety issue resolution, permitting and licensing, configuration control)

- Interface Control Document (ICD) Issues (e.g., physical and functional interfaces, interface requirements, responsibilities for the Privatization Contractor, the PHMC, and the DOE, contract uncertainties, sampling requirements, feed delivery procedures)

- Waste Feed Staging DQO Issues (e.g., tank characterization, process testing, feed specifications, tank space implications, analytical uncertainties, "best-basis inventory")

- Hardware Selection Issues (e.g., Phase I HLW pretreatment requirements, mixer pump performance testing, technical requirements specifications, cost estimates)

Complete and more detailed lists of issues are being prepared as part of each of these four activities. Several of these issues, as they relate to waste feed mobilization and delivery, will be addressed in the next revision of Papp (1997). The resolution of selected issues may be useful for evaluating the Privatization Contractor proposals to establish the terms of the Phase IB contracts, and/or to establish the operating scenario to be included in a future revision of this document. Other issues are uncertainties regarding negotiable parameters related to the selection of a HLW pretreatment strategy.

Within this framework, the actions and issues addressed in this section will fall under one or more of the following categories:

1. Enabling assumptions that need to be clarified or verified in order to reduce the major uncertainties in this evaluation (Sections 3.2.3.1, 3.2.3.2, 3.2.3.3, and 3.2.3.6)

2. Additional engineering analyses that must be completed in order to optimize the operating scenario for HLW pretreatment and feed staging (Sections 3.2.3.4 and 3.2.3.5)

3.2.3.1 Transfer System Upgrades. The available characterization data has been verified against the proposed design for the waste transfer system in Galbraith et al. (1996), and it is concluded that the proposed system will be sufficient to complete the necessary waste transfers. 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 241-AZ-101 and 241-AZ-102, as reported in tank characterization reports, are within this range. Table 3.2-6 shows the calculated transfer velocity, head loss, and pressure drop, compared with the design capabilities (limits) of the proposed transfer system.

Table 3.2-6. High-Level Waste Transfer System Design Comparison with Candidate Feeds Reynolds Number Set to 20,000 (Fowler 1995a).

Case	Reynolds number	Velocity	Head loss	Pressure drop
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)
AZ-101 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)
AZ-101 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)
AZ-102 (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)
AY-102/C-106	No data	No data	No data	No data

SpG = Specific gravity
Visc. = Viscosity
[a]This case, further explained below, may be limited by the pump head capabilities (approximately 140 m [450 ft] for the New Generation Transfer Pump), based on an overly conservative Reynolds number requirement of >20,000.

With the exception of 241-AZ-101 (Core 2) and 241-AY-102/241-C-106, 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 241-AY-102/241-C-106 wastes will need to be verified when additional data become available during sluicing retrieval of C-106 into AY-102 (Project W-320).

Fowler (1995b) establishes a Reynolds number requirement of 20,000, referred to as the Waste Pumpability Rule. Based on this rule, all waste transfers must maintain this minimum

Reynolds number, to minimize the potential for line plugging. However, this requirement may be too conservative. The tank characterization reports for 241-AZ-101 and 241-AZ-102 provide critical Reynolds numbers ranging from 4,100 to 9,400, and conclude that the washed solids can be pumped in this lower range. Validation of the requirement from Fowler (1995b) 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 likely entail pipeline flow testing with simulated waste. This verification of the Waste Pumpability Rule would eliminate the uncertainty with 241-AZ-101 (Core 2) in Table 3.2-6. The Reynolds number issue needs to be resolved (or the transfer system design appropriately modified), so that Phase I wastes can be delivered to the Privatization Contractor within the physical property limits of Waste Envelope D.

3.2.3.2 Installation and Testing of In-Tank Processing Equipment. The in-tank processing equipment need dates (i.e., beneficial use dates) are impacted by the assumptions that were made to define the "Base Case." Uncertainties in the chemical inventory, pretreatment efficiency, pretreatment process selection (water or caustic washing), percent solids mobilization (mixer pump efficiency), and the retrieval efficiency will influence the need dates, because they will affect the quantity of feed and the time required to immobilize each of the 3 HLW feeds. (Each successive HLW sludge tank must be prepared well ahead of the expected feed delivery date to minimize facility downtime). The Privatization Contractor's immobilization processing rate will also impact the need dates.

As shown in Tables 3.2-7 and 3.2-8, the in-tank processing equipment need dates for each tank can vary by as much as 35 months for 241-AY-102 due to the uncertainties above.

Table 3.2-7. In-Tank Processing Equipment Need Dates.

Retrieval efficiency	Minimum[c] (241-AZ-101: 90% retrieval 241-AZ-102: 60% retrieval 241-AY-102/241-C-106: 85% retrieval)				Maximum (100% retrieval)			
Pretreatment process	Water wash		Caustic wash		Water wash		Caustic wash	
Processing rate	Min[a]	Incr[b]	Min	Incr	Min	Incr	Min	Incr
241-AZ-101	9/00	9/00	6/00	6/00	9/00	9/00	6/00	6/00
241-AZ-102	11/01	8/01	9/01	6/01	1/02	9/01	10/01	7/01
241-AY-102/ 241-C-106	1/04	5/03	11/02	5/02	4/05	9/04	9/03	1/03

[a]Min = Minimum IHLW processing rate (60 MT of waste oxides excluding sodium and silicon per year)

[b]Incr = Increased IHLW processing rate (76.7 MT of waste oxides excluding sodium and silicon per year)

[c]These are estimate of the minimum retrieval efficiencies predicted for two 300-hp mixer pumps, based on the analysis in Grams (1995).

The final selection of the pretreatment process and the IHLW processing rate is expected to occur in FY 1998. After this selection, the uncertainty in the equipment need dates will decrease significantly. For example, if the water washing and the minimum processing rate are selected (shaded in Table 3.2-7), the uncertainty for 241-AY-102/241-C-106 reduces to 15 months (1/04 to 4/05). This leaves only the retrieval efficiency, which will remain an uncertainty until more information is obtained from mixer pump and transfer pump testing.

Switching the tank order can potentially alleviate some of the uncertainty regarding the equipment need dates. For example, as shown in Table 3.2-8, the uncertainty in the beneficial use date could be reduced by nine months for the third tank if 241-AY-102 is processed before 241-AZ-102. The tanks which are processed first in the sequence should be those for which the most information is available, or those for which the range of uncertainty is the smallest. This methodology will increase the predictability for when each successive in-tank processing system is needed.

Table 3.2-8. In-Tank Processing Equipment Need Dates--Alternate Sequencing.

Retrieval Efficiency	Minimum[c] (241-AZ-101: 90% retrieval 241-AZ-102: 60% retrieval 241-AY-102/241-C-106: 85% retrieval)				Maximum (100% retrieval)			
Pretreatment Process	Water Wash		Caustic Wash		Water Wash		Caustic Wash	
Processing Rate	Min[a]	Incr[b]	Min	Incr	Min	Incr	Min	Incr
AZ-101	9/00	9/00	6/00	6/00	9/00	9/00	6/00	6/00
AY-102/C-106	5/02	1/02	9/01	6/01	7/02	3/02	10/01	7/01
AZ-102	8/04	9/03	11/03	3/03	4/05	3/04	5/04	7/03

[a]Min = Minimum IHLW processing rate (60 MT of waste oxides excluding sodium and silicon per year)

[b]Incr = Increased IHLW processing rate (76.7 MT of waste oxides excluding sodium and silicon per year)

[c]These are estimates of the minimum retrieval efficiencies predicted for two 300-hp mixer pumps based on the analysis in Grams (1995).

Therefore, in the next revision of this plan, it is recommended to exchange 241-AZ-102 and 241-AY-102/241-C-106 in the tank processing sequence. (It is assumed that the sluicing of 241-C-106 into 241-AY-102 will be complete by the earliest need date to support the delivery of feed to the HLW contractor. Another benefit of processing 241-AY-102/ 241-C-106 earlier in the sequence is that if 241-AY-102 is emptied sooner, it increases the potential for being able to fill 241-AY-102 with additional sludge retrieved from C Tank Farm to provide additional feed material in the optional Phase I extension (see Appendix G).

The "Waste Feed Delivery Mid-Level Logic Diagram for HLW Processing" (Boston 1997) indicates that the late start date for Project W-211's conceptual design of the 241-AZ-102 retrieval system is June 1998. Therefore, if the recommendation to exchange 241-AZ-102 with 241-AY-102 in the Phase I HLW retrieval sequence is accepted, the appropriate changes to the Project W-211 schedule will need to be made before this date.

3.2.3.3 Immobilization Facility Design Parameters. While many of aspects of the HLW facility design are specified in the TWRS Privatization contracts, there are several parameters that remain to be negotiated during Phase IA and contract specifications are subject to change. To develop the "Base Case," several assumptions have been made (as discussed in Appendix A).

The final design of the Private Contractor's immobilization facility may impose additional requirements on the HLW feed. Any differences can have significant impacts on both the selection of the preferred Phase I HLW pretreatment strategy and the proposed feed delivery schedule. At this point in time, some of these impacts cannot be evaluated completely. Some of the major facility design uncertainties which affect this plan include the HLW processing rate, the feed/receipt tank capacity, and the HLW product formulation. (Note: The HLW processing rate and feed/receipt tank capacity will be replaced by a single assumption for the feed delivery schedule once these have been mutually agreed to between the PHMC/DOE and the Privatization Contractor).

3.2.3.3.1 High-Level Waste Processing Rate. An important consideration in the development of the HLW feed staging plan is the rate at which the HLW is immobilized by the Privatization Contractor. This rate, combined with the facility's feed/receipt capacity (discussed in the following section), can be used to determine how frequently the HLW batches will need to be transferred during Phase I, and how soon the HLW feeds will need to be prepared. To avoid penalties for "Idle Facilities" (Contract Clause H.30), it will be the responsibility of the DOE/PHMC to maximize the availability of feed. For example, facility idle time could potentially result if the HLW immobilization facility processes the feed at a faster rate than the PHMC can deliver the feed batch(es).

A Monte Carlo analysis has been performed (Appendix E of the "Low-Level Waste Feed Staging Plan [Certa et al. 1996]), evaluating the potential for conflicts between waste transfers, and determined that the waste feed delivery system will be able to comfortably support an immobilized HLW processing rate of approximately 28 percent above the minimum system capacity, or 0.2 MT NVOL per day versus 0.164 MT NVOL per day. (NVOL = non-volatile oxides excluding sodium and silicon). However, the study considered only the transfers of pretreated HLW feeds to the Privatization Contractor, and not the transfers of decanted wash solutions during pretreatment. The TWRS O&UP develops a tank farm operating scenario for the waste feed delivery system that can manage these decanted wash solutions, but DST space will still be very constrained. A trade study, which is planned for FY 1998, will address the issue of the "maximum" immobilized HLW processing rate.

Since the HLW feeds are pretreated and delivered sequentially from separate tanks, construction projects (e.g., Project W-211) will also have to support the higher processing rates. For example, very high immobilized HLW processing rates might require in-tank processing systems to be installed in AZ-101, AZ-102, and AY-102 in parallel. Therefore, even if the waste transfers can be supported, the immobilized HLW processing rate limitation may be related to the available funding for W-211.

Once the HLW processing rate is known, a feasible feed delivery schedule can be established between the Privatization Contractor and the PHMC. Conversely, the potential for waste transfer conflicts or delays can be evaluated to establish either the maximum HLW processing rate or to provide a basis for negotiating an agreement between the DOE and the Privatization Contractor regarding the penalty for "Idle Facilities." The results of such an

evaluation, to be completed next year, may therefore be of particular interest to the DOE for establishing the Phase IB contract in May 1998.

The enabling assumption in this plan is that the immobilized HLW Contractor will operate at the minimum HLW processing rate of 60 MT of waste oxides excluding sodium and silicon per year starting on June 1, 2002 (Appendix A, Items 2.1 and 6.1). No contingency is factored into the pretreatment schedule (Section 3.2.2), and a much higher processing rate may require the installation of in-tank processing equipment (for the second and third tanks, 241-AZ-102 and 241-AY-102, respectively) sooner than planned in this document. The next update of this plan will integrate new assumptions for the HLW immobilization processing rate, if available.

3.2.3.3.2 Feed/Receipt Capacity. To comply with the Phase IA Privatization contract requirements, the results of the analysis in Chapter 5.0 of Manuel et al. (1996) suggest that the Privatization Contractor's feed/receipt tank must have the capacity to receive at least 587,000 L (155,000 gal) of HLW slurry feed per batch transfer. This "derived" requirement is required to satisfy the following three requirements from the TWRS Privatization contracts:

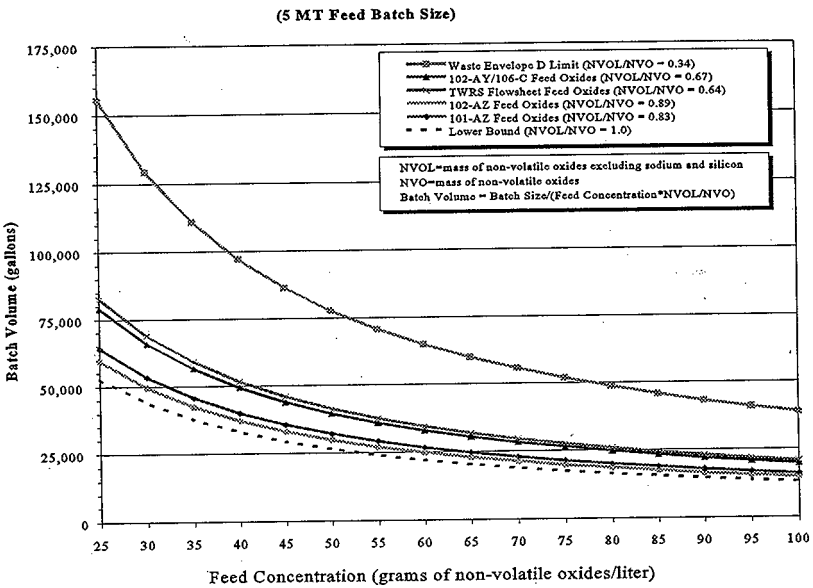
1. The minimum initial batch size (5 MT of waste oxides excluding sodium and silicon)

2. The full range of Waste Envelope D compositions

3 The feed concentration requirements (25 to 100 g equivalent non-volatile oxides/L).

The actual Privatization Contractor HLW feed/receipt capacity is not explicitly defined in the TWRS Privatization contracts, but any proposal of less than the minimum capacity calculated in Manuel et al. (1996) will require modifications to this plan and to any or all of the three contract requirements/specifications mentioned above. Figure 3.2-3 illustrates how the feed/receipt capacity requirement is derived.

Figure 3.2-3. High-Level Waste Batch Transfer Volumes.



Minimum Batch Size (to be established in Phase IA). The Privatization contracts do not specify a minimum feed batch size for the HLW batches following the initial batch. Contract Clause H.9, "Ordering and Contract Order Quantities," states that these quantities are yet to be established. For this analysis, it is assumed that the minimum feed batch size will remain at 5 MT of waste oxides excluding sodium and silicon for the remaining HLW feeds. However, if this value is increased above 5 MT, it will also increase the feed/receipt capacity requirement for the Privatization Contractor.

Waste Envelope D. The Privatization Contractor is required to design the HLW immobilization facility for the full range of Waste Envelope D compositions. The top curve in Figure 3.2-2 represents the upper limit for Waste Envelope D in terms of the ratio of the mass of non-volatile oxides excluding sodium and silicon to the total mass of non-volatile oxides. The area in between the top and bottom curves in Figure 3.2-2 represents the "envelope" of valid HLW feeds. In this evaluation, the estimated feed compositions from 241-AZ-101, 241-AZ-102, and AY-102/C-106 are much below the upper limit.

Waste Envelope D and Feed Concentration Limits. It is recommended to transfer the waste at much higher than the minimum concentration of 25 g equivalent non-volatile oxides/L. As stated in Section 3.2.1.2, it is assumed that the HLW feeds are transferred at 100 g/L. Figure 3.2-3 shows that the batch transfer volume can vary widely depending upon the composition of the waste. However, the upper and lower curves (limits) are farthest apart toward the lower concentration range. Therefore, operation close to the lower concentration limit will pose some risk of not being able to deliver the 5 MT minimum batch size, because of the feed composition variability. Operating closer to the upper concentration limit (i.e., 100 g equivalent non-volatile oxides/L) will decrease the risk of not satisfying the minimum batch size. This recommendation is for planning purposes only and is not intended to be a recommendation to modify the Privatization Contractor's feed/receipt capacity requirement.

Feed Concentration Limits. If the Privatization Contractor determines that the feed/receipt tank volume significantly drives plant cost, the Privatization Contractor may negotiate for higher concentrations of feed to reduce the required feed/receipt capacity, subject only to the waste transfer system restrictions. (The current waste transfer system design can handle a broader range of feed concentrations.) For example, at a concentration of 100 g equivalent non-volatile oxides/L, only 151,000 L (40,000 gal) is required to receive a 5 MT batch of Waste Envelope D (see Figure 3.2-3). This will involve modifying the requirements stated in the TWRS Privatization contracts, and any such negotiations of contract requirements is an uncertainty in this plan.

Based on the tank characterization reports for AZ-101 and AZ-102, 100 g/L corresponds to a viscosity of approximately 10.0 cP, which is the upper design limit for the Project W-314, "Tank Farm Restoration and Safe Operations," transfer system upgrades. Therefore, transfers at higher than a 100 g/L concentration will not be possible without modification to the W-314 transfer system design. Secondly, referring to Figure 3.2-3, the Privatization Contractor will not significantly reduce the required receipt capacity for the HLW feed batches if the feeds are delivered at higher than approximately 75 g/L.

3.2.3.3.3 High-Level Waste Product Formulation. The formulation of the HLW product can be used to determine how much product volume reduction can be achieved with additional processing beyond the minimum processing required to satisfy the Waste Envelope D limits. Optimizing the extent to which the HLW sludges must be pretreated is important due to tank space limitations, and knowledge of the impact on the HLW product volume can help to support a caustic leaching decision (see Section 3.2.3.4). In other words, the HLW product formulation (or some correlation between the extent of pretreatment and the HLW product loading) can allow the pretreatment strategy to be more accurately tailored to meet additional feed processing needs. Also, 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. This performance assessment could then be used to determine the suitability of the Phase I immobilization process for treating Phase II feeds.

The feed processability assessment (Lambert and Stegen 1996) describes a candidate glass formulation based on glass property models developed by Pacific Northwest National Laboratory (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 Privatization Contractor will actually propose. Therefore, these models will be used until the Privatization Contractor's actual product formulation is known.

3.2.3.4 Caustic Leaching in Phase I High-Level Waste Pretreatment. Caustic leaching of the Phase I feeds is considered incremental processing because based on current analyses it does not increase the ability to satisfy the contract requirements (i.e., Waste Envelope D) compared with water washing only. Caustic leaching versus water washing can potentially reduce the cost for geologic disposal, by reducing the volume of immobilized HLW. The following are among the benefits of caustic leaching versus water washing the sludges:

- Potential product volume reduction: This reduction can be achieved by either reducing the feed oxide quantity by reducing the amount of solids in the feed and/or by removing specific components from the feed which may limit the HLW product loading. Both mechanisms for reducing the HLW product volume are a function of the HLW product formulation, which is used to determine the product loading as a function of feed composition (see Section 3.2.3.3.3).

- Obtaining process information: Caustic leaching is the current sludge pretreatment baseline, and valuable process information can be obtained for possible application during Phase II pretreatment.

The option to caustic leach the Phase I HLW sludges is being evaluated in a separate trade study (Manuel 1997). Tank space impacts must also be evaluated for this additional processing to be considered viable. The Phase I pretreatment trade study will include a DST space projection, and will be used to establish the base case for Revision 1 of the TWRSO&UP. The trade study will be updated in FY 1998 to reflect Privatization Phase IB contract specifications, and the base case in Revision 1 of the TWRSO&UP will reflect that update.

3.2.3.5 Additional/Alternative Phase I High-Level Waste Feeds. The results of this analysis show that the sludges from AZ-101, AZ-102, and AY-102/C-106 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 identification of additional/alternative HLW feeds will proceed by the following steps:

1. Identify which sludges will be available (or can be made available) to support the extension of Phase I HLW processing

2. Evaluate which of the available sludges (if any) will satisfy the Waste Envelope D composition limits (TWRS Privatization Contract Specification 8)

3. For the available sludges which do not satisfy Waste Envelope D, evaluate if they satisfy the Expanded Design Basis for HLW Processing (TWRS Privatization Contract Attachment 2)

4. For the available sludges which do not satisfy either Waste Envelope D or the Expanded Design Basis limits, propose a separate waste envelope which will encompass the additional candidate feeds.

5. Rank the sludges identified.

Appendix G identifies the feeds which are available to meet the criteria described above. These additional feeds are identified, but not part of the "Base Case."

3.2.3.6 Best-Basis Inventory Assumptions. The inventory assumptions from the latest revision of the *Best-Basis Inventories of Chemicals and Radionuclides in Hanford Site Tank Waste* (Kupfer et al. 1997) need to be integrated into the HTWOS model. These new tank inventories will also have an impact on the Phase II portion of this plan. The standardized inventories will eliminate any inventory inconsistencies in the related documents.

3.2.4 Recommendations

Some of the actions listed below are pertinent to project schedules and are therefore drivers for the requirements of other tank farm operations (e.g., Projects W-211 and W-314) to be performed by the PHMC.

1. Action: Implement the transfer system upgrades (HLW Option 3) recommended in Galbraith et al. (1996) and consistent with the "Base Case" waste transfer schedule described in this document.

   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).

Status: The W-211 and W-314 schedules and scope are being modified so they are consistent with Galbraith et al. (1996) and the TWRS O&UP.

2. Action: Make sure that the required in-tank processing equipment is installed in time to support the pretreatment schedule in Table 3.2-5. Integrate the results of mixer pump operations and process testing into this plan, when available.

   Consequence of not performing: Delays will be incurred in delivering the pretreated HLW feed to the Privatization Contractor's facility.

   Status: The scope and schedules of projects are being revised.

3. Action: Obtain and integrate information on the immobilization facility design (e.g., processing rates, feed/receipt capacities, product formulation), 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. The selected pretreatment strategy (which will be evaluated separately in Manuel [1997]) will not be optimized, and will not provide the greatest benefit to life-cycle cost.

   Status: A preliminary recommendation will be made in September 1997, and will be revised in FY 1998 to reflect information on the Phase IB contracts.

4. Action: Complete a trade study to determine if caustic leaching should be included in this plan.

   Consequence of not performing: The "Base Case" operating scenario described for the Phase I High-Level Waste Pretreatment and Feed Staging section of this document is 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.

   Status: A preliminary recommendation will be made in September 1997, and will be revised in FY 1998 to reflect information on the Phase IB contracts

5. Action: Confirm the additional or alternative sources of feed which have been identified in this plan, and update the relevant projects and plans.

Consequence of not performing: The PHMC will not have a plan to provide additional sources of feed to support the maximum feed order quantity. For the optional Phase I extension, schedule delays in HLW pretreatment and feed staging may result.

Status: This work is planned for Revision 1 of the TWRSO&UP.

6. Action: Integrate the most current tank-by-tank inventories into the next revision of this plan.

   Consequence of not performing: Detailed planning for Phase I Privatization will not be based on the most recent (or most reliable) data.

   Status: Global best-basis inventory numbers were used for this work. Incorporation of the tank-by-tank inventories is planned for Revision 1 of the TWRSO&UP.

3.3 SINGLE-SHELL TANK RETRIEVAL SEQUENCE

The retrieval sequence as a whole is described in Section 4.3. The description includes the sequence drivers for the sequence as a whole, the tank-by-tank retrieval summary, and a discussion of impacts on the Disposal Program schedule. This section briefly describes the SST retrieval occurring before 2011.

SST retrieval during the period prior to 2011 (during the Phase I time period) is to be performed by the PHMC Team. It is severely restricted because of the small amount of space available in the DSTs to receive waste from retrieval of the SSTs. Therefore, it is totally dependent upon Phase I LAW and HLW processing for providing the space needed to allow SST retrieval to proceed.

The four tanks (241-AX-103, 241-C-103, 241-A-102, and 241-C-105) chosen for the Initial Single-Shell Tank Retrieval System (ISSTRS) were assumed to be retrieved first. This fits with the ISSTRS assumptions, and it could potentially provide the feed needed for maximum order quantities for the HLW processing because the waste from the ISSTRS tanks should meet the requirements of privatization Envelope D (see Appendix G).

The remaining tanks that will have waste retrieved prior to 2011 have been called the Subsequent Single-Shell Tank Retrieval System (SSSTRS). This system was to retrieve an additional 31 tanks to meet the current Tri-Party Agreement milestones (M-45-05-TXX series) and retrieve all of the waste from a tank farm (AX tank farm has been tentatively chosen) prior to 2011. However, as discussed later in Section 4.3, there was not enough space available to allow retrieval of a total of 35 tanks, including all of the AX farm tanks, before the start-up of the Phase II processing facilities.

The tanks to be retrieved prior to 2011 will not be varied (changed) in the sequences that are searched by a genetic algorithm optimization process. This is because the tanks were carefully selected to allow maximization of the number of tanks to be retrieved, to ensure that all of the tanks in the AX tank farm are retrieved prior to 2011, and to minimize the amount of retrieval equipment needed to achieve these goals. In future studies, the sequence of these tanks may be varied either as a separate set, or with special restrictions using the genetic algorithm as discussed in Section 4.3.

3.4 PHASE I DISPOSAL PROGRAM PROCESS SUMMARY

Figures 3.4-1a and 3.4-1b provide a top-level depiction of material flow in Phase I. For the purposes of this process summary, one Private Contractor (LMAES or BNFL) is assumed to secure the Combined High-Level and Low-Activity Waste Processing work scope, and the other secures a Low-Activity Waste Only work scope.

3.4.1 Results

The preparation of feeds for Phase I includes the following:

1. Supernate and salt slurry retrieval, adjustment of properties, and staging of batches to Private Contractors (Section 3.4.2)

2. Sludge retrieval, adjustment of properties (i.e., pretreatment), and staging of batches to Private Contractors (Section 3.4.3).

The PHMC prepares LAW feed in tanks 241-AP-102 and 241-AP-104, and stages LAW feed to Private Contractor tanks 241-AP-106 and 241-AP-108. The PHMC stages approximately 4,500 MT[1] of soluble sodium to each Private Contractor for a total of approximately 8,900 MT of sodium. Feed is delivered when the Private Contractors' tanks have 30 days worth of feed remaining. (This is a modeling parameter, not a contract requirement.) This staging strategy enables the Private Contractors to operate their facilities continuously, and avoids the inefficiency and inconvenience of plant shutdowns and restarts between discrete batches of feed. Material balances for LAW feed staging are in Appendix E. The content of batches prepared by the PHMC is summarized in in Section 3.4.2.4.

[1]See Section 3.1.1 for a discussion on the ability to meet Envelope A feed quantities.

Figure 3.4-1a. High-Level Waste and Low-Activity Waste Processing.

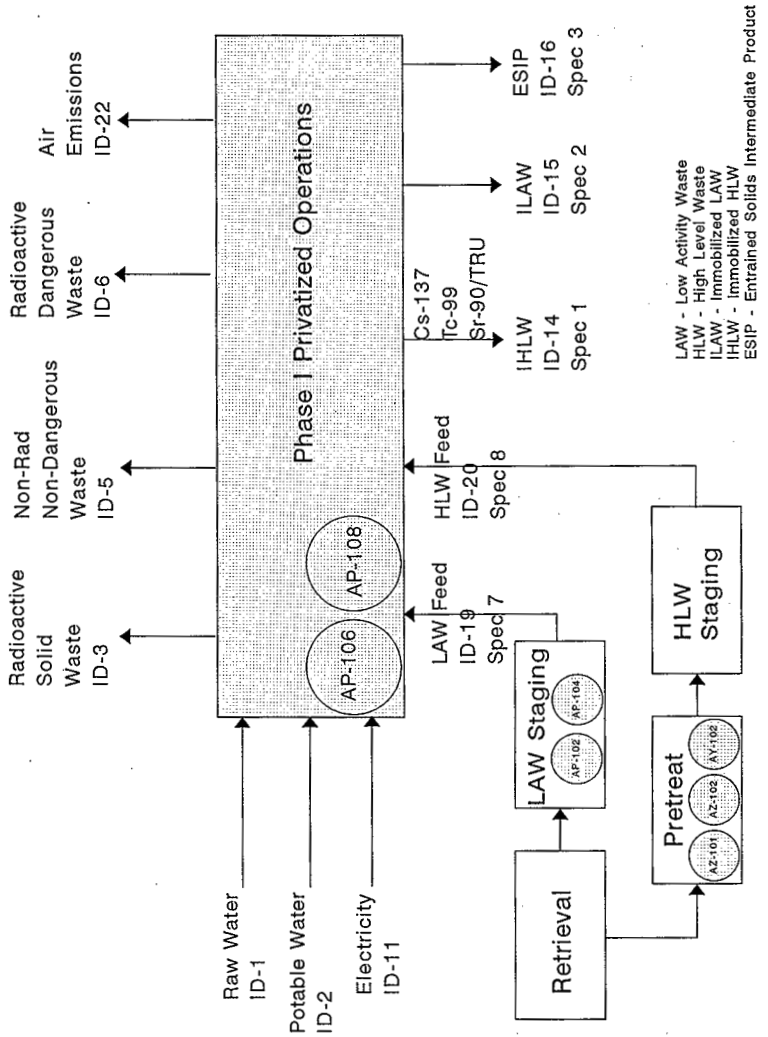
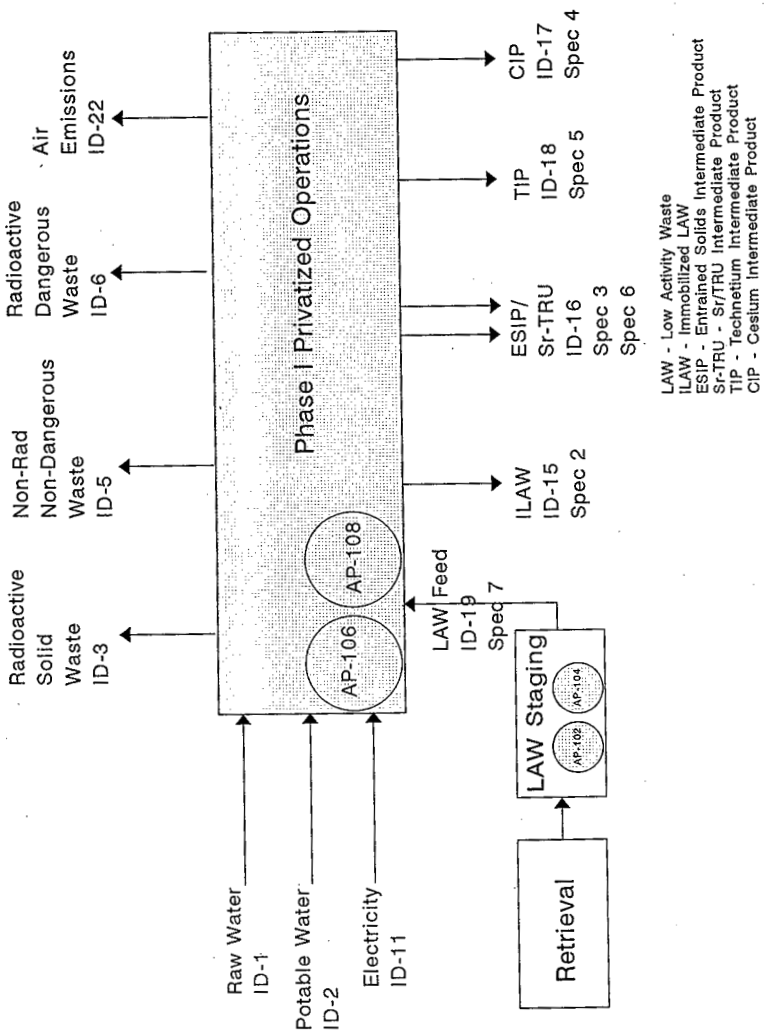


Figure 3.4-1b. Low-Activity Waste Only Processing.



The Private Contractors separate solids and remove (as needed to satisfy ILAW specifications) strontium/TRU, cesium, and technetium from the LAW supernate. The Private Contractors immobilize pretreated LAW in an unspecified waste form (assumed to be glass) in 2.6 m^3 ILAW packages. Figure 3.4-1b includes certain intermediate products (Sr/TRU, Technetium, and Cesium) that are returned to the PHMC by the Private Contractor who does not produce IHLW. Table 3.4-1 summarizes the production of ILAW packages (which totaled 11,370). Intermediate radionuclide products from each Private Contractor must be within contractual limits on content and volume.

Table 3.4-1. Phase I Immobilized Low-Activity Waste and Intermediate Product Summary.

Product stream	Interface Control Document	Controlling specification	Volume or package count
ILAW	15	2	11,370 packages
Sr/TRU-ESIP	16	6 3	Volume TBD but slurry must be: >20 vol% solids, or >50% of solids content at which slurry viscosity is 30 cP or >50% of solids content at which slurry density is 1.5
TIP	18	5	Volume TBD but must be less than 45,000 L.
CIP	17	4	Package count TBD

The PHMC pretreats HLW sludges in 241-AZ-101, 241-AZ-102, and 241-AY-102 (including retrieved 241-C-106 sludge) and stages up to 450 MT of washed sludges (oxide equivalent, not including Na and Si) in 11 batches to the HLW Private Contractor.[1] The mass of washed solids is more than the minimum order of 245 MT but less than the maximum order of 465 MT. Table 3.4-2 summarizes the washing scenario for each tank and the mass of IHLW returning from the HLW Private Contractor, assuming a non-volatile waste oxide

[1]The maximum amount of washed sludge is based on complete retrieval of sludges and no caustic leaching. Partial retrieval and caustic leaching result in less feed for the Private Contractors.

loading of 25 wt% (not including Na, Si, or Private Contractor added material). Material balances for the pretreatment and immobilization of each tank are provided in Appendix F. For the sludge washing base case and DWPF canister size (1.65 MT or 0.62 m^3), the canister count is 1,100.[1] The Private Contractors are evaluating other canister sizes. The enhanced sludge washing results are provided in Table 3.4-2 for information and comparison only. Candidate wastes for additional feeds to meet the maximum order are identified in Appendix G. Future work will be performed to determine which wastes are the most desirable feeds and to identify the impact of staging and pretreating those wastes on the use of the DSTs.

Table 3.4-2. Phase I Immobilized High-Level Waste Summary.

Tank	Leaches	Washes	Washed oxide MT	Glass MT (wt%)
241-AZ-101	0	3	96.4	386 (25%)
	1	3	66.6	266 (25%)
241-AZ-102	0	4	161.5	646 (25%)
	1	2	114	456 (25%)
241-AY-102 (incl. 241-C-106)	0	2	193.8	775 (25%)
	1	2	152.9	612 (25%)
Sludge Washing Only			451.7	1,807
Enhanced Sludge Washing			333.5	1,334

3.4.2 Project Hanford Management Contractor Team Supernate Feed Preparation (Low-Activity Waste Staging)

A detailed schedule of feed staging operations was provided in Section 3.1. The following section tentatively identifies the equipment for retrieval, describes the primary transfer system for moving Phase I feeds to the intermediate staging tanks, and elaborates on the characteristics and chemical behavior of the feeds. Staging material balances are also provided.

[1]The minimum order quantity produces 595 canisters.

3.4.2.1 Retrieval and Transfer Equipment for Phase I Supernates and Salt Slurries. The equipment, tentatively identified here, is subject to confirmation by more rigorous engineering studies.

Tanks (241-AN-105, 241-AN-104, 241-AW-101, 241-AN-103) containing salt slurries without sludge heels are equipped with one or two mixer pumps[1] and a slurry transfer pump. This configuration will ensure consistency because precipitated salts and supernate will be mobilized and retrieved at the same rate. Temperature, concentration, or in some instances, composition adjustment by in-line dilution may be necessary to yield transport properties (density and viscosity) that are within the transfer system's range of specifications. The pasty consistency of the 241-AN-103 slurry may require incremental insertion of the mixer pump. An alternative approach is to decant supernates first and salt slurries second, after adding dilution water to the tank.

Tanks (241-AY-101, 241-AN-107, 241-AN-102, 241-AN-106) containing dilute or concentrated supernates with or without sludge heels require a slurry transfer or decant pump. Tanks containing concentrated supernate should have the additional capability for in-line adjustment of density and viscosity.

Tanks in the 200 West Area (241-SY-101 and 241-SY-103) containing salt slurries and having sludge heels will be retrieved into the AN Tank Farm where supernate and sludge are separated by gravity settling. The tanks are equipped with two mixer pumps and a slurry transfer pump, and the capability for in-line adjustment of density and viscosity.

Except for 241-AW-101 and 241-AY-101, all of the Phase I supernates are transferred to the PHMC's intermediate staging tanks from the AN Tank Farm. A study has recommended the routing to be used during LAW staging (see Appendix H, Figure H-2) (Galbraith et al. 1996). The maximum transfer distance is 1,020 m (3,340 ft).

Transfer lines instrumented for flow, pressure, density, and viscosity are common requirements for all retrievals.

The future use of a tank should be considered in making decisions pertaining to Phase I retrieval equipment. The intermediate staging tanks (241-AP-102 and 241-AP-104) will require equipment to homogenize (mix) supernates before transfer to the Private Contractors and to purge the tanks of settled solids. These tanks are also set aside for future handling of retrieved sludges.

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[1]A mixer pump for gas dissipation has been demonstrated successfully in 241-SY-101. This pump was designed with the suction inlet high in the tank. Some variation of the design would be required to mobilize a slurry while the tank is being drawn down simultaneously.

3.4.2.2 Physical Characteristics of Phase I Supernate Sources. Previously, tanks earmarked for Envelope A feed (241-AN-105, 241-AN-104, 241-AW-101, 241-AN-103) were thought to contain salt slurries. Recent core sampling has confirmed that a large layer (typically 40 to 50 vol%) of precipitated salt exists in these tanks, although cooling between the time of sampling and extrusion of the sample may account for some of this. One of the Envelope A tanks (241-AN-103), which was evaporated beyond the sodium aluminate phase boundary, has a very pasty consistency. (See the Tank Characterization Reports for respective tanks.)

The bulk density of waste specified as future Envelope A ranges from 1.45 to 1.54 with bulk sodium content ranging from 10 to 14.6 moles per liter of waste.

The liquid portion of the most recent PUREX Plant HLW raffinates, currently contained in the AZ tank farm, will provide the Envelope B LAW feed. Phase I pretreatment operations will involve moving these supernates to 241-AY-101 (and perhaps another DST). These supernates have not been concentrated through the tank farm evaporator. They are not known to contain precipitated salts. The sodium content of these supernates will be adjusted to 5*M* by in situ evaporation in the AZ tanks before they are decanted. The density is expected to be approximately 1.2 SpG. The AZ tanks also contain Envelope D sludges.

Envelope C feeds (241-AN-107, 241-AN-102, 241-AN-106, 241-SY-101, 241-SY-103) are likewise supernates and/or salt slurries with densities ranging from 1.32 to 1.61, and sodium concentration ranging from 9.2 to 16.1 moles per liter of waste. Several of the Envelope C tanks are known to contain sludge heels.

There is no intention to remove sludge heels from Envelope A, B, or C tanks during Phase I staging (except 241-SY-101 and 241-SY-103). Inadvertent entrainment of sludges is always a possibility, however, and the PHMC is obligated to deliver no more than 5 vol% settled solids in Phase I supernates.

3.4.2.3 Solid-Liquid Phase Behavior of Phase I Supernates. Transfer systems, which are generally designed to operate within a narrow range of conditions, could be shut down by a dramatic change in the rheology of a solution or slurry while a transfer is in progress. Most of the Phase I feed tanks contain solid and liquid phases because the solubility of the solutes has been exceeded. To avoid the adverse consequences of spontaneous precipitation at inopportune times during retrieval and staging, the solid-liquid phase behavior of tank wastes is an important consideration.

All of the Phase I feeds exist as near-saturated solutions or saturated solutions with precipitated salts. Consequently, they are sensitive to changes in water content and temperature. As little as 1 to 2 percent reduction in water content can change a near-saturated salt solution into a highly viscous slurry. Dehydration and/or absorption of CO_2 from the air results in salt crusts.

Saturated liquids can likewise become highly viscous with negative changes in temperature. A supernate that is near saturation should not be transferred through an unheated underground pipeline because a temperature change of up to 20 °C can occur in transit as heat flows to the surroundings. New Phase I pipelines installed by Project W-314 will not be heat traced. Many existing underground piping systems are heat traced, but relying on heat tracing for the long-term is not advisable since it is impractical to repair failed heat tracing on underground lines.

Preheating is a possible strategy for transferring near-saturated material. It is certainly feasible to equip tanks for preheating, assuming mixer pump heating is insufficient. There are, however, safety limitations on the rate of temperature rise in a DST's concrete shell that have to be considered when transferring hot waste into a tank. All things considered, temperature control is not a satisfactory approach for PHMC, which is obligated to deliver supernates (not slurries) to the Private Contractors.

To avoid the pitfalls of handling saturated materials in the underground piping system, and to deliver the contractually required supernates to the Private Contractors, concentration adjustment is the preferred strategy for controlling the rheology and preserving the liquidity of wastes during staging. Concentration is controlled by dilution (water and chemical additions, as necessary) to maintain a comfortable distance from saturation for any reasonable temperature that would be encountered during handling.

All of the Phase I source tanks contain aluminum-bearing salt supernates/slurries. Aluminum in the Na_2O-Al_2O_3-H_2O system can exhibit peculiar behavior during dilution depending on the initial composition and the extent of dilution. Dissolving and keeping the aluminum salts in solution during retrieval and staging is preferred. Since dilution is a necessary step during retrieval and staging, predicting the behavior of aluminum during dilution is of particular interest.

Phase equilibria in waste solutions is a problem of sufficient complexity that thermodynamic modeling is warranted. Solubility is being assessed with the aid of the ESP,[1] a commercially available electrolyte model. The main purpose for simulating the chemistry of Phase I feeds is to identify tanks that have the potential to be problematical when water is added during retrieval.

1ESP is a trademark of OLI Systems, Inc. ESP results provide insight into the chemistry of high ionic strength mixtures, but experimental verification is advisable. This version of ESP is known to have difficulty projecting the sodium aluminate phase boundary, but that deficiency is not significant for the purposes of this assessment. ESP predictions of the gibbsite phase boundary are qualitatively consistent with experimental observation. Improved data on both of the systems mentioned above will be incorporated in future releases of ESP.

This model is becoming more reliable as improved data pertaining to aluminum and other waste components are added to the database. For example, based on the data of Barney and others, a database was developed for practical modeling of aluminum species (Reynolds 1995). Reynold's WESOL[1] database can be used in conjunction with ESP for modeling aluminum solubility. Examples of ESP calculations using the WESOL database are plotted in Figure 3.4-4, showing that ESP does a reasonably good job of simulating aluminum solubility.

A supplemental database (SPECIAL) was added recently to deal with the double salt phenomenon ($Na_7F(P_4)_2.19H_2O$).

All Phase I feed tank inventories that have been modeled by ESP to date have exhibited precipitation at 40 °C. Core sampling has so far confirmed that actual wastes are indeed saturated with precipitates present. Table 3.4-3 provides a comparison of ESP-simulated versus average measured concentrations found in AN-105 supernate. Table 3.4-3 provides corroborating evidence that ESP is capable of simulating solubility with adequate accuracy.

Table 3.4-3. Simulated Versus Measured Properties in 241-AN-105 Supernate.

Property	ESP supernate (simulated)	Actual supernate (measured)
Density (g/ml)	1.44	1.42
Wt% water	45	50
Al (molarity)	1.6	1.5
Cl	0.22	0.28
NO_2	2.4	2.6
NO_3	2.6	2.6
OH	3.2	3.4
Na	10.8	10.7

ESP = Environmental Simulation Program.

The following paragraphs, Tables 3.4-4 through 3.4-7, and Figures 3.4-2 through 3.4-5 discuss the chemical and phase equilibrium of 241-AN-105, 241-AN-104, 241-AW-101, and

[1]We are in the process of evaluating the HANFORD private database which may replace WESOL in the future. The HANFORD database, prepared by OLI from data developed at PNNL (Sterner et al. 1996), addresses aluminum and a number of other important Hanford species.

241-AN-103 for a unit mass of supernate/salt slurry as it is diluted with water at 40 °C as simulated with the ESP. These Envelope A tanks typically contain non-complexed waste with sodium ranging from 10 to 15 moles per liter of waste.

241-AN-105. Dilution of 241-AN-105 (Table 3.4-4 and Figure 3.4-2) with water down to approximately 9.5*M* Na dissolves the salts. Dilution beyond 8.5*M* Na favors the precipitation of gibbsite ($Al(OH)_3$). Continuing the dilution down to 7*M* Na generates approximately 0.14 kg gibbsite per kg diluted supernate (0.2 kg gibbsite per kg of supernate). Such extensive precipitation would exceed the allowable 5 vol% settled solids in feeds transferred to the Private Contractors, and should not be done on the PHMC side of the feed interface.

241-AN-104. The phase equilibrium and chemistry of AN-104 supernate during dilution at 40 °C is depicted in Table 3.4-5 and Figure 3.4-3. The presence of $NaNO_3$ precipitate indicates that this supernate is saturated at this temperature, so pipeline transfer without heating or dilution is not advisable. Dilution beyond 6*M* Na generates gibbsite. Tank 241-AN-104 will be staged at 8.4*M*.

241-AW-101. The phase equilibrium and chemistry of AW-101 supernate during dilution at 40 °C is depicted in Table 3.4-6 and Figure 3.4-4. The presence of KNO_3 precipitate indicates that this supernate is saturated at this temperature, so pipeline transfer without heating or dilution is not advisable. Dilution beyond 5*M* Na begins to generate gibbsite. Tank 241-AW-101 will be staged at 6.5*M*.

241-AN-103. Finally, the phase equilibrium and chemistry of AN-103 supernate during dilution at 40 °C was modeled with ESP. The results are provided in Table 3.4-7 and Figure 3.4-5. The abundance of precipitated salt is consistent with this tank's designation as a Double-Shell Slurry (DSS) tank. Pipeline transfer without heating or dilution is not advisable.

A known deficiency of the version of ESP used in this assessment is that it does not predict the existence of $NaAlO_2$ precipitate when that compound should obviously be present. DSS (241-AN-103) was the only Hanford waste concentrated beyond the $NaAlO_2$ phase boundary, but the ESP modeling shows none is present. This is a deficiency of the PUBLIC database that comes with ESP. Modeling with the WESOL or other database will overcome this deficiency.

The gibbsite equilibrium in Figure 3.4-9, however, should still be valid. Dilution down to 8*M* Na without gibbsite formation appears to be possible, but gibbsite precipitates beyond 6.5*M* Na.

Table 3.4-4. Tank 241-AN-105 Dilution at 40 °C.

Mass kgs	OHION moles/L	ALOH4ION moles/L	NAION moles/L	NO2ION moles/L	NO3ION moles/L	ALOH3PPT moles/L	NANO3PPT moles/L
1.000	3.180	1.635	10.823	2.450	2.600	0.000	0.309
1.099	2.761	1.420	9.668	2.128	2.519	0.000	0.000
1.198	2.460	1.265	8.605	1.896	2.241	0.000	0.000
1.297	2.310	1.062	7.788	1.716	2.028	0.082	0.000
1.395	2.218	0.866	7.117	1.568	1.853	0.180	0.000
1.494	2.112	0.723	6.542	1.442	1.703	0.239	0.000
1.593	2.006	0.616	6.050	1.333	1.575	0.273	0.000
1.692	1.903	0.534	5.620	1.239	1.464	0.292	0.000
1.791	1.806	0.469	5.246	1.156	1.366	0.302	0.000
1.890	1.715	0.417	4.917	1.084	1.281	0.306	0.000

Figure 3.4-2. Tank 241-AN-105 Dilution at 40 °C.

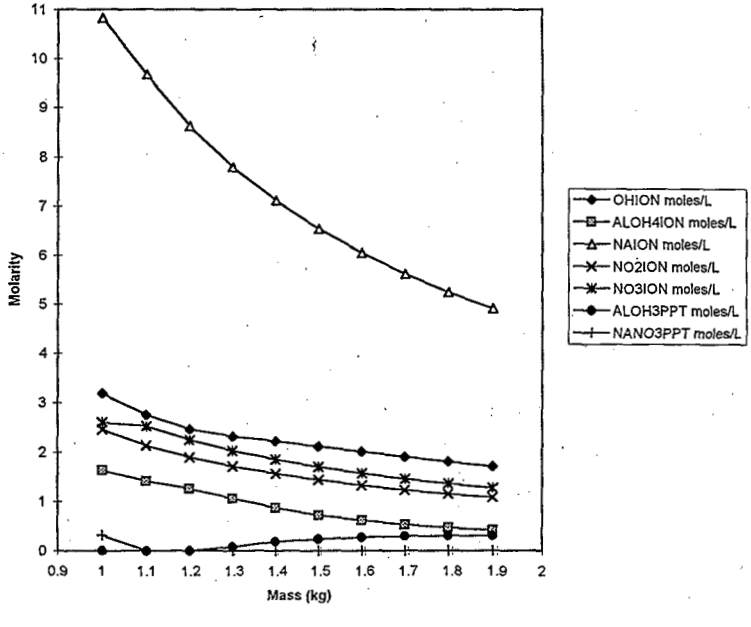


Table 3.4-5. Tank 241-AN-104 Dilution At 40 °C.

Mass kgs	OHION moles/L	ALOH4ION moles/L	NAION moles/L	NO2ION moles/L	NO3ION moles/L	ALOH3PPT moles/L	NANO3PPT moles/L
1.000	4.015	1.320	10.590	1.822	2.547	0.000	0.375
1.107	3.420	1.124	9.552	1.552	2.483	0.000	0.000
1.213	3.024	0.994	8.443	1.373	2.194	0.000	0.000
1.320	2.711	0.891	7.564	1.230	1.964	0.000	0.000
1.427	2.454	0.806	6.844	1.113	1.777	0.000	0.000
1.534	2.257	0.722	6.255	1.017	1.624	0.014	0.000
1.640	2.133	0.615	5.768	0.938	1.497	0.064	0.000
1.747	2.016	0.533	5.348	0.870	1.389	0.097	0.000
1.854	1.907	0.468	4.983	0.810	1.294	0.119	0.000
1.960	1.806	0.416	4.663	0.758	1.211	0.133	0.000

Figure 3.4-3. Tank 241-AN-104 Dilution at 40 °C.

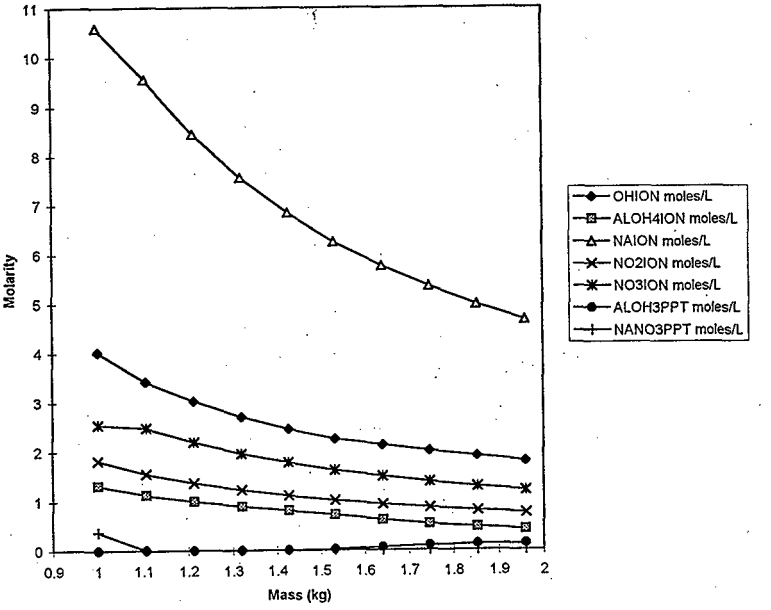


Table 3.4-6. Tank 241-AW-101 Dilution At 40 °C.

Mass kgs	OHION moles/L	ALOH4ION moles/L	NAION moles/L	NO2ION moles/L	NO3ION moles/L	ALOH3PPT moles/L	KNO3PPT moles/L
1.000	3.392	0.964	9.227	2.067	3.139	0.000	0.051
1.112	2.932	0.833	7.969	1.786	2.754	0.000	0.000
1.225	2.584	0.734	7.023	1.574	2.426	0.000	0.000
1.337	2.308	0.656	6.273	1.406	2.166	0.000	0.000
1.450	2.085	0.592	5.666	1.270	1.956	0.000	0.000
1.562	1.899	0.540	5.162	1.157	1.783	0.000	0.000
1.674	1.777	0.467	4.749	1.064	1.640	0.029	0.000
1.787	1.672	0.406	4.399	0.985	1.519	0.054	0.000
1.899	1.576	0.357	4.094	0.917	1.414	0.071	0.000
2.012	1.489	0.318	3.827	0.857	1.322	0.082	0.000

Figure 3.4-4. Tank 241-AW-101 Dilution At 40 °C.

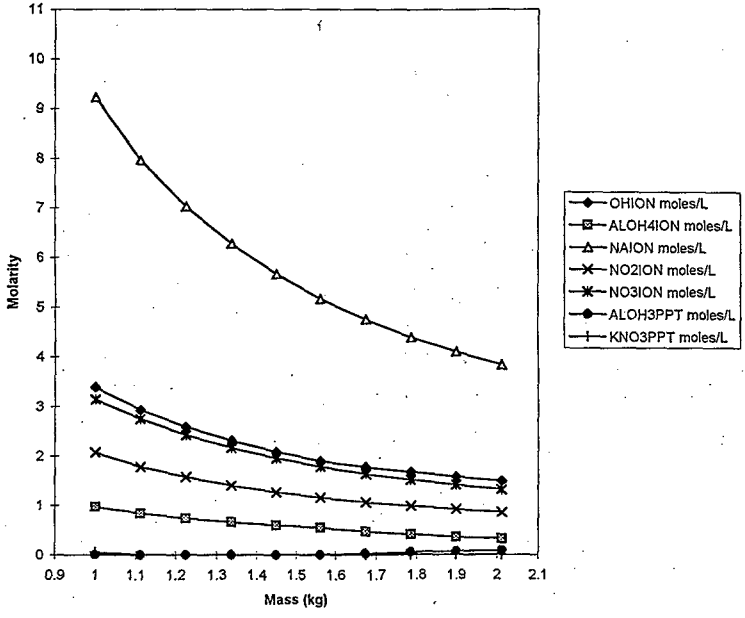
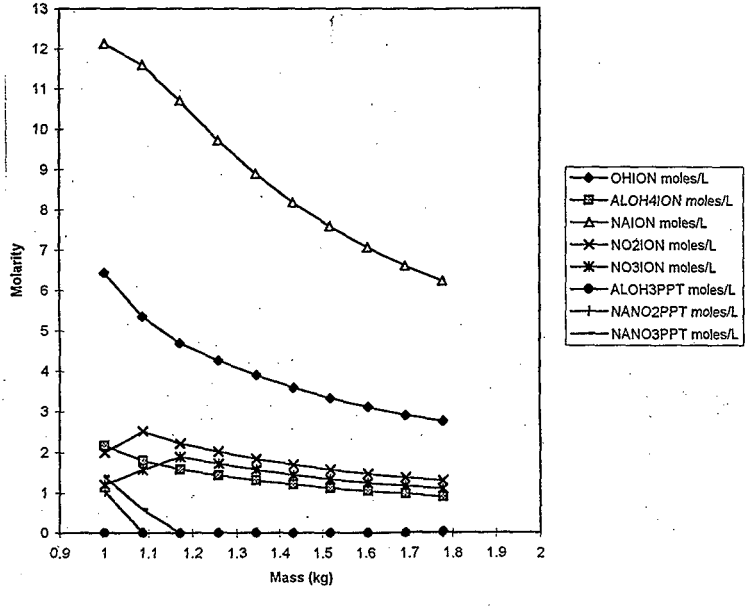


Table 3.4-7. Tank 241-AN-103 Dilution At 40 °C.

Mass kg	OHION moles/L	ALOH4ION moles/L	NAION moles/L	NO2ION moles/L	NO3ION moles/L	ALOH3PPT moles/L	NANO2PPT moles/L	NANO3PPT moles/L
1.000	6.445	2.162	12.143	1.995	1.201	0.000	1.043	1.405
1.086	5.345	1.793	11.596	2.520	1.570	0.000	0.000	0.587
1.173	4.699	1.576	10.703	2.215	1.890	0.000	0.000	0.000
1.259	4.268	1.432	9.721	2.012	1.714	0.000	0.000	0.000
1.346	3.905	1.310	8.895	1.841	1.567	0.000	0.000	0.000
1.432	3.598	1.207	8.193	1.696	1.443	0.000	0.000	0.000
1.519	3.335	1.119	7.594	1.572	1.337	0.000	0.000	0.000
1.605	3.107	1.042	7.073	1.465	1.245	0.000	0.000	0.000
1.692	2.908	0.975	6.619	1.371	1.165	0.000	0.000	0.000
1.778	2.758	0.896	6.229	1.290	1.096	0.021	0.000	0.000

Figure 3.4-5. Tank 241-AN-103 Dilution At 40 °C.



As a general caveat, even a perfect simulator of complicated chemical equilibria can produce results no more reliable than the chemical inventories provided as input. It is always advisable to confirm simulation results experimentally.

Since Envelope B supernate is suitable for staging without dilution, it was not modeled.

Organic salt speciation would have to be known, and appropriate thermodynamic data present in the ESP database to model Envelope C. Consequently, the dilution of Envelope C was not modeled. The precipitation phenomenon has been observed in the laboratory with complexed waste samples. Further testing is advisable to identify potential problems.

3.4.2.4 Tabulation of Phase I Supernate Batches. Tables 3.4-8 and 3.4-9 summarize the actual supernate material batched to each Private Contractor from the intermediate staging tanks (241-AP-102 and 241-AP-104). Refer to Appendix E for detailed flow diagrams and material balances for Phase I LAW staging. The stream numbers identified in Tables 3.4-8 and 3.4-9 are referenced to the diagrams in Appendix E.

Table 3.4-8. Private Contractor 1 Batches. (Sheet 1 of 5)

Table 3.4-8. Private Contractor 1 Batches (5 Sheets)

Envelope	A	A	A	A	B	C	C	C	C	C-west	C-west
Stream	7	15	23	31	6	7	9	17	25	22	26
	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles
Liquids											
137-CS	5.20E-02	6.40E-02	6.90E-02	7.40E-02	1.90E-01	1.80E-02	4.10E-02	4.20E-02	4.00E-02	3.60E-02	2.80E-02
14-C	3.03E-06	1.17E-07	7.57E-06	1.17E-06	1.83E-08	6.32E-10	1.44E-09	4.79E-04	7.36E-04	1.13E-04	5.85E-06
237-NP	9.05E-09	3.48E-10	1.19E-11	1.84E-12	2.86E-14	9.90E-16	2.26E-15	1.54E-16	2.04E-06	7.55E-06	4.96E-07
239-240-PU	4.47E-06	1.72E-07	7.98E-05	1.24E-05	2.31E-07	9.33E-04	2.00E-03	7.00E-03	5.81E-04	4.21E-04	2.34E-05
241-AM	8.42E-08	3.24E-09	1.85E-06	2.87E-07	2.75E-08	3.86E-04	8.81E-04	1.93E-04	8.28E-06	9.21E-06	1.84E-06
90-SR	1.58E-05	6.41E-05	1.05E-04	1.92E-05	4.21E-04	4.00E-03	9.00E-03	1.20E-02	3.00E-03	4.00E-03	2.00E-03
99-TC	3.34E-01	1.30E-02	1.61E-01	2.50E-02	3.92E-04	7.00E-02	1.60E-01	3.23E-01	1.33E+00	3.13E-01	1.90E-01
AG+	2.01E-01	1.84E-01	6.00E-03	9.72E-04	1.52E-05	5.24E-07	1.20E-06	8.15E-08	8.00E-02	7.00E-03	2.98E-04
AL(OH)4-	2.75E+03	2.64E+03	1.96E+03	3.87E+03	3.57E+02	5.04E+01	1.15E+02	1.01E+03	1.02E+03	3.51E+03	3.20E+03
AL+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AS+5	8.56E-05	3.30E-06	1.12E-07	1.74E-08	2.71E-10	9.37E-12	2.14E-11	1.46E-12	2.70E-02	1.00E-03	3.39E-05
B+3	8.29E+00	3.19E-01	1.10E-02	9.37E+00	1.46E-01	5.00E-03	1.20E-02	7.86E-04	7.30E-02	1.40E-02	4.69E+00
BA+2	1.00E-03	4.17E-05	1.42E-06	2.20E-07	3.43E-09	1.19E-10	2.71E-10	1.85E-11	3.50E-02	3.00E-03	1.20E-04
BE+2	1.96E-04	7.55E-06	2.57E-07	3.98E-08	6.21E-10	2.15E-11	4.89E-11	3.34E-12	1.14E-13	4.73E-15	1.24E-16
BI+3	9.70E-02	4.00E-03	1.27E-04	1.97E-05	1.00E-03	3.60E-05	8.22E-05	5.60E-06	2.07E+00	2.01E-01	1.00E-02
CA+2	3.00E-03	1.24E-04	1.49E+00	2.30E-01	1.10E-02	6.99E+00	1.59E+01	2.06E+01	1.03E+00	2.63E+01	1.56E+01
CANCRINITE	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CD+2	9.15E-04	3.52E-05	1.20E-06	3.50E-02	5.39E-04	1.86E-05	4.25E-05	2.90E-06	4.70E-02	3.00E-03	1.10E-04
CE+3	3.40E-02	1.00E-03	4.40E-05	6.81E-06	1.06E-07	3.67E-09	8.38E-09	5.71E-10	7.05E-01	6.90E-02	3.00E-03
CL-	5.41E+02	4.65E+02	2.78E+02	4.14E+02	1.12E+01	4.02E+01	9.18E+01	1.97E+02	2.55E+02	6.64E+02	5.41E+02
CM+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CO+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CO3-2	1.55E+03	2.33E+03	4.47E+02	7.01E+02	4.33E+02	5.17E+02	1.18E+03	2.06E+03	1.56E+03	2.86E+03	1.36E+03
CR(OH)4-	1.49E+01	2.49E+01	8.43E+00	2.22E+01	1.65E+01	2.79E+00	6.37E+00	1.13E+01	6.63E+00	1.14E+02	3.05E+01
CR+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.76E+00	6.07E+00
CS+	4.77E-07	1.84E-08	6.25E-10	9.69E-11	1.51E-12	5.22E-14	1.19E-13	8.13E-15	4.00E-03	1.82E-04	4.74E-06
CU+2	4.00E-03	1.40E-04	4.77E-06	7.39E-07	1.15E-08	3.98E-10	9.09E-10	6.20E-11	7.80E-02	8.00E-03	3.70E-04
F-	1.04E+02	1.35E+02	4.59E+00	8.60E+01	8.60E+01	2.97E+00	6.78E+00	1.79E+02	4.54E+02	3.10E+01	1.15E+00
FE+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FE+3	1.35E-01	5.00E-03	1.77E-04	2.74E-05	2.00E-03	1.37E+01	3.12E+01	2.13E+00	4.47E+01	7.30E+00	1.71E+00
FECN6-3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
H+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
H2O	1.09E+05	1.11E+05	1.25E+05	1.15E+05	5.07E+04	2.81E+04	6.42E+04	1.30E+05	1.08E+05	1.68E+05	1.13E+05
HG+2	6.17E-08	2.37E-09	8.08E-11	1.25E-11	1.95E-13	6.74E-15	1.54E-14	1.05E-15	5.83E-05	2.41E-06	6.30E-08
I-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
K+	3.06E+02	3.10E+02	1.44E+03	7.82E+02	1.13E+02	2.93E+01	6.68E+01	1.67E+02	6.94E+01	2.52E+02	2.01E+02

Table 3.4-8. Private Contractor 1 Batches. (Sheet 2 of 5)

Table 3.4-8. Private Contractor 1 Batches (5 Sheets)

Envelope	A	A	A	A	B	C	C	C	C	C-west	C-west
Stream	7	15	23	31	6	7	9	17	25	22	26
	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles
LA+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LI+	1.70E-02	1.82E+00	6.20E-02	1.00E-02	1.50E-04	5.18E-06	1.18E-05	8.06E-07	3.59E-01	3.50E-02	2.00E-03
MG+2	9.00E-03	3.50E-04	2.76E+00	4.27E-01	7.00E-03	2.30E-04	5.26E-04	3.58E-05	6.93E-01	3.90E-02	1.00E-03
MN+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MN+4	7.90E-02	3.00E-03	8.13E-01	1.26E-01	6.50E-02	4.63E+00	1.06E+01	7.20E-01	2.60E+01	1.09E+00	2.90E-02
MNO2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MO+6	1.22E+00	9.50E-01	8.00E-01	1.24E-01	2.00E-03	6.68E-05	1.52E-04	1.04E-05	8.60E-02	7.00E-03	3.25E-04
NA+[a]	2.24E+04	2.33E+04	1.86E+04	2.54E+04	5.12E+03	5.18E+03	1.18E+04	2.08E+04	1.79E+04	2.68E+04	1.97E+04
NB+5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NI+3	2.40E-02	9.07E-04	3.09E-05	4.78E-06	3.20E-02	3.88E+00	8.86E+00	1.09E+01	6.19E+00	5.08E+00	2.32E+00
NI2FECN6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NO2-	5.05E+03	4.60E+03	4.00E+03	4.98E+03	1.43E+03	5.96E+02	1.36E+03	3.24E+03	3.16E+03	6.92E+03	5.18E+03
NO3-	5.48E+03	5.19E+03	5.86E+03	6.29E+03	1.16E+03	1.90E+03	4.33E+03	6.48E+03	4.85E+03	6.17E+03	4.89E+03
OH-	5.93E+03	7.50E+03	7.72E+03	8.33E+03	7.16E+02	7.11E+02	1.62E+03	5.00E+02	1.62E+03	3.91E+03	2.95E+03
P2O5:24WO2:44H2O	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PB+4	5.67E-01	2.20E-02	2.02E+00	9.04E-01	1.40E-02	8.14E-01	1.86E+00	1.27E-01	1.77E-01	1.10E-02	4.50E-04
PO4-3	1.02E+02	9.08E+01	4.29E+01	4.49E+01	1.18E+01	3.25E+00	7.42E+00	9.17E+01	9.09E+01	2.04E+02	2.29E+02
PU+4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RB+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RE+7	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RH+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RU+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SB+5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SE+6	1.73E-05	6.65E-07	5.40E-04	8.36E-05	1.30E-06	4.51E-08	1.03E-07	7.01E-09	5.22E-04	4.20E-05	1.91E-06
SI+4	1.71E+01	1.90E+01	6.46E-01	1.41E+01	2.60E-01	9.00E-03	2.00E-02	1.00E-03	1.08E+02	4.60E+00	1.73E+00
SM+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SN+4	3.00E-03	1.16E-04	3.95E-06	6.13E-07	9.56E-09	3.30E-10	7.54E-10	5.14E-11	6.30E-02	6.00E-03	3.05E-04
SO4-2	1.24E+02	2.05E+02	2.62E+01	5.50E+01	2.21E+02	7.68E+01	1.75E+02	2.78E+02	2.07E+02	1.30E+02	1.02E+02
SR+2	6.76E-04	2.60E-05	8.86E-07	1.37E-07	7.69E-04	2.66E-05	6.06E-05	4.13E-06	1.40E-02	1.00E-03	6.82E-05
TE+6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TH+4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TI+4	5.00E-03	1.78E-04	1.27E-01	2.00E-02	3.07E-04	1.06E-05	2.42E-05	1.65E-06	9.90E-02	1.00E-02	4.69E-04
TL+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TOC	1.11E+03	7.79E+02	3.95E+02	4.70E+02	1.17E+02	1.75E+03	3.99E+03	4.13E+03	4.06E+03	4.15E+03	2.31E+03
UNKNOWN	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
UO2+2	1.86E-04	7.16E-06	1.28E+00	2.05E-01	8.00E-03	3.16E-01	7.22E-01	4.90E-02	9.79E+00	6.39E-01	8.30E-02
V+5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 3.4-8. Private Contractor 1 Batches. (Sheet 3 of 5)

Table 3.4-8. Private Contractor 1 Batches (5 Sheets)

Envelope	A	A	A	A	B	C	C	C	C	C-west	C-west
Stream	7	15	23	31	6	7	9	17	25	22	26
	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles
W+6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ZN+2	5.73E-01	2.55E-01	6.19E+00	1.20E+00	1.90E-02	6.46E-04	1.00E-03	1.01E-04	7.47E-01	1.69E+00	4.96E-01
ZR+4	9.00E-03	1.82E-01	7.14E-01	1.82E-01	2.80E-02	9.83E-04	2.00E-03	1.53E-04	2.02E-01	1.90E-02	9.34E-04
ZRO2:2H2O	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Liquids (gal)	686500	684700	740300	753200	277000	170400	389000	770700	646100	1014000	711200
	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles
Solids											
137-CS	1.92E-08	7.39E-10	3.59E-12	3.66E-12	3.26E-06	2.70E-05	6.15E-05	2.12E-05	1.23E-05	1.57E-05	6.06E-06
14-C	8.54E-11	3.29E-12	1.60E-14	1.63E-14	5.28E-15	1.70E-15	3.88E-15	2.65E-16	6.49E-10	2.30E-08	8.44E-10
237-NP	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
239-240-PU	2.02E-04	2.08E-04	1.01E-06	2.74E-05	8.89E-06	1.52E-05	3.47E-05	7.38E-06	1.04E-05	3.97E-04	1.02E-04
241-AM	5.83E-06	5.84E-06	2.84E-08	7.76E-07	2.52E-07	8.45E-07	1.93E-06	1.77E-06	1.47E-06	5.90E-05	1.93E-05
90-SR	1.00E-03	1.00E-03	6.16E-06	1.72E-04	2.29E-04	8.41E-05	1.92E-04	3.33E-05	1.61E-04	5.09E-05	3.19E-05
99-TC	7.66E-08	1.31E-01	5.00E-03	2.30E-02	7.00E-03	2.00E-03	5.00E-03	3.70E-04	5.20E-05	4.00E-03	2.00E-03
AG+	6.56E-06	2.52E-07	1.23E-09	1.25E-09	4.05E-10	1.30E-10	2.98E-10	2.03E-11	4.94E-05	2.00E-03	6.48E-05
AL(OH)4-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AL+3	3.00E-03	1.28E-04	6.24E-07	6.35E-07	9.77E-01	1.69E+00	3.86E+00	2.63E-01	1.14E+00	9.40E-01	3.40E-02
AS+5	1.36E-07	5.22E-09	2.54E-11	2.59E-11	8.38E-12	2.70E-12	6.16E-12	4.20E-13	1.02E-06	3.65E-05	1.34E-06
B+3	2.97E-07	1.14E-08	5.56E-11	1.80E+00	5.83E-01	1.88E-01	4.28E-01	2.90E-02	1.00E-03	1.21E-04	4.02E-06
BA+2	2.06E-06	7.92E-08	3.85E-10	3.92E-10	1.27E-10	4.09E-11	9.34E-11	4.69E-04	3.15E-05	5.55E-04	2.04E-05
BE+2	1.54E-06	5.93E-08	2.89E-10	2.94E-10	9.53E-11	3.07E-11	7.00E-11	4.77E-12	1.16E-05	4.15E-04	1.52E-05
BI+3	3.30E-01	1.30E-02	2.60E-02	2.60E-02	8.00E-03	3.00E-03	6.00E-03	4.22E-04	8.82E-05	3.65E-06	9.54E-08
CA+2	1.10E+01	7.43E+00	8.24E-01	8.39E-01	3.09E-01	1.01E-01	2.29E-01	4.70E-02	4.30E-02	1.57E-01	2.40E-02
CANCRINITE	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CD+2	1.35E-05	5.20E-07	2.53E-09	2.57E-09	8.35E-10	2.69E-10	6.13E-10	4.18E-11	1.02E-04	4.00E-03	1.33E-04
CE+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.32E-08	9.60E-10	2.51E-11
CL-	1.55E-04	8.35E+01	4.58E+00	4.66E+00	1.51E+00	4.86E-01	1.11E+00	7.60E-02	5.40E-02	4.40E-02	2.00E-03
CM+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CO+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CO3-2	1.27E-05	4.90E-07	8.65E+01	8.80E+01	2.85E+01	9.18E+00	2.10E+01	1.99E+00	4.16E-01	1.80E-02	1.44E-01
CR(OH)4-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CR+3	3.07E+01	2.55E+01	2.71E+00	2.76E+00	9.07E-01	3.00E-01	6.86E-01	9.10E-02	3.10E-02	3.00E+00	4.18E+00
CS+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CU+2	1.33E-05	5.12E-07	2.49E-09	2.53E-09	8.22E-10	2.64E-10	6.03E-10	2.00E-03	1.80E-04	4.00E-03	1.32E-04
F-	7.00E-06	2.70E-07	6.45E+00	6.56E+00	2.13E+00	8.57E-01	1.96E+00	1.33E-01	2.80E-02	3.00E-03	1.62E+00
FE+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 3.4-8. Private Contractor 1 Batches. (Sheet 4 of 5)

Table 3.4-8. Private Contractor 1 Batches (5 Sheets)

Envelope	A	A	A	A	B	C	C	C	C	C-west	C-west
Stream	7	15	23	31	6	7	9	17	25	22	26
	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles
FE+3	1.40E+00	2.23E+00	1.19E-01	1.21E-01	1.65E-01	1.95E-01	4.44E-01	9.80E-02	1.30E-01	7.07E-01	1.01E+00
FECN6-3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
H+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
H2O	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.84E-16	3.25E-17	8.48E-19
HG+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
K+	1.18E-04	4.56E-06	2.22E-08	2.26E-08	7.32E-09	2.36E-09	5.37E-09	3.66E-10	1.90E-02	3.20E-02	4.00E-03
LA+3	1.72E-06	6.60E-08	3.21E-10	3.27E-10	9.00E-03	3.00E-03	7.00E-03	4.61E-04	9.00E-03	8.14E-04	2.61E-05
LI+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MG+2	1.62E-04	6.22E-06	3.03E-08	3.08E-08	2.40E-02	8.00E-03	1.70E-02	1.30E-02	2.30E-02	4.40E-02	2.00E-03
MN+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MN+4	3.78E-01	4.23E-01	2.00E-03	2.00E-03	2.20E-02	1.40E-02	3.10E-02	2.40E-02	2.30E-02	1.06E-01	4.00E-03
MNO2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MO+6	8.94E-07	3.44E-08	1.67E-10	1.70E-10	5.52E-11	1.78E-11	4.06E-11	1.00E-03	4.22E-05	2.44E-04	8.92E-06
NA+	1.50E-02	5.95E-04	2.89E-06	3.03E+01	1.05E+01	3.39E+00	7.74E+00	7.43E+00	3.36E+00	4.63E+00	4.48E-01
NB+5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NI+3	7.80E-01	1.42E+00	6.70E-02	6.80E-02	2.40E-02	8.00E-03	1.80E-02	1.00E-03	2.00E-03	1.09E-01	3.60E-02
NI2FECN6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NO2-	1.00E-03	5.31E-05	2.58E-07	2.63E-07	8.52E-08	2.79E-01	6.38E-01	4.30E-02	4.90E-01	3.86E-01	1.40E-02
NO3-	3.00E-03	1.25E-04	6.09E-07	6.20E-07	2.01E-07	6.47E-08	1.48E-07	1.01E-08	6.26E-01	8.94E-01	3.30E-02
OH-	1.74E-05	6.68E-07	3.25E-09	3.31E-09	1.07E-09	3.45E-10	7.88E-10	5.37E-11	4.52E-01	5.00E-02	6.00E-03
P2O5:24WO2:44H2O	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PB+4	2.00E-02	4.25E+00	2.10E-02	2.10E-02	7.00E-03	3.00E-03	7.00E-03	5.09E-04	3.01E-04	8.00E-03	2.92E-04
PO4-3	2.00E-03	7.21E-05	4.95E+00	5.04E+00	1.70E+00	6.59E-01	1.50E+00	1.03E-01	1.02E-01	5.23E-01	4.60E-02
PU+4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RB+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RE+7	2.35E-09	9.04E-11	4.40E-13	4.48E-13	1.45E-13	4.67E-14	1.07E-13	7.27E-15	1.77E-08	6.32E-07	2.32E-08
RH+3	2.16E-06	8.32E-08	4.05E-10	4.12E-10	1.34E-10	4.30E-11	9.82E-11	6.69E-12	1.63E-05	5.82E-04	2.14E-05
RU+3	5.22E-08	2.01E-09	9.77E-12	9.95E-12	3.23E-12	1.04E-12	2.37E-12	1.62E-13	3.93E-07	1.41E-05	5.16E-07
SB+5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SE+6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SI+4	2.01E-01	1.82E+01	6.78E-01	2.98E+00	9.85E-01	3.17E-01	7.23E-01	1.71E-01	3.30E-02	2.58E-01	9.00E-03
SM+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SN+4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SO4-2	1.62E-04	6.25E-06	5.97E+00	6.08E+00	1.97E+00	6.35E-01	1.45E+00	5.13E-01	4.20E-02	7.00E-02	2.10E-02
SR+2	4.86E-06	1.87E-07	9.10E-10	9.26E-10	3.00E-10	9.67E-11	2.21E-10	5.55E-04	5.56E-05	1.00E-03	4.81E-05
TE+6	2.90E-08	1.12E-09	5.44E-12	5.54E-12	1.79E-12	5.77E-13	1.32E-12	8.99E-14	2.21E-07	7.82E-06	2.87E-07

Table 3.4-8. Private Contractor 1 Batches. (Sheet 5 of 5)

Table 3.4-8. Private Contractor 1 Batches (5 Sheets)

Envelope	A	A	A	A	B	C	C	C	C	C-west	C-west
Stream	7	15	23	31	6	7	9	17	25	22	26
	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles
TH+4	5.39E-05	2.08E-06	1.01E-08	1.03E-08	3.34E-09	1.07E-09	2.45E-09	1.67E-10	4.06E-04	1.50E-02	5.33E-04
TI+4	1.45E-05	5.58E-07	2.72E-09	2.76E-09	8.96E-10	2.88E-10	6.58E-10	4.49E-11	1.09E-04	4.00E-03	1.43E-04
TL+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.35E-07	5.61E-09	1.47E-10
TOC	6.97E+01	1.11E+02	2.86E+01	3.63E+01	1.18E+01	3.79E+00	8.65E+00	5.90E-01	1.58E-01	2.36E-01	3.90E-02
UNKNOWN	1.00E-03	4.03E-05	1.09E+02	1.11E+02	3.59E+01	1.16E+01	2.64E+01	1.80E+00	4.77E-01	2.00E-02	5.16E-04
UO2+2	4.05E-01	8.50E-01	4.00E-03	4.00E-03	1.00E-03	4.39E-04	1.00E-03	1.50E-02	7.42E-04	9.00E-03	5.70E-02
V+5	1.41E-06	5.44E-08	2.65E-10	2.70E-10	8.74E-11	2.81E-11	6.42E-11	4.38E-12	1.06E-05	3.81E-04	1.40E-05
W+6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ZN+2	3.47E-05	1.34E-06	6.51E-09	9.00E-02	2.90E-02	9.00E-03	2.10E-02	5.00E-03	4.19E-04	9.00E-03	6.00E-03
ZR+4	1.61E-05	1.56E-01	7.59E-04	7.73E-04	2.51E-04	8.07E-05	1.84E-04	1.50E-02	8.11E-04	4.00E-03	1.30E-02
ZRO2:2H2O	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solids (gal)	282	686	1581	1687	552	184	420	51	25	44	31
Start	7/10/01	1/5/03	9/29/03	5/3/04	3/18/05	7/13/05	8/10/05	12/24/05	8/20/06	3/13/07	1/16/08
End	7/13/01	1/9/03	10/2/03	5/7/04	3/20/05	7/14/05	8/12/05	12/27/05	8/24/06	3/19/07	1/19/08

*The PHMC Contractor will revise the feed staging plans to include the staging and delivery of the additional Envelope A feed needed to meet the minimum order quantities by either blending of existing Envelope A feed with near-Envelope A feed or by shimming near-Envelope A feed with caustic to adjust the analyte:sodium ratios. Additionally, the DOE/WIT are working on refined LAW feed envelopes that will reclassify a significant quantity of Envelope C waste as Envelope A. If this is done, the delivered quantity of Envelope A may be as large as 9,200 MT Na.

Table 3.4-9. Private Contractor 2 Batches. (Sheet 1 of 5)

Table 3.4-9. Private Contractor 2 Batches (5 Sheets)

Envelope	A	A	A	A	B	C	C	C	C	C-west	C-west
Stream	8	16	24	32	7	8	10	18	26	24	27
	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles
Liquids											
137-CS	5.20E-02	6.40E-02	6.90E-02	7.40E-02	1.87E-01	1.80E-02	4.10E-02	4.20E-02	4.00E-02	3.60E-02	2.10E-02
14-C	3.34E-06	1.29E-07	7.57E-06	1.17E-06	1.83E-08	6.42E-10	1.46E-09	4.79E-04	7.36E-04	3.59E-05	1.13E-06
237-NP	1.03E-08	3.96E-10	1.35E-11	2.09E-12	3.25E-14	1.14E-15	2.61E-15	1.78E-16	2.04E-06	8.10E-07	4.40E-08
239-240-PU	5.08E-06	1.96E-07	7.98E-05	1.24E-05	2.31E-07	9.33E-04	2.00E-03	7.00E-03	5.81E-04	2.00E-04	1.16E-05
241-AM	8.88E-08	3.42E-09	1.85E-06	2.87E-07	2.71E-08	3.86E-04	8.81E-04	1.93E-04	8.28E-06	7.33E-05	4.89E-06
90-SR	1.55E-05	6.41E-05	1.05E-04	1.92E-05	4.15E-04	4.00E-03	9.00E-03	1.20E-02	3.00E-03	4.00E-03	2.00E-03
99-TC	3.35E-01	1.30E-02	1.61E-01	2.50E-02	3.91E-04	7.00E-02	1.60E-01	3.23E-01	1.33E+00	3.09E-01	1.41E-01
AG+	2.01E-01	1.84E-01	6.00E-03	9.72E-04	1.51E-05	5.32E-07	1.21E-06	8.28E-08	8.00E-02	4.00E-03	1.07E-04
AL(OH)4-	2.75E+03	2.64E+03	1.96E+03	3.87E+03	3.52E+02	5.05E+01	1.15E+02	1.01E+03	1.02E+03	3.50E+03	2.51E+03
AL+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AS+5	8.11E-05	3.12E-06	1.06E-07	1.65E-08	2.56E-10	9.00E-12	2.06E-11	1.40E-12	2.70E-02	1.00E-03	2.98E-05
B+3	8.29E+00	3.19E-01	1.10E-02	9.37E+00	1.46E-01	5.00E-03	1.20E-02	7.97E-04	7.30E-02	4.00E-03	4.65E+00
BA+2	1.00E-03	4.64E-05	1.58E-06	2.45E-07	3.81E-09	1.34E-10	3.05E-10	2.08E-11	3.50E-02	2.00E-03	4.58E-05
BE+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
BI+3	1.10E-01	4.00E-03	1.45E-04	2.24E-05	1.00E-03	3.60E-05	8.23E-05	5.61E-06	2.07E+00	9.70E-02	3.00E-03
CA+2	4.00E-03	1.41E-04	1.49E+00	2.30E-01	1.10E-02	6.99E+00	1.59E+01	2.06E+01	1.03E+00	2.68E+01	1.06E+01
CANCRINITE	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CD+2	8.61E-04	3.31E-05	1.13E-06	3.50E-02	5.38E-04	1.89E-05	4.31E-05	2.94E-06	4.70E-02	2.00E-03	5.68E-05
CE+3	3.80E-02	1.00E-03	5.00E-05	7.75E-06	1.21E-07	4.24E-09	9.68E-09	6.60E-10	7.05E-01	3.30E-02	1.00E-03
CL-	5.40E+02	4.65E+02	2.78E+02	4.14E+02	1.11E+01	4.02E+01	9.18E+01	1.97E+02	2.55E+02	6.65E+02	4.11E+02
CM+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CO+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CO3-2	1.55E+03	2.33E+03	4.47E+02	7.01E+02	4.26E+02	5.17E+02	1.18E+03	2.06E+03	1.56E+03	2.87E+03	8.19E+02
CR(OH)4-	1.48E+01	2.49E+01	8.43E+00	2.22E+01	1.63E+01	2.79E+00	6.37E+00	1.13E+01	6.63E+00	1.15E+02	8.18E+00
CR+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.79E+00	5.48E+00
CS+	5.43E-07	2.09E-08	7.11E-10	1.10E-10	1.72E-12	6.03E-14	1.38E-13	9.38E-15	4.00E-03	1.81E-04	4.84E-06
CU+2	4.00E-03	1.60E-04	5.43E-06	8.41E-07	1.31E-08	4.60E-10	1.05E-09	7.16E-11	7.80E-02	4.00E-03	1.11E-04
F-	1.04E+02	1.35E+02	4.59E+00	8.60E+01	8.47E+01	2.98E+00	6.79E+00	1.79E+02	4.54E+02	1.90E+01	5.15E-01
FE+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
FE+3	1.53E-01	6.00E-03	2.00E-04	3.10E-05	2.00E-03	1.37E+01	3.12E+01	2.13E+00	4.47E+01	9.85E+00	7.74E-01
FECN6-3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
H+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
H2O	1.09E+05	1.11E+05	1.25E+05	1.15E+05	5.00E+04	2.81E+04	6.42E+04	1.30E+05	1.08E+05	1.61E+05	8.23E+04
HG+2	7.01E-08	2.70E-09	9.19E-11	1.42E-11	2.22E-13	7.79E-15	1.78E-14	1.21E-15	5.83E-05	2.41E-06	6.44E-08
I-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
K+	3.05E+02	3.10E+02	1.44E+03	7.82E+02	1.12E+02	2.93E+01	6.68E+01	1.67E+02	6.94E+01	2.50E+02	1.52E+02

Table 3.4-9. Private Contractor 2 Batches. (Sheet 2 of 5)

Table 3.4-9 Private Contractor 2 Batches (5 Sheets)

Envelope	A	A	A	A	B	C	C	C	C	C-west	C-west
Stream	8	16	24	32	7	8	10	18	26	24	27
	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles
LA+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
LI+	2.00E-02	1.82E+00	6.20E-02	1.00E-02	1.50E-04	5.26E-06	1.20E-05	8.18E-07	3.59E-01	1.70E-02	5.09E-04
MG+2	1.00E-02	3.98E-04	2.76E+00	4.27E-01	7.00E-03	2.34E-04	5.34E-04	3.64E-05	6.93E-01	3.00E-02	8.26E-04
MN+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MN+4	8.90E-02	3.00E-03	8.13E-01	1.26E-01	6.40E-02	4.63E+00	1.06E+01	7.20E-01	2.60E+01	1.93E+00	7.30E-02
MNO2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MO+6	1.22E+00	9.50E-01	8.00E-01	1.24E-01	2.00E-03	6.78E-05	1.55E-04	1.06E-05	8.60E-02	4.00E-03	1.14E-04
NA+	2.23E+04	2.33E+04	1.86E+04	2.54E+04	5.05E+03	5.18E+03	1.18E+04	2.08E+04	1.79E+04	2.68E+04	1.47E+04
NB+5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NI+3	2.10E-02	7.90E-04	2.69E-05	4.17E-06	3.20E-02	3.88E+00	8.87E+00	1.09E+01	6.19E+00	5.28E+00	1.48E+00
NI2FECN6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NO2-	5.05E+03	4.60E+03	4.00E+03	4.98E+03	1.40E+03	5.96E+02	1.36E+03	3.24E+03	3.16E+03	6.91E+03	3.85E+03
NO3-	5.47E+03	5.19E+03	5.86E+03	6.29E+03	1.15E+03	1.90E+03	4.33E+03	6.48E+03	4.85E+03	6.19E+03	3.76E+03
OH-	5.92E+03	7.50E+03	7.72E+03	8.33E+03	7.07E+02	7.11E+02	1.62E+03	5.00E+02	1.62E+03	4.01E+03	2.20E+03
P2O5:24WO2:44H2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PB+4	5.67E-01	2.20E-02	2.02E+00	9.04E-01	1.40E-02	8.14E-01	1.86E+00	1.27E-01	1.77E-01	1.58E-01	8.00E-03
PO4-3	1.01E+02	9.07E+01	4.29E+01	4.49E+01	1.16E+01	3.25E+00	7.42E+00	9.17E+01	9.09E+01	2.00E+02	1.89E+02
PU+4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RB+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RE+7	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RH+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RU+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SB+5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SE+6	1.96E-05	7.54E-07	5.40E-04	8.36E-05	1.30E-06	4.57E-08	1.04E-07	7.12E-09	5.22E-04	2.36E-05	6.91E-07
SI+4	1.71E+01	1.90E+01	6.46E-01	1.41E+01	2.59E-01	9.00E-03	2.10E-02	1.00E-03	1.08E+02	4.49E+00	1.72E+00
SM+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SN+4	3.00E-03	1.32E-04	4.50E-06	6.97E-07	1.09E-08	3.81E-10	8.70E-10	5.93E-11	6.30E-02	3.00E-03	9.00E-05
SO4-2	1.23E+02	2.05E+02	2.62E+01	5.50E+01	2.18E+02	7.68E+01	1.75E+02	2.78E+02	2.07E+02	1.28E+02	8.03E+01
SR+2	7.69E-04	2.96E-05	1.01E-06	1.56E-07	7.57E-04	2.66E-05	6.07E-05	4.14E-06	1.40E-02	6.66E-04	2.02E-05
TE+6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TH+4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TI+4	5.00E-03	2.02E-04	1.27E-01	2.00E-02	3.06E-04	1.08E-05	2.46E-05	1.68E-06	9.90E-02	5.00E-03	1.41E-04
TL+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
TOC	1.11E+03	7.79E+02	3.95E+02	4.70E+02	1.15E+02	1.75E+03	3.99E+03	4.13E+03	4.06E+03	4.28E+03	1.57E+03
UNKNOWN	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
UO2+2	3.26E-05	1.25E-06	1.28E+00	2.05E-01	7.00E-03	3.16E-01	7.22E-01	4.90E-02	9.79E+00	6.95E-01	4.00E-02
V+5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Page 2

Table 3.4-9. Private Contractor 2 Batches. (Sheet 3 of 5)

Table 3.4-9 Private Contractor 2 Batches (5 Sheets)

Envelope	A	A	A	A	B	C	C	C	C	C-west	C-west
Stream	8	16	24	32	7	8	10	18	26	24	27
	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles
W+6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ZN+2	5.73E-01	2.55E-01	6.19E+00	1.20E+00	1.90E-02	6.56E-04	1.00E-03	1.02E-04	7.47E-01	1.71E+00	1.67E-01
ZR+4	1.00E-02	1.82E-01	7.14E-01	1.82E-01	2.80E-02	9.85E-04	2.00E-03	1.53E-04	2.02E-01	9.00E-03	2.84E-04
ZRO2:2H2O	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Liquids (gal)	686500	684700	740300	753200	273000	170500	389100	770700	646100	978400	524700
	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles
Solids											
137-CS	2.18E-08	8.40E-10	4.09E-12	4.16E-12	3.18E-06	2.70E-05	6.16E-05	2.12E-05	1.23E-05	2.43E-05	4.01E-06
14-C	9.72E-11	3.74E-12	1.82E-14	1.85E-14	5.92E-15	1.96E-15	4.47E-15	3.05E-16	6.49E-10	4.95E-09	1.41E-10
237-NP	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
239-240-PU	2.02E-04	2.08E-04	1.01E-06	2.74E-05	8.76E-06	1.53E-05	3.48E-05	7.39E-06	1.04E-05	1.56E-04	7.01E-05
241-AM	5.86E-06	5.84E-06	2.84E-08	7.76E-07	2.48E-07	8.47E-07	1.93E-06	1.77E-06	1.47E-06	3.02E-05	1.35E-05
90-SR	1.00E-03	1.00E-03	6.16E-06	1.72E-04	2.24E-04	8.43E-05	1.93E-04	3.33E-05	1.61E-04	9.45E-05	2.25E-05
99-TC	8.72E-08	1.31E-01	5.00E-03	2.30E-02	7.00E-03	2.00E-03	5.00E-03	3.75E-04	5.22E-05	8.00E-03	1.00E-03
AG+	7.46E-06	2.87E-07	1.40E-09	1.42E-09	4.55E-10	1.50E-10	3.43E-10	2.34E-11	4.94E-05	3.80E-04	1.08E-05
AL(OH)4-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
AL+3	4.00E-03	1.46E-04	7.09E-07	7.22E-07	9.50E-01	1.69E+00	3.87E+00	2.63E-01	1.14E+00	2.56E-01	7.00E-03
AS+5	1.54E-07	5.94E-09	2.89E-11	2.94E-11	9.40E-12	3.11E-12	7.09E-12	4.84E-13	1.02E-06	7.85E-06	2.23E-07
B+3	3.38E-07	1.30E-08	6.33E-11	1.80E+00	5.75E-01	1.90E-01	4.34E-01	3.00E-02	1.00E-03	5.91E-05	1.61E-06
BA+2	2.34E-06	9.01E-08	4.38E-10	4.46E-10	1.43E-10	4.71E-11	1.08E-10	4.69E-04	3.16E-05	1.20E-04	3.41E-06
BE+2	1.75E-06	6.75E-08	3.28E-10	3.34E-10	1.07E-10	3.53E-11	8.06E-11	5.50E-12	1.16E-05	8.92E-05	2.54E-06
BI+3	3.30E-01	1.30E-02	2.60E-02	2.60E-02	8.00E-03	3.00E-03	6.00E-03	4.27E-04	8.84E-05	3.66E-06	9.77E-08
CA+2	1.10E+01	7.43E+00	8.24E-01	8.39E-01	3.04E-01	1.02E-01	2.32E-01	4.70E-02	4.30E-02	4.20E-02	1.50E-02
CANCRINITE	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CD+2	1.54E-05	5.91E-07	2.88E-09	2.93E-09	9.36E-10	3.09E-10	7.06E-10	4.82E-11	1.02E-04	7.82E-04	2.22E-05
CE+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.32E-08	9.59E-10	2.56E-11
CL-	1.77E-04	8.35E+01	4.58E+00	4.66E+00	1.49E+00	4.92E-01	1.12E+00	7.70E-02	5.40E-02	1.10E-02	3.12E-04
CM+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CO+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CO3-2	1.45E-05	5.58E-07	8.65E+01	8.80E+01	2.81E+01	9.30E+00	2.12E+01	2.01E+00	4.17E-01	1.70E-02	1.14E-01
CR(OH)4-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CR+3	3.07E+01	2.55E+01	2.71E+00	2.76E+00	8.94E-01	3.04E-01	6.94E-01	9.20E-02	3.10E-02	6.26E+00	3.12E+00
CS+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CU+2	1.51E-05	5.82E-07	2.83E-09	2.88E-09	9.21E-10	3.05E-10	6.95E-10	2.00E-03	1.80E-04	7.73E-04	2.20E-05
F-	7.96E-06	3.07E-07	6.45E+00	6.56E+00	2.10E+00	8.66E-01	1.98E+00	1.35E-01	2.80E-02	4.00E-03	1.28E+00
FE+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 3.4-9. Private Contractor 2 Batches. (Sheet 4 of 5)

Table 3.4-9 Private Contractor 2 Batches (5 Sheets)

Envelope	A	A	A	A	B	C	C	C	C	C-west	C-west
Stream	8	16	24	32	7	8	10	18	26	24	27
	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles
FE+3	1.40E+00	2.23E+00	1.19E-01	1.21E-01	1.61E-01	1.95E-01	4.45E-01	9.80E-02	1.30E-01	7.88E-01	7.72E-01
FECN6-3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
H+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
H2O	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.86E-16	3.26E-17	8.70E-19
HG+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
I-	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
K+	1.35E-04	5.18E-06	2.52E-08	2.57E-08	8.20E-09	2.71E-09	6.19E-09	4.22E-10	1.90E-02	8.00E-03	2.00E-03
LA+3	1.95E-06	7.51E-08	3.66E-10	3.72E-10	9.00E-03	3.00E-03	7.00E-03	4.61E-04	9.00E-03	4.51E-04	1.22E-05
LI+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MG+2	1.84E-04	7.07E-06	3.44E-08	3.50E-08	2.30E-02	8.00E-03	1.70E-02	1.30E-02	2.30E-02	1.00E-02	2.91E-04
MN+2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MN+4	3.78E-01	4.23E-01	2.00E-03	2.00E-03	2.10E-02	1.40E-02	3.10E-02	2.40E-02	2.30E-02	2.40E-02	6.70E-04
MNO2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
MO+6	1.02E-06	3.91E-08	1.90E-10	1.94E-10	6.19E-11	2.05E-11	4.68E-11	1.00E-03	4.22E-05	5.32E-05	1.51E-06
NA+	1.80E-02	6.77E-04	3.29E-06	3.03E+01	1.04E+01	3.43E+00	7.83E+00	7.45E+00	3.37E+00	1.79E+00	2.37E-01
NB+5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NI+3	7.80E-01	1.42E+00	6.70E-02	6.80E-02	2.40E-02	8.00E-03	1.80E-02	1.00E-03	2.00E-03	2.23E-01	2.20E-02
NI2FECN6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
NO2-	2.00E-03	6.03E-05	2.94E-07	2.99E-07	9.55E-08	2.80E-01	6.39E-01	4.40E-02	4.91E-01	1.02E-01	3.00E-03
NO3-	4.00E-03	1.42E-04	6.92E-07	7.05E-07	2.25E-07	7.45E-08	1.70E-07	1.16E-08	6.27E-01	2.12E-01	6.00E-03
OH-	1.97E-05	7.60E-07	3.70E-09	3.76E-09	1.20E-09	3.98E-10	9.08E-10	6.19E-11	4.52E-01	8.80E-02	3.00E-03
P2O5:24WO2:44H2	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
PB+4	2.00E-02	4.25E+00	2.10E-02	2.10E-02	7.00E-03	3.00E-03	8.00E-03	5.14E-04	3.02E-04	2.00E-03	4.92E-05
PO4-3	2.00E-03	8.21E-05	4.95E+00	5.04E+00	1.68E+00	6.66E-01	1.52E+00	1.04E-01	1.02E-01	1.47E-01	2.40E-02
PU+4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RB+	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
RE+7	2.67E-09	1.03E-10	5.00E-13	5.09E-13	1.63E-13	5.38E-14	1.23E-13	8.38E-15	1.77E-08	1.36E-07	3.87E-09
RH+3	2.46E-06	9.47E-08	4.61E-10	4.69E-10	1.50E-10	4.96E-11	1.13E-10	7.71E-12	1.63E-05	1.25E-04	3.56E-06
RU+3	5.93E-08	2.28E-09	1.11E-11	1.13E-11	3.62E-12	1.20E-12	2.73E-12	1.86E-13	3.93E-07	3.02E-06	8.59E-08
SB+5	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SE+6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SI+4	2.01E-01	1.82E+01	6.78E-01	2.98E+00	9.71E-01	3.21E-01	7.33E-01	1.72E-01	3.30E-02	5.60E-02	2.00E-03
SM+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SN+4	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
SO4-2	1.85E-04	7.11E-06	5.97E+00	6.08E+00	1.94E+00	6.43E-01	1.47E+00	5.15E-01	4.20E-02	6.40E-02	1.40E-02
SR+2	5.53E-06	2.13E-07	1.04E-09	1.05E-09	3.37E-10	1.11E-10	2.54E-10	5.55E-04	5.56E-05	2.82E-04	8.02E-06
TE+6	3.30E-08	1.27E-09	6.18E-12	6.30E-12	2.01E-12	6.65E-13	1.52E-12	1.04E-13	2.21E-07	1.68E-06	4.78E-08

Table 3.4-9. Private Contractor 2 Batches. (Sheet 5 of 5)

Table 3.4-9. Private Contractor 2 Batches (5 Sheets)

Envelope	A	A	A	A	B	C	C	C	C	C-west	C-west
Stream	8	16	24	32	7	8	10	18	26	24	27
	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles	kg-moles
TH+4	6.14E-05	2.36E-06	1.15E-08	1.17E-08	3.74E-09	1.24E-09	2.82E-09	1.92E-10	4.06E-04	3.00E-03	8.88E-05
TI+4	1.65E-05	6.35E-07	3.09E-09	3.15E-09	1.01E-09	3.32E-10	7.58E-10	5.17E-11	1.09E-04	8.39E-04	2.39E-05
TL+3	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.35E-07	5.61E-09	1.50E-10
TOC	6.97E+01	1.11E+02	2.86E+01	3.63E+01	1.16E+01	3.84E+00	8.77E+00	5.98E-01	1.58E-01	5.18E-01	1.50E-02
UNKNOWN	1.00E-03	4.58E-05	1.09E+02	1.11E+02	3.54E+01	1.17E+01	2.67E+01	1.82E+00	4.78E-01	2.00E-02	5.29E-04
UO2+2	4.05E-01	8.50E-01	4.00E-03	4.00E-03	1.00E-03	4.45E-04	1.00E-03	1.50E-02	7.42E-04	1.30E-02	4.50E-02
V+5	1.61E-06	6.19E-08	3.01E-10	3.07E-10	9.80E-11	3.24E-11	7.40E-11	5.04E-12	1.06E-05	8.18E-05	2.33E-06
W+6	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
ZN+2	3.95E-05	1.52E-06	7.40E-09	9.00E-02	2.90E-02	9.00E-03	2.20E-02	5.00E-03	4.19E-04	2.00E-03	5.00E-03
ZR+4	1.83E-05	1.56E-01	7.59E-04	7.73E-04	2.47E-04	8.17E-05	1.86E-04	1.50E-02	8.12E-04	9.59E-04	1.00E-02
ZRO2:2H2O	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Solids (gal)	282	686	1581	1687	544	186	426	51	25	43	23
Start	7/14/01	1/9/03	10/2/03	5/7/04	3/20/05	7/16/05	8/13/05	12/27/05	8/24/06	3/19/07	1/19/08
End	7/17/01	1/12/03	10/6/03	5/10/04	3/21/05	7/17/05	8/15/05	12/31/05	8/27/06	3/23/07	1/22/08

[a]The PHMC Contractor will revise the feed staging plans to include the staging and delivery of the additional Envelope A feed needed to meet the minimum order quantities by either blending of existing Envelope A feed with near-Envelope A feed or by shimming near-Envelope A feed with caustic to adjust the analyte:sodium ratios. Additionally, the DOE/WIT are working on refined LAW feed envelopes that will reclassify a significant quantity of Envelope C waste as Envelope A. If this is done, the delivered quantity of Envelope A may be as large as 9,200 MT Na.

3.4.3 Project Hanford Management Contractor High-Level Waste Feed Preparation

A detailed schedule of feed pretreatment operations was provided in Section 3.2. Pretreatment entails washing the sludges in three tanks (241-AZ-101, 241-AZ-102, and 241-AY-102), and any additional sludges that are currently being identified to make up the maximum order quantity. The intent of this section is to elaborate on the characteristics and chemical behavior of the sludges, and the equipment that has been proposed for mobilization and washing.

3.4.3.1 Retrieval, Washing and Transfer Equipment for Phase I High-Level Waste Sludges. The primary processing equipment includes mixer pumps, decant pumps, and transfer pumps. Project W-151 installs the mixer pumps in 241-AZ-101. Project W-211 and some expense funding installs all other equipment. Similar systems are recommended for 241-AZ-102 and 241-AY-102. In-tank processing equipment and instruments are depicted in Figure 3.4-6.

Mixer Pumps. Two 300-hp mixer pumps are proposed for each of the three Envelope D sludge tanks. The number of pumps eventually installed in other tanks is subject to revision pending evaluation of the 241-AZ-101 mixer pump performance.

Decant Pumps. Each Phase I HLW tank will be equipped with a floating suction decant pump. The floating suction is tethered for retraction from the liquid while the mixer pumps are operating. The discharge of the decant pump can be diverted back to the tank It is assumed that the supernatant can be pumped down to 0.25 m (10 in.) above the settled sludge/liquid interface. This leaves approximately 105 m^3 (27,500 gal) of supernatant liquid in addition to the interstitial liquid within the settled sludge.

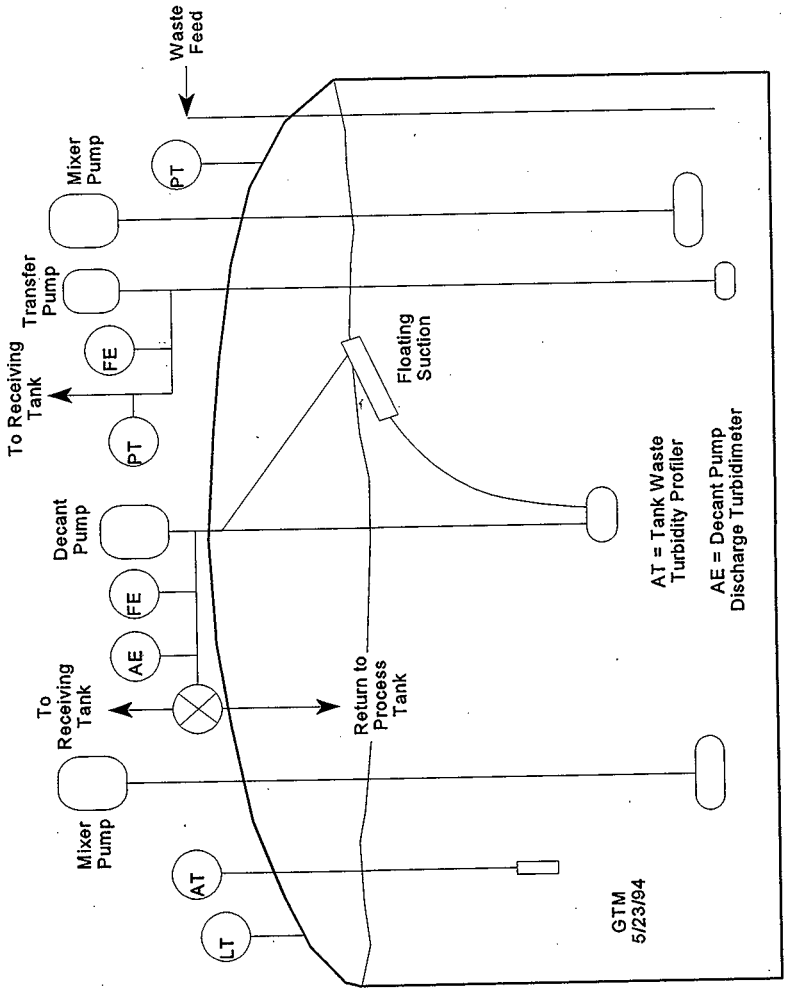
Transfer Pumps. A transfer pump is outfitted into each tank for the slurry transfers of HLW batches to the Private Contractor feed tanks. This pump operates in conjunction with the mixer pumps to keep the solids in suspension during the transfer.

Other Processing Equipment. Instrumentation and process control equipment has been designed for and installed into tank 241-AZ-101. If this proves to be sufficient, a similar set of equipment is proposed for installation into tanks 241-AZ-102 and 241-AY-102 for Project W-211. Additional detail regarding the DST in-tank sludge processing equipment can be found in *Tank Processing of Hanford Wastes* (MacLean 1995).

Routing. A study (Galbraith et al. 1996) has recommended the routing to be used for HLW staging (see Appendix H, Figure H-2).

3.4.3.2 Physical Characteristics of Phase I High-Level Waste Sludges. The sludge physical characteristics of primary interest are the shear strength, particle density and particle size. Shear strength relates to the efficiency of sludge mobilization, while particle density and size relate to the suspendability of the slurry.

Figure 3.4-6. In-Tank Processing Equipment and Instruments.



Mobilization. Truly accurate shear strength measurements are difficult to obtain because in-situ measurement of shear strength is not a current capability. Sampling and sample extrusion disturb the sludge, affecting the shear strength. The measured shear strength of extruded Phase I sludges is reported in Table 3.4-10. The variability of shear strength within a given segment and from segment to segment is apparent. The variability probably reflects differences in the extent to which the sample was disturbed during sample preparation, and also the fill history of the tank.

Simulant studies reported in 1995 (Powell et al. 1995) attempted to correlate the effective cleaning radius (ECR) of a mixer pump with various sludge properties including shear strength, sludge cohesion, sludge yield strength, tensile strength and other properties. Since measured shear strength is available for Phase I sludges while other properties are not, the shear strength correlation has by default become the basis for estimating mixer pump effectiveness. The referenced work acknowledges that "resistance of ... simulants to the mobilizing action of mixer pump jets was not found to adequately correlate with simulant vane shear strength."

Consequently, projections of mobilization based on shear strength must be regarded with skepticism. This should not be construed to mean that mixer pumps will not work. However, given the apparent variability of shear strength in sludge layers, the difficulty of measuring it, and the poorness of the experimental correlation between ECR with shear strength, the current method for projecting the ECR of mixer pumps is very imprecise.

There is reason to believe that Powell's ECR correlation is intentionally conservative to accommodate the scatter in the experimental data. Based on the ECR correlation, Grams (1995) calculated the percent of tank sludge that can be mobilized with a two-mixer pump system. The results at four levels of shear strength are provided in Table 3.4-12. Considering all the caveats, the fullscale mobilization test (Project W-151) will be very important for demonstrating the actual capability of mixer pumps.

Suspendability. For the purpose of determining whether sludges can be suspended uniformly by liquid agitation, particle density and size are the most significant characteristics. *Lange's Handbook of Chemistry* (Lange 1979) shows the density of goethite (iron(III) hydroxide oxide) as 4.28. Actual particle density has not been measured in any sludge. However, the calculated particle density of 3.8[1] can be deduced from other physical measurements of 241-AZ-101 sludges. This is consistent with the presence of a lower-density gibbsite phase in the high-iron 241-AZ-101 solids. Other Phase I solids containing appreciable concentrations of aluminum have calculated densities lower than 241-AZ-101 solids, as expected. Therefore, 3.8 is a reasonable density for evaluating the suspendability of solids.

[1]ESP calculates a similar density for 241-AZ-101 solids.

Table 3.4-10. Shear Strength of Phase I Sludges.

Sample	Shear strength (dynes/cm^2)	Temperature (°C)
241-AY-102 Segment 1R top Segment 1R middle Segment 1R bottom	 53,600 16,700 21,700	 35 35 35
241-AZ-101 First Core Sample	2,100 and 2,600	28 and 28
241-AZ-101 Second Core Sample	15,000	30
241-AZ-102 Segment 1	15,400 and 13,140	31 and 31
241-AZ-102 Segment 2	26,500	31

Table 3.4-11. Effective Cleaning Radius and Mobilization Using Two Mixer Pumps.

Shear strength (dynes/cm^2)	Effective cleaning radius (m)	% mobilized
7,000	12.5	99
14,000	7.9	75
28,000	4.9	36
70,000	2.7	11

A composite of the second 241-AZ-101 core was analyzed on the Brinkman Model 2010 particle size analyzer (1) as-is, and (2) after washing. Table 3.4-12 shows the mean particle diameter on a volume and population basis. There was essentially no difference between unwashed and washed solids. The Brinkman instrument registered few 241-AZ-101 particles bigger than 13 microns, and 90 percent (by population) were less than 2 microns. The same samples were analyzed again after six weeks, yielding essentially the same results.

Table 3.4-12. Mean Particle Diameter.

Sample	Volume basis (microns)	Population basis (microns)
241-AZ-101 (as-is)	5.3	1.2
241-AZ-101/241-AZ-102 (as-is)	8.5	0.3
241-AZ-101 (washed)	4.6	1.1
241-AZ-101/241-AZ-102 (washed)	9.0	0.4
241-C-106 (as-is)	10.6	0.2
241-C-106 (washed)	5.6	0.2

A composite of 241-AZ-101 and 241-AZ-102 sludge was analyzed on the Microtrac[1] X100 particle size analyzer (1) as-is, and (2) after washing. There was essentially no difference between unwashed and washed solids. Particles ranged in size from 0.2 to 50 microns (Rapko and Wagner 1997). The results are in Table 3.4-12.[2].

Tank 241-C-106 grab samples were analyzed with a Microtrac X100 particle size analyzer. Particles up to 75 microns were found, but by population, virtually all the particles were less than 1 micron. On a volume basis, it appears that washing may have broken down some of the larger particles but, on average, 241-C-106 is very similar to 241-AZ-101.

As an engineering rule-of-thumb, solids that have a terminal velocity less than 10 ft/min (0.17 ft/s) can be suspended with reasonable uniformity by liquid agitation (McCabe and Smith 1976). Liquid agitation should therefore be capable of suspending 3.8 SpG, 100 micron particles (terminal velocity of 0.06 ft/s) or even 200 micron particles (terminal velocity 0.12 ft/s). Most of the sludge material is considerably smaller.

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[1]Microtrac is a tradename of Leeds and Northrup, North Wales, Pennsylvania.

[2]The particle size of the first 241-AZ-101 core was analyzed on the HIAC/ROYCO™ particle size analyzer. Particles between 5 and 225 micron are measured by the apparatus. By far, most of the particles fell within the 11.4 to 13.5 micron range on a population (95 percent) and volume (75 percent) basis. Virtually nothing was found below this range, suggesting that the solids were not completely deagglomerated.

3.4.3.3 Liquid-Solid Behavior of Phase I High-Level Waste Sludges. The following discussion pertains to the current base case HLW pretreatment scenario which is washing Phase I HLW sludge with water (or dilute caustic). The two aspects of solid-liquid behavior pertinent to calculating the Phase I material balance are (1) the initial partition of tank contents between liquid and solid phases before washing, and (2) the extent of thickening achieved by in-tank gravity settling.

The initial partition is provided by modeling tank contents with ESP (MacLean 1997). Experimental laboratory- and bench-scale studies provide a cross check on ESP modeling, and insight into slurry settling and thickening behavior (Lumetta et al. 1996, Brooks et al. 1996, Brooks et al. 1997, Rapko et al. 1997).

While simple washing of Phase I sludges is the base case, the ESW scenario is nonetheless worth discussing as an alternative to the base case because of the potential for making less IHLW. ESP computer simulations of Phase I caustic leaching and washing were completed and compared with the results of actual leaching experiments (MacLean 1997).

The initial ESP partition of waste into liquid and solid phases is the starting point for both simple washing and ESW pretreatment modeling.

Solubility of Sludge Components. The best-basis inventory of the tanks (241-AZ-101, 241-AZ-102, and 241-AY-102 including waste retrieved from 241-C-106) does not come distributed into liquid and solid phases. Consequently, the best-basis inventory is modeled with ESP to determine the initial partition (MacLean 1997). This initial partition can be seen in the Appendix E material balance for Phase I pretreatment.

Subsequent dissolution of solids in base case sludge washing is limited to sodium oxalate, a major constituent which dissolves readily at low sodium concentration. For the base case sludge washing scenario, the initial partition essentially defines the residual solids composition because the physical separations (dilution, settling and decanting) predominantly affect the concentration of the interstitial liquid rather than the composition of the residual solids.

The effectiveness of ESW on Phase I sludges has been shown by two methodologies. First, the entire ESW process has been modeled by ESP starting with the initial partition mentioned above. Second, the composition and amount of residual solids has been extrapolated from experimental ESW results. Agreement between the modeled and experimental residual solids is good (MacLean 1997).

From the ESP modeled results it is possible to derive a leach factor (i.e., the fraction of the initial solids that is subsequently removed by caustic leaching). Table 3.4-13 lists the effective leach factors derived from ESP modeling. Note that the Al leach factor for amphoteric aluminum is very high. Relatively non-leachable aluminosilicates carried by the ESP model, which account for most of the residual aluminum, are also indicated in the table.

Table 3.4-13. Leach Factors Derived from Environmental Simulation Program Modeling of Enhanced Sludge Washing.

Component	241-AZ-101	241-AZ-102	241-AY-102/ 241-C-106 blend
Al (as Gibbsite)	0.99	1.00	1.00
Total Ca	0.00	0.00	0.00
C_2O_4 (as sodium oxalate)	1.00	1.00	1.00
Total CO_3	0.00	0.00	0.00
Cr (III)	0.00	0.00	0.004
F (as sodium fluoride)	0.00	0.99	NA
Fe	0.00	0.00	0.00
La	0.00	0.00	0.00
Mn	0.00	0.00	0.00
Total Na	0.98	0.35	1.00
Ni	0.00	0.00	0.00
OH	0.43	0.46	0.37
Pb	0.00	0.01	0.00
PO_4	0.00	0.00	0.35
Pu	0.00	0.00	0.00
Sr	0.00	0.04	0.04
UO_2	0.00	0.00	0.00
Zr	0.00	0.00	0.007
$KAlSiO_4$	0.20	0.12	0.00
$NaAlSiO_4$	0.00	0.00	0.03

NA = No data available.

Experimental ESW data are now available for a composite of 241-AZ-101/241-AZ-102 core samples and a composite of 241-C-106 grab samples. ESW testing on 241-AY-102 has not been completed, but 241-AY-102 sludge does not represent a large fraction of the combined 241-C-106/241-AY-102 feed (See Section 3.3.2.4 for additional clarification on this

point). The results of these tests are summarized in Table 3.4-14. The standard ESW test is by no means optimized for a particular sludge. More than likely, chemical usage can be diminished and solubility can be improved by tuning conditions for specific sludges.

Table 3.4-14. Enhanced Sludge Washing Results for Phase I Sludges. (2 Sheets)

Component	AZ-type waste (percent)[a]	241-C-106 waste lab-scale (percent)[b]	241-C-106 waste bench-scale (percent)[c]
Al	80	47	31
Cr	60	32	49
P	63	68	35
Ag	16	<9	0 to 1
As	30	NA	NA
B	13	NA	83
Ba	0	<2	<2
Be	100	NA	NA
Bi	100	<33	2 to 11
Ca	12	<5	<4
Cd	2	<14	<10
Ce	0	<14	NA
Co	0	NA	NA
Cu	0	NA	16 to 18
Fe	0	0	0
K	69	20	NA
La	0	<23	NA
Mg	0	<11	<5
Mn	0	<2	<1
Mo	100	NA	NA
Na	NA	61	57
Nd	0	<13	<15
Ni	1	<2	0 to 2

Table 3.4-14. Enhanced Sludge Washing Results for Phase I Sludges. (2 Sheets)

Component	AZ-type waste (percent)[a]	241-C-106 waste lab-scale (percent)[b]	241-C-106 waste bench-scale (percent)[c]
Pb	12	6	8 to 9
Pd	100	NA	NA
Rh	100	NA	NA
Ru	0	NA	NA
Sb	100	NA	NA
Se	100	NA	NA
Si	30	9	7
Sn	100	<22	NA
Sr	0	<24	<17
Te	100	NA	NA
Ti	0	<4	<2
U	19	91	NA
V	100	NA	NA
W	100	NA	NA
Y	0	NA	NA
Zn	34	<35	NA
Zr	0	1	3 to 5

NA = Not available
[a]Rapko and Wagner 1997
[b]Lumetta et al. 1996
[c]Brooks et al. 1997.

The 241-AZ-101/102 ESW test (Rapko and Wagner 1997) departed somewhat from the standard test format. The initial 3*M* hydroxide leach was approached stepwise with two step increases in hydroxide, followed by a step increase in leachate to sludge ratio, followed by two more step increases in hydroxide. At each step, the slurry digested for 5 hours at 80 °C, amounting to 25 hours of digestion before the first 3*M* leach was completed. This liquor was then decanted and the second 3*M* leach was completed with fresh caustic. The test, therefore, evaluated the effectiveness of leaching at free hydroxide concentrations other than the standard 3*M*.

Analysis of the 241-AZ-101/102 data shows that virtually all of the sludge dissolution occurred during the initial caustic leach. The first step of the initial leach (0.2*M* free hydroxide) is where most of the chromium went into solution, suggesting Cr(VI). An additional amount went into solution in the second step (1*M* free hydroxide), but subsequent steps dissolved no additional chromium. About 60 percent of the chromium was in solution after the test.

Aluminum and phosphate solubility both increased dramatically in the second step (1*M* free hydroxide) of the initial leach. Beyond the second step, increasing the leachate to sludge ratio and the free hydroxide had small but measurable effects. The initial leach put 75 percent of the aluminum and 60 percent of the phosphate into solution. The second leach dissolved an additional 5 percent of the aluminum and 3 percent of the phosphate. Overall, 80 percent of the aluminum and 63 percent of the phosphate went into solution.

Tank 241-C-106 sludges were leached under standard test conditions (Lumetta et al. 1996) and in conjunction with bench-scale washing, settling and thickening studies (Brooks et al. 1997). These results are provided in Table 3.4-14.

The composition analyses of the 241-C-106 composite for the lab-scale testing and bench-scale testing yielded results that were considerably different in certain components. There were likewise differences between lab-scale and bench-scale pertaining to analytical mass recovery and leaching conditions. In spite of the differences in certain particulars, the net results (i.e., the residual sludge) of lab-scale and bench-scale caustic leaching were quite similar.

Solids in Gravity--Settled Sludges. One of the key process parameters for calculating material balances is the weight percent solids in settled sludges. This parameter determines how much interstitial liquid is present, and consequently drives the extent of washing required to achieve the desired interstitial concentration.

To obtain settling and thickening data that is scalable, standard wastewater examination methods recommend larger-than-laboratory scale tests in 10-cm-diameter, 1-m-tall columns (Greenburg 1992). Settling and thickening phenomenon are hindered by wall effects in laboratory-scale experiments, so lab results are often misleading. Leaching and washing behavior can also be examined at this larger bench-scale.

Bench-scale settling and thickening results are currently available for two SST sludges: 241-C-107 and 241-C-106 (Brooks et al. 1996a; Brooks et al. 1996b). Tank 241-C-107 sludge is high in iron, and may therefore bear some similarity to AZ sludges. Tank 241-C-106 is one of the Phase I sludges. Experiments were conducted with sludge samples of 800 grams and 3,000 grams, respectively.

Settling and thickening results for 241-C-107, shown in Table 3.4-15, depend on the stage of the process (retrieval versus caustic leaching versus washing), starting solids concentration (5.3 to 9.3 wt%), and temperature (27 to 85 °C). Trends are consistent with the changes in density and viscosity of the liquid one would expect for each set of conditions. It is significant that even at this bench-scale where sludge columns were typically less than 10 cm tall, final compaction usually was 20 wt% solids or greater.

Table 3.4-15. Tank 241-C-107 Sludge Settling and Thickening Results.

Enhanced sludge wash step	Initial wt % solids	Temp. (°C)	Half/all	Settling rate (cm/h)	Final compaction (vol%)	Final compaction (wt%)
Retrieval	7.6 (9.4)	85	All	4.1	36	20 (24)
Caustic 1	5.4	85	All	15.5	24	21
Caustic 2	5.5	85	Half	10.4	22	23
Caustic 2	5.8	85	All	9.1	21	21
Caustic 2	8.7	27	All	1.0	43	18
Caustic 2	8.8	85	Full	4.6	43	20
Wash 1	5.7	50	All	11.7	20	25
Wash 2	5.4	50	Half	16.0	21	24
Wash 2	5.7	50	All	12.9	19	25
Wash 2	5.5	27	All	7.6	18	23
Wash 2	9.3	50	All	7.4	33	25

aBrooks based his weight percent solids on the final leached solids rather than the actual solids, i.e., the final leached solids divided by the mass of sludge present at each step. Therefore, the actual weight percent solids is slightly higher, as indicated by the numbers in parentheses.

Using bench-scale data, Brooks also simulated full-scale settling and thickening of 241-C-107 sludge out to 800 hours (33 days) with a computational sedimentation model. The results of the simulation are shown in Table 3.4-16. For the caustic leach step, the solids were still thickening at 800 hrs, but 20 wt% solids was reached in 17 and 28 days for slurries that were initially 5 wt% and 10 wt%, respectively. For the washing steps, compaction reached equilibrium in 3 and 5 days, respectively.

Comparable experimental results were obtained for bench-scale settling and thickening of 241-C-106 sludge. The most important conclusions to be derived from this bench-scale work are that (1) solids thickening to 20 wt% or greater in full-scale processing is reasonable, and (2) the desired degree of thickening occurs within an acceptable period of time.

Table 3.4-16. Simulation of C-107 Sludge Settling and Thickening.

Enhanced sludge wash step	Initial wt% solids	Temp. (°C)	Settling rate (cm/h)	Compaction (vol%)	Compaction (wt%)	@ days
Caustic	5	85	15.1	10.3	20	17
Caustic	10	85	3.5	10.3	20	28
Wash	5	50	15.0	16.7	33	3
Wash	10	50	6.4	18.1	35	5

Historically, material balance calculations for in-tank gravity thickening and washing have assumed that settled sludge layers are 20 wt% solids. The bench-scale thickening results confirm that this is a reasonable if not somewhat conservative basis for the Phase I sludges.

3.4.3.4 Tabulation of Phase I High-level Waste Batches. The following pretreatment flowsheet has been developed for the preparation of the HLW feeds for delivery to the Privatization Contractors. A schedule for each of these waste transfers was presented in Section 3.2.2.1. This section summarizes the "Base Case" HLW feed preparation flowsheet (i.e., washing with water).

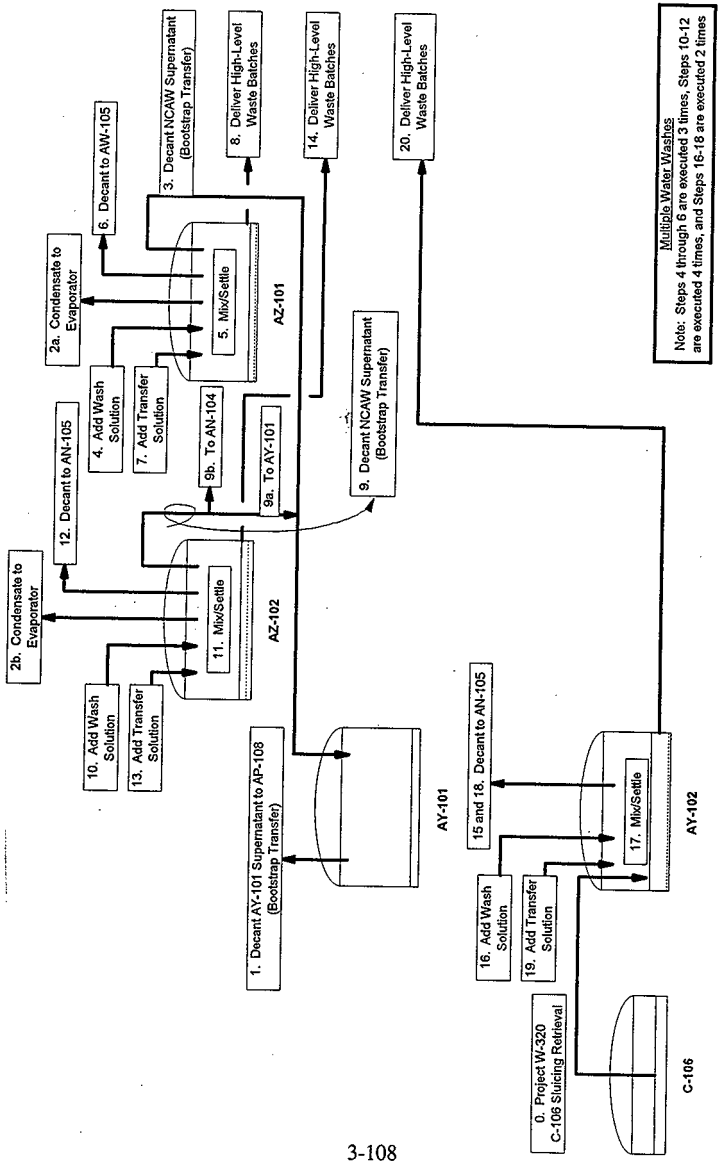
The streams in Figure 3.4-7 are numbered chronologically, beginning with Stream #0, the sluicing retrieval of 241-C-106 into 241-AY-102. For simplicity, although some of the processing steps may actually overlap, as depicted in the schedule provided in Table 3.2-3, the steps are shown in the process flow diagram as occurring in series. The 3 DSTs are processed in the following sequence: 241-AZ-101 --> 241-AZ-102 --> 241-AY-102/241-C-106.

The flow diagram integrates aspects of the in-tank retrieval test (Project W-151), the SST retrieval demonstration project (Project W-320), and waste consolidation activities (Bacon 1996), as appropriate.

The initial distribution of each tank into aqueous species and solid species was derived from ESP modeling (MacLean 1997) of the best-basis inventory (except 241-AY-102, which was based on the core sample of the sludge and a grab sample of the liquid, no best-basis inventory being available for this tank).

Tank 241-AZ-101 Sludge Pretreatment Process Summary. It is assumed that the supernatant in 241-AZ-101 is in-tank concentrated to the 5*M* sodium limit (Stream #2a). It is also assumed that prior to any transfer of solids or supernatant, the solids have already been mobilized as part of the Project W-151 mixer pump testing. Mobilization of the solids results in a 20 wt% insoluble solids layer, after 30 days of settling.

Figure 3.4-7. Phase I High-Level Waste Pretreatment and Feed Staging.



After the supernatant from 241-AY-101 is decanted (Stream #1, "Bootstrap Transfer"), the supernatant from 241-AZ-101 is decanted down to 0.25 m (10 in.) above the solids level, and routed into tank 241-AY-101 (Stream #3, "Bootstrap Transfer"). The 241-AZ-101 sludge is subsequently washed three times (Streams #4, #5, and #6 repeated 3 times) with dilute caustic solution (0.1*M* NaOH and 0.01*M* $NaNO_2$). The wash solutions are added in a 1:1 dilution ratio with the settled solids volume to minimize the volume and the impact on DST storage space.

The decanted wash solutions (Streams #6a, b, and c) from 241-AZ-101 are sent to 241-AW-105 to be later evaporated. Staging of liquids to the evaporator is not shown, but is modeled in the HTWOS simulation.

In the final step for 241-AZ-101, enough transfer solution (Stream #7) is added to the tank to dilute the solids to the maximum slurry concentration of 100 g/L waste oxides. The slurry is transferred to the HLW immobilization facility in two batches (Stream #8).

Tank 241-AZ-102 Sludge Pretreatment Process Summary. For 241-AZ-102, it is also assumed that the supernatant is in-tank concentrated to the 5*M* sodium limit (Stream #2b). However, instead of the evaporation step being followed by sludge mobilization (mixer pump testing), the supernatant is decanted (Stream #9) to 0.25 m (10 in.) above the sludge, and the tank is refilled with wash solution (Stream #10) in a 1:1 dilution ratio with the settled solids volume. The solution from the initial decant is split between tank 241-AY-101 (i.e., Stream #9a is combined with Stream #3 in 241-AY-101) and tank 241-AN-104 (Stream #9b). Approximately two-thirds of the initial decant can be stored in the remaining space available in 241-AY-101.

The sludge is washed four times with dilute caustic solution (Stream #10a,b,c,d) in a 1:1 dilution ratio with the settled solids volume. Decanted wash solutions (Stream #12a,b,c,d) are sent to 241-AN-105. Transfer solution (Stream #13) is added to achieve a 100 g of waste oxides/L slurry, and the slurry is transferred to the HLW immobilization facility in four batches (Stream #14a, b, c, d).

Tank 241-AY-102/241-C-106 Sludge Pretreatment Process Summary. Based on the current Project W-320 schedule, 100 percent of 241-C-106 is assumed to be present in 241-AY-102 before the start of pretreatment. After the retrieval of 241-C-106, the supernatant is decanted (Stream #15) down to 0.25 m (10 in.) above the settled solids layer. The wash solution (Stream #16a, b) is 1 times the settled solids volume and requires two washes.

The wash solutions (Stream #18a,b) resulting from these pretreatment steps, including the initial decant, are routed to 241-AN-105. Transfer solution (Stream 19) 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 batches (Stream 20a, b, c, d, e) to the Private Contractor.

The potential limitations of mixer pump retrieval technology were discussed in Section 3.4.3.2. One may refer to that section to get an idea of the relative difficulty of mobilizing Phase I sludges. The material balance (see Appendix E) for Figure 3.4-7, however, assumes that the sludges are completely mobilized. Therefore, the material balance indicates the maximum amount of sludge that could be processed from the three source tanks.

The primary deficiency of the HLW pretreatment simulation is that all soluble species are assumed to be in solution initially. No further dissolution (except sodium oxalate) occurs during water washing (i.e., water washing removes interstitial solutes by simple dilution). Consequently, the results of this water washing simulation are highly dependent on the initial tank inventory being correctly partitioned between liquid and solid phases. More rigorous ESP simulations of Phase I enhanced sludge washing have been completed (MacLean 1997), but ESP simulations of water washing are not yet available.

3.4.4 Lockheed Martin Advanced Environmental Systems or British Nuclear Fuels, Ltd. Process Summary

Details of the LMAES or BNFL processes are currently not available to the PHMC. However, based on DOE-provided parameters and the amount of feed staged to the Private Contractors, the total ILAW and IHLW volume is summarized in Table 3.4-17 and 3.4-18.

Table 3.4-17. Phase I Private Contractor Low-Activity Waste Feeds and Products.

Private Contractor 1	Envelope			Total
	A	B	C	
MT Na	2,060	120	2,320	4,500
m^3 ILAW	6,560	940	7,390	14,890
Packages	2,530	360	2,850	5,740
Private Contractor 2	A	B	C	Total
MT Na	2,060	120	2,230	4,410
m^3 ILAW	6,556	940	7,100	14,600
Packages	2,531	360	2,740	5,630
Total	A	B	C	Total
MT Na	4,120[a]	240	4,550	8,900
m^3 ILAW	13,120	1,880	14,490	29,490
Packages	5,060	720	5,590	11,370

[a]The PHMC Contractor will revise the feed staging plans to include the staging and delivery of the additional Envelope A feed needed to meet the minimum order quantities by either blending of existing Envelope A feed with near-Envelope A feed or by shimming near-Envelope A feed with caustic to adjust the analyte:sodium ratios. Additionally, the DOE/WIT are working on refined LAW feed envelopes that will reclassify a significant quantity of Envelope C waste as Envelope A. If this is done, the delivered quantity of Envelope A may be as large as 9,200 MT Na.

Table 3.4-18. Phase I Immobilized High-Level Waste Summary.

Tank	Leaches	Washes	Washed oxide MT	Glass MT (wt%)
241-AZ-101	0	3	96.4	386 (25%)
	1	3	66.6	266 (25%)
241-AZ-102	0	4	161.5	646 (25%)
	1	2	114	456 (25%)
241-AY-102 (incl. 241-C-106)	0	2	193.8	775 (25%)
	1	2	152.9	612 (25%)
Sludge Washing Only			451.7	1,807
Enhanced Sludge Washing			333.5	1,334

Table 3.4-18 summarizes the equivalent washed oxides staged to the HLW Private Contractor. Per the Privatization contracts, the mass of glass is set at 25 wt% waste oxide loading and volume is determined at density of 2.66 MT/m^3.

The total IHLW production of 1,807 MT generates 1,095 DWPF canisters (1,650 kg or 0.62 m^3 per canister).

Enhanced Sludge Washing is capable of producing 334 MT of the washed oxides compared to 452 MT created by water washing.

3.4.4.1 LMAES or BNFL Intermediate Products (Low-Activity Waste Processing Only).

Reserved for future use.

3.4.5 Issues and Caveats

Reserved for future use.

3.4.6 Recommendations

Reserved for future use.

3.5 PROJECT SUPPORT SCHEDULE

Table 3.5-1 shows the need date for the various facilities, equipment or systems needed to support[1] the Phase IB of Privatization. Figure H-1 in Appendix H shows the schedule that was used to establish the need date and the projected date of first use. The baseline project completion dates are shown for comparison. The discrepancies result from either a failure to make allowances for schedule slippage and assumption changes when establishing the project schedules (see Section 3.5.1) or from project coordination issues (see Section 3.5.2). Where prudent and feasible, future revisions to the operating scenario will reflect the baseline project completion dates.

The first use of a given system or component was defined by the base case operating scenario documented in this revision of the TWRSO&UP. The need dates were then determined by adjusting the base case use date by the duration of any intervening activities on the Mid-Level Logic Diagrams. For example, the retrieval of waste from 241-AN-105 is planned to begin on March 17, 2001. There are two parallel intervening activities: (1) Degas - 60 days, and (2) TWRS Management Assessment - 60 days. Therefore, the need date for 241-AN-105's retrieval system is January 15, 2001 (60 days before the base case use date).

In most cases, the base case use date was determined from Table H-1 in Appendix H; this table lists all of the modeled waste transfers through October 2011. Exceptions are that the 241-AZ-101 mixer pump test and retrieval of the hard heel in 241-C-106 were shown to begin on their currently scheduled dates of April 30, 1998, and October 20, 2000, respectively.

3.5.1 Management of Schedule Slack

The need dates, do not reflect schedule slack. They are sensitive to changes in many assumptions (discussed in Appendix A), most notably the actual processing rates[2] and available quantities of LAW and HLW Feed. The schedule for many of the projects were based on a preliminary version of these dates. This often results in discrepancies between need dates and

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[1]Specifically, only the projects needed to support the PHMC Teams' side of the following process-related interfaces were considered:

ICD 14, Immobilized High-Level Waste (IHLW)
ICD 15, Immobilized Low-Activity Waste (ILAW)
ICD 16, ^{90}Strontium/Transuranics/Entrained Solids
ICD 19, Low-Activity Waste Feed
ICD 20, High-Level Waste Feed.

[2]These are 2.0 MT Na/day/contractor for two LAW Privatization Contractors and 0.164 MT NVOL/day for one HLW Privatization Contractor.

project completion dates. Since it is unrealistic to expect project need dates to be changed every time an assumption changes, it is recommended that fixed milestones be placed on the mid-level logic diagrams (or the corresponding P3[1] Baseline Schedule) that define when each upgrade project (or portion thereof) must be completed. A corresponding milestone should be used to "lock-in" the desired allocation of slack or assumption contingency by defining the earliest date (after the project completion milestone) that the equipment can be used. The intention is to de-couple, to a degree, the operating scenario base case use dates from project completion dates. The duration between these fixed milestones represents schedule slack that is under the control of the Disposal Program. Revisions to the project schedules or operating scenario would then be made within the constraints imposed by the fixed milestones; changes to the milestones would require formal change control approval.

A set of appropriate assumptions (e.g., higher processing rates, higher ILAW external package volume to Feed ratios, smaller quantities of available feed) and a reasonable amount of schedule slack (perhaps up to 1 year) need to be used to establish these milestones. The Disposal Program and Project W-211 are currently examining the funding and feasibility impacts on several sets of alternative assumptions.

Table 3.5-1. Need Dates for Supporting Projects. (2 Sheets)

Facility, equipment, or system	Acquisition strategy	Need date	Project baseline completion date
241-AZ-101 Mixing System	W-151	4/15/98	11/17/97
Sluicing System Upgrades (241-C-106 and 241-AY-102)	W-320	7/1/98	7/1/98
Hard Heel Removal System (241-C-106 and 241-AY-02A)	HTI	8/25/00	8/25/00
AW-Farm Jumper Manifolds	W-454	10/1/00	5/1/00
241-AP-102 and -104 Mixing/Decant/Chem Add/Dilution System	W-211	10/1/00	2/28/01[a]
241-AZ-02A Central Pump Pit Extension	W-211	8/17/00	3/31/01[b]
Transfer Lines, Jumper Manifolds and Master Pump Shutdown (Phase I)	W-314	8/17/00	5/1/00
Chemical Addition/Dilution System for AN-, AY- and AZ-Farms	W-211	8/18/00	3/31/01[b]
241-AN-105 Mixing/Decant/Chem Add-Dilution System Tie-In	W-211	1/15/01	3/31/01
241-AN-104 Mixing/Decant/Chem Add-Dilution System Tie-In	W-211	8/1/01	9/30/01

[1]Primavera Project Planner (P3) is a trademark of Primavera Systems Incorporated.

Table 3.5-1. Need Dates for Supporting Projects. (2 Sheets)

Facility, equipment, or system	Acquisition strategy	Need date	Project baseline completion date
Four Converted Grout Vaults for ILAW Disposal	W-465	7/1/02	6/3/02
Two Retrofitted IHLW Vaults for Interim Storage (CSB)	W-464	7/1/02	6/3/02
Additional ILAW Disposal Facility	W-520	4/30/05	12/30/05
241-AZ-101 Decant/Chem Add-Dilution System Tie-In	Expense	8/18/00	7/1/99
241-AZ-102 Mixing/Decant/Chem Add-Dilution System Tie-In	W-211	1/10/02	3/3/02
AW Farm TMACS	W-457	11/10/02	?
241-AW-101 Mixing/Decant/Chem Add/Dilution System	W-211	11/9/02	12/31/02
241-AN-103 Mixing/Decant/Chem Add-Dilution System Tie-In	W-211	8/3/03	5/31/03
241-AY-101 Decant System	Expense	5/15/04	-
241-AN-107 [Mixing ?]/Decant/Chem Add-Dilution System Tie-In	W-211	3/20/05	10/31/03
241-AY-102 Mixing/Decant/Chem Add-Dilution System Tie-In	W-211	3/26/05	5/31/04
241-AN-102 [Mixing]/Decant/Chem Add-Dilution System Tie-In	TBD	8/13/05	-
241-AN-106 Mixing/Decant/Chem Add-Dilution System Tie-In	TBD	12/18/05	-
241-SY-102 Mixing/Decant/Chem Add/Dilution System	W-211	1/1/06	9/30/05
241-SY-101 [Mixing?]/Decant/Chem Add/Dilution System	TBD	1/31/06	-
241-SY-103 Mixing/Decant/Chem Add/Dilution System	TBD	6/15/06	-

HTI = Hanford Tank Initiative

[a]Project W-211's scheduled completion date was changed from October 1, 2000, to February 28, 2001, after the base case operating scenario was established. This was to accommodate existing resource limitations.

[b]See Section 3.5.2 for discussion of project integration issues.

3.5.2 Potential Project Integration Issues

The following potential project coordination issues were identified and are discussed in Table 3.5-2. The Disposal Program is working with the Projects to better define these issues, assess their validity, and to determine their resolution.

Table 3.5-2. Potential Project Integration Issues. (2 Sheets)

ID[a]	Acquisition strategy[b]	Issue
4	-	During the mixer pump test in 241-AZ-101, the NCAW supernate and sludge will be mixed together and then allowed to separate. The NCAW supernate, as it currently sits in 241-AZ-101, is projected to meet Envelope B specifications. The issue is whether or not this test could adversely affect the composition of the NCAW supernate. See recommendation in Section 3.1.3.
7 18 19	W-211 W-314	Several projects and activities require the use of or access to the 241-AY-02A Central Pump Pit, potentially at the same time. Project W-314 will be installing new transfer lines (ID 18); Project W-211 will be installing the Chemical Addition/Dilution System for AN-, AY- and AZ-Farms (ID 19); C-106 will be conducting sluicing operations (ID 7). The issue is to insure that the use of 241-AY-02A Central Pump Pit during these upgrade, tie-in and operational activities is coordinated.
17 18	W-314 W-211	Project W-211 will be extending the 241-AZ-02A Central Pump Pit (ID 17); Project W-314 will terminate new transfer lines into this extension (ID 18). The issue is to insure that the construction schedules for these two activities coincide at the appropriate times.
15 21 24 37 40	W-211 Expense	Project W-211 will install a chemical addition/dilution system that supports retrieval systems in AN, AY and AZ-Farm (ID 15). The chemical addition/dilution system will be installed as part of the upgrades to 241-AN-105 (ID 21). One issue is to insure that when this system is installed, all of the transfer pipeline tie-ins to AN, AY and AZ-Farms are made (a matter of efficiency). The second issue is to insure that this system is in place (and tie-ins complete (ID 37)) in time to support pretreatment of sludge in 241-AZ-101 (ID 40) and retrieval of waste from 241-AN-105 (ID 21/24).

Table 3.5-2. Potential Project Integration Issues. (2 Sheets)

ID[a]	Acquisition strategy[b]	Issue
15	W-211	The PHMC Team will need to use tanks 241-AP-102 and -104 for waste management activities during the same time frame that Project W-211 is preparing them for use as intermediate feed staging tanks (ID 15). The issue is to insure that the operational use of these tanks is coordinated with the construction schedule (See § 3.1.1.2).
16 39 40	W-481 W-482	Projects W-481 (241 AY/AZ TMACS Installation) and W-482 (241-AP TMACS Installation) install new tank monitoring and control systems in their respective tank farms. The issue is if these systems (neither are shown on Figure H-1) are required or desired before beginning Phase I feed pretreatment and staging activities (ID 16, 39, 40).

[a]ID refers to the task ID on Figure H-1 in Appendix H.
[b]Acquisition strategy refers to the acquisition strategy on Figure H-1 in Appendix H.

4.0 PRIVATIZATION PHASE II

DOE's strategy for Phase II is to privatize the retrieval and treatment of all waste remaining in the tank farms after Phase I. This section documents the selected SST retrieval sequence and provides a process summary which is a high-level roll-up of the TWRS Process Flowsheet (Orme et al. 1996). The process summary features the recently completed standard inventory (Kupfer et al. 1997) and updated water solubility and leach factors (Colton 1997).

4.1 LOW-ACTIVITY WASTE PROCESSING

(Section reserved for future Phase II staging studies.)

4.2 HIGH-LEVEL WASTE STAGING

(Section reserved for future Phase II staging studies.)

4.3 SINGLE-SHELL TANK RETRIEVAL SEQUENCE

This section of the report documents the selected SST retrieval sequence for the TWRS. The disposal program retrieval sequence is a listing of the single-shell tanks showing the proposed retrieval order (sequence), and the proposed retrieval dates.

The objective of this work for FY 1997 is to update the TWRS baseline retrieval sequence, and to report the sequence to satisfy the requirements of Tri-Party Agreement milestone M-45-02B. The work performed during FY 1997 is based upon the results of the retrieval sequence studies performed during FY 1995 (Certa 1995) and FY 1996 (Penwell 1996). It is also based upon the results of the FY 1997 LAW and HLW feed staging studies described in this report, and the other major bases and assumptions described in Appendix A of this report.

The sequence is developed for several other reasons. The studies associated with development of a sequence determine the impact of program and system assumptions on the feasibility of meeting retrieval, LAW processing, and HLW processing goals and milestones. Retrieval studies also determine the effects of the blending associated with various retrieval sequences and system configurations upon the HLW glass volume. Retrieval studies determine the effects of various sequences upon the quantity of retrieval equipment which will be needed for retrieval. Also, retrieval studies determine the impact of the sequence for retrieval of SSTs upon meeting the retrieval and processing milestones.

For the studies this year, it is assumed that funding will not be available to build the waste retrieval facilities for the northern quadrants until Phase II. (See Appendix A for the detailed assumptions such as availability dates, configurations, etc.) It is assumed that the funding to

support the baseline configuration and the developed sequences is available. However, it is recognized that the level of funding needed to install equipment and retrieve the large number of tanks required to meet the Tri-Party Agreement target dates may not be available prior to Phase II. Therefore, a future sequence, which will support Phase I HLW maximum order quantity processing, will be developed that retrieves waste from fewer tanks, but retrieves tanks with larger waste volumes, and retrieves higher risk SST wastes. This case will be documented and released by September 30, 1997, as an engineering change notice to this document.

As part of the work associated with properly integrating the retrieval sequence work, and determining what studies and decisions are needed at what time, two mid-level logic diagrams have been developed and are being updated to include need dates for the required studies and projects. The diagrams are provided as Appendix F. One of the diagrams shows the logic for the Subsequent Single-Shell Tank Retrieval System (SSSTRS), which is the PHMC SST retrieval that will occur before the start of Phase II SST retrieval (before January 1, 2011). The other diagram shows the logic for Phase II SST retrieval.

4.3.1 Selected Retrieval Sequence

The selected SST retrieval sequence was chosen based on evaluation of how the resulting output fit with the development drivers described below. Using base case assumptions (see Appendix A, sections 2, 3, 4, 6, 7, 8, and 11), it does not meet the retrieval end date milestone. However, the selected sequence performs well with respect to the other evaluation criteria. It is also consistent with the tanks selected for the Initial SST Retrieval System, which is the current TWRS baseline.

The tank retrieval order was used for the TWRS baseline case for the OWVP projections. However, since the HTWOS model was not fully ready to run cases at the time that the input to the OWVP was needed, the information provided for the OWVP projections was based upon the same tank order per farm, but retrieved at hand calculated estimated rates to match hand calculated processing rates. The objective is to have the model fully integrated for the calculations performed for the FY 1998 studies.

At the assumed baseline operating conditions, this year's selected sequence completes retrieval in November 2019. This is due to changes in timing associated with the incorporation of privatization, changes in the modeled retrieval system configuration, and the changes in estimated inventory. For the retrieval sequence study, the assumed IHLW for all calculations is glass. The selected sequence results in production of 15,655 m^3 of HLW glass and is at approximately 30 percent of the no-blend/total-blend span, the difference in HLW glass production between totally blending all solids, and processing the solids of each tank individually. These results are based upon using the glass properties models, and other process assumptions as described in Appendix A, Section 7.0. The change to using the glass properties models has a dramatic impact upon the estimated amount of HLW glass produced. The glass properties model used for this study does not have a specific component limit for chromium. Instead, the chromium impact upon the glass calculations is defined by spinel production, which varies based upon the

concentrations of other components in the batch of HLW glass feed. This allows the maximum concentration of chromium in a batch of glass to vary up to approximately 4 wt% based upon the other constituents, versus the previously used component limit of 0.5 wt%, which is used for the process flowsheet during this revision of the TWRSO&UP report. Therefore, in spite of increases in the estimated chromium inventory, the glass volume is not greatly affected by the amount of chromium. Further experimental work may be needed to ensure that glass properties are being accurately predicted for typical SST HLW glass feed.

The following retrieval sequence drivers are used for sequence generation. These drivers are used to a greater or lesser extent for all simulations other than bounding cases. The emphasis placed upon each of these drivers are balanced against the other drivers as they impact achieving a certain goal.

- Retrieve any SSTs required to support the Phase I HLW feed staging. (Top priority)

- Select SSTs that contain small amounts of insoluble (after water and caustic washing) solids and small amounts of total retrieved waste for retrieval before the start of Phase I privatization period. This minimizes the downtime associated with the solids storage space, decreasing the problems encountered with ILAW facility shutdown, and decreasing the capacity of the ILAW facility needed to meet the retrieval milestone.

  A desirable secondary effect is that the number of sluicers needed is decreased by maximizing the number of tanks retrieved during Phase I, when retrieval will be slower. This effect is because a year is assumed (for removal, decontamination, repair, and reinstallation) between when a retrieval operation completes in a SST, and when that equipment is ready to be used in another SST. During Phase II, there are 10 simultaneous retrievals, versus a maximum of four during the period before Phase II starts. Therefore, the number of retrieval machines required to keep the system utilized to full capacity when retrieving tanks with short retrieval durations is much greater during Phase II when more simultaneous retrievals are occurring.

- Retrieve the waste from all AX farm tanks prior to 2011.

  Note: This must be balanced against the previous driver. Retrieval of 241-AX-101 will require approximately 8,330 m^3 (2.2 Mgal) of DST storage space, but 241-AX-101 does have a very low retrieved solids volume, which does help in avoiding solids build-up before the Phase II HLW facility starts up.

- Minimize HLW glass volume.

- Keep the LLW and HLW glass plants operating. (If the LLW and HLW glass plants are kept operating, they will complete processing as soon as possible for their capacity.

- Select tanks posing the greatest risk. (This item is not reflected in the current study, but will be considered in future studies pending input from tank closure.)

- Minimize the time required to complete retrieval of the SST waste.

- Minimize the number of sluicers required for SST retrieval.

4.3.1.1 Single-Shell Tanks. Figure 4.3-1 shows the retrieval schedule for the chosen sequence including durations for each SST. Superimposed are the Tri-Party Agreement milestones for the initiation of retrieval of the appropriate number of SSTs.

Table 4.3-1 shows the data in Figure 4.3-1 (except for the milestone dates) for the selected sequence, and includes the as-retrieved volumes of the waste from each tank. As-retrieved volumes include the minimum dilution water necessary to bring the sodium concentration down to $\leq 5M$ and the insoluble solids content down to ≤ 10 wt%.

4.3.1.2 Double-Shell Tanks. Most of the sequence for the DSTs is not as clearly defined as the SST sequence. The Phase I input from the LAW and HLW feed staging studies are incorporated into the baseline for this study.

However, the DST sequence can significantly affect the results of the study. Early sequence runs showed problems associated with washed solids accumulating and shutting down retrieval until the HLW glass plant clears up enough space to allow solids from sludge washing to be transferred to the HLW feed staging tanks. However, careful examination of the problem revealed that most of the solids processed during the first 1½ years of Phase II came from 4 DSTs that had primarily DSSF waste in them. Processing of those DSTs is delayed to prevent the solids from those tanks becoming a bottleneck. Part of the problem associated with solids in the DSTs may be that there are currently no water wash factors in the model for some of the DSTs. Therefore, none of the solids in those tanks are calculated as being dissolved when those tanks are retrieved. If any of the DSTs that are high in solids are retrieved before SST retrieval is completed, additional space must be allocated for solids storage, which will result in a short delay (the time to process one DST through pretreatment and the ILAW facility) because the waste from a tank must be processed to free the additional space for storage of washed solids.

Appendix A, section 11 describes the assumed system architecture, initial conditions and assignments for the DSTs. The waste from any DST that is assigned to receive SST waste is mixed with the incoming waste and blends into the LLW and HLW feed batches. The waste from a DST will dominate the batch if it has a significant amount of waste in it when it is designated as available for use.

4.3.2 Blending Strategy

During the FY 1995 and FY 1996, the incidental blending, which occurs without any special effort during retrieval and processing, was shown to be very effective at reducing HLW glass volumes (Certa 1995 and Penwell 1996). Since it is a form of undirected blending, it is indiscriminate; there is no precise control over blending. Small changes early in the sequence can significantly affect the fraction of waste contributed to a batch by each tank. Only incidental blending is used for the modeling work this year. No special blending studies are performed for the FY 1997 work.

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Figure 4.3-1. Cumulative Number of Single-Shell Tanks Initiated for Retrieval.

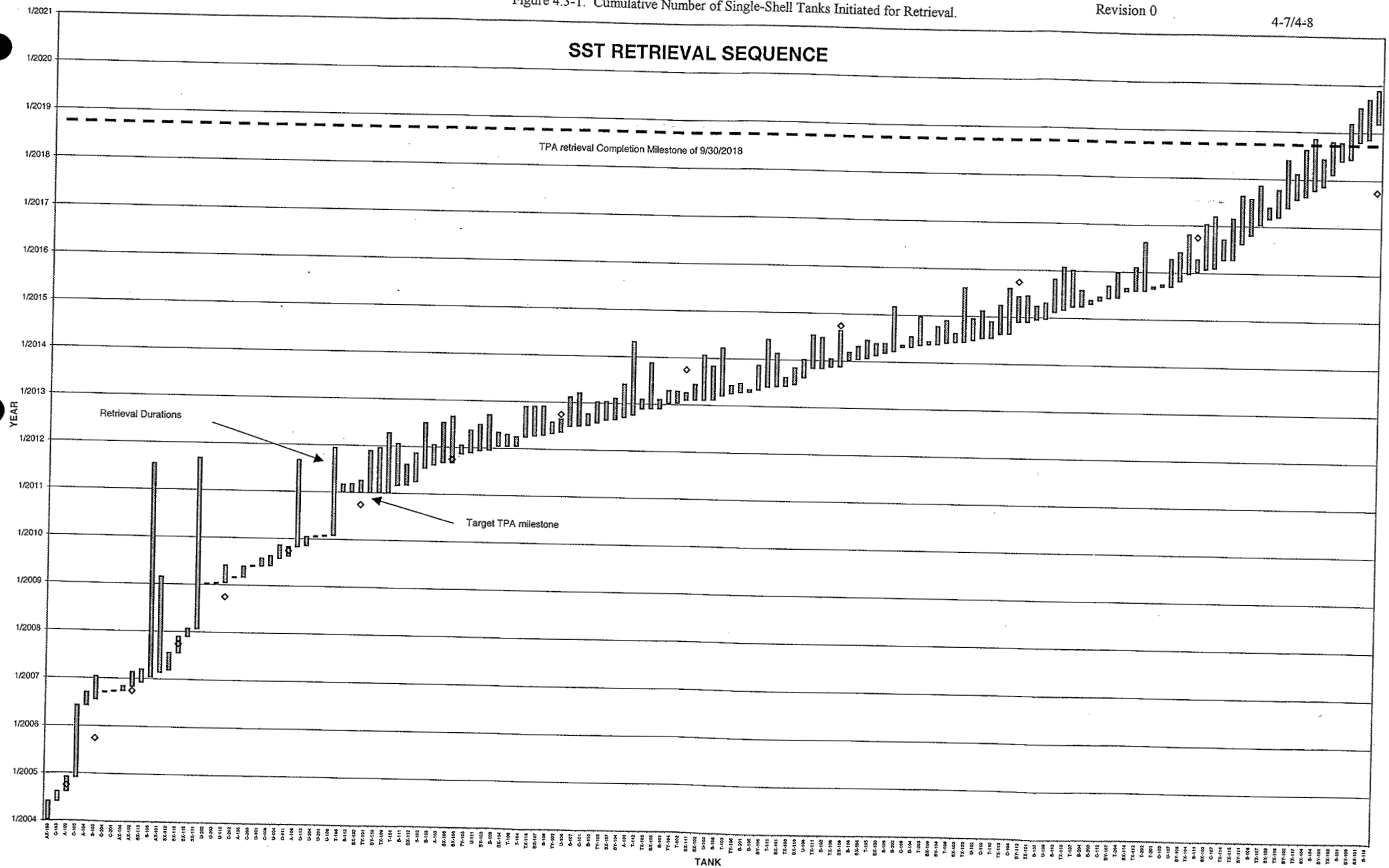

Table 4.3-1. Initial Retrieval Sequence With As-Retrieved Volumes. (5 Sheets)

Tank	Retrieval start date	Retrieval duration	Retrieval end date	Retrieved liquid vol. (gal)	Retrieved solids vol. (gal)	Total retrieved vol. (gal)
AX-103	1/10/04	140	5/29/04	315,297	2,846	318,143
C-103	5/29/04	75	8/12/04	300,973	10,424	311,397
A-102	8/12/04	110	11/30/04	102,914	744	103,658
C-105	11/30/04	554	6/7/06	923,104	31,875	954,979
A-104	6/7/06	100	9/15/06	30,152	832	30,984
S-103	7/23/06	176	1/15/07	720,237	1,011	721,248
C-204	9/15/06	7	9/22/06	3,864	55	3,919
C-201	9/22/06	6	9/28/06	2,581	59	2,640
AX-104	9/28/06	36	11/3/06	20,164	572	20,736
AX-102	11/3/06	110	2/21/07	89,508	897	90,405
SX-113	12/5/06	98	3/13/07	11,602	399	12,002
S-105	1/15/07	1647	7/20/11	1,500,000	2,459	1,502,459
AX-101	2/21/07	736	2/26/09	2,200,000	6,072	2,206,072
SX-112	3/13/07	132	7/23/07	501,737	16,406	518,143
SX-110	7/23/07	125	11/25/07	294,841	8,910	303,751
SX-115	11/25/07	62	1/26/08	52,569	1,557	54,126
SX-111	1/26/08	1318	9/5/11	626,430	19,768	646,198
U-202	1/3/09	8	1/11/09	30,853	1,061	31,914
U-203	1/11/09	6	1/17/09	15,622	538	16,160
U-110	1/17/09	134	5/31/09	331,980	10,620	342,600
C-202	2/26/09	5	3/3/09	1,236	28	1,264
A-105	3/3/09	84	5/26/09	54,524	1,545	56,069
C-203	5/26/09	7	6/2/09	6,580	151	6,730
U-101	5/31/09	60	7/30/09	29,298	668	29,966
C-108	6/2/09	77	8/18/09	125,512	3,842	129,353
U-104	7/30/09	103	11/10/09	53,292	1,221	54,512
C-111	8/18/09	73	10/30/09	211,915	7,081	218,996
A-106	10/30/09	674	9/4/11	265,391	5,796	271,187
U-112	11/10/09	69	1/18/10	190,126	6,391	196,517
U-204	1/18/10	6	1/24/10	14,658	503	15,161
U-201	1/24/10	7	1/31/10	30,855	1,061	31,916
U-106	1/31/10	680	12/12/11	661,108	1,633	662,741
T-106	1/3/11	59	3/3/11	86,288	2,929	89,217
B-112	1/3/11	65	3/9/11	74,986	1,083	76,069
BX-102	1/3/11	91	4/4/11	79,738	2,445	82,183

Table 4.3-1. Initial Retrieval Sequence With As-Retrieved Volumes. (5 Sheets)

Tank	Retrieval start date	Retrieval duration	Retrieval end date	Retrieved liquid vol. (gal)	Retrieved solids vol. (gal)	Total retrieved vol. (gal)
TY-101	1/3/11	324	11/23/11	339,257	8,418	347,675
BY-110	1/3/11	348	12/17/11	1,100,000	18,582	1,118,582
TX-109	1/3/11	465	4/12/12	1,200,000	38,750	1,238,750
T-101	3/3/11	323	1/20/12	264,066	9,170	273,236
B-111	3/9/11	159	8/15/11	392,691	11,932	404,623
BX-112	4/4/11	222	11/12/11	398,896	12,630	411,526
S-102	7/20/11	351	7/5/12	1,700,000	3,263	1,703,263
B-103	8/15/11	156	1/18/12	159,484	321	159,805
A-103	9/4/11	311	7/11/12	1,100,000	2,560	1,102,560
SX-106	9/5/11	358	8/28/12	1,400,000	2,612	1,402,612
BX-106	11/12/11	68	1/19/12	98,086	3,153	101,239
TY-105	11/23/11	175	5/16/12	237,738	6,942	244,681
U-111	12/12/11	202	7/1/12	940,269	5,014	945,283
BY-103	12/17/11	274	9/16/12	1,400,000	5,297	1,405,297
B-109	1/18/12	106	5/3/12	240,186	3,574	243,760
BX-104	1/19/12	91	4/19/12	54,710	1,260	55,970
T-109	1/20/12	73	4/2/12	164,759	310	165,069
T-104	4/2/12	236	11/24/12	1,100,000	35,439	1,135,439
TX-118	4/12/12	229	11/27/12	1,200,000	7,864	1,207,864
BX-107	4/19/12	224	11/29/12	996,293	32,591	1,028,884
B-108	5/3/12	90	8/1/12	215,864	3,382	219,246
TY-102	5/16/12	99	8/23/12	214,239	379	214,618
U-105	7/1/12	226	2/12/13	1,100,000	2,603	1,102,603
S-107	7/5/12	255	3/17/13	1,300,000	41,872	1,341,872
C-101	7/11/12	87	10/6/12	332,759	11,071	343,830
B-110	8/1/12	162	1/10/13	402,213	12,344	414,558
TY-103	8/23/12	143	1/13/13	414,450	7,772	422,222
SX-107	8/28/12	165	2/9/13	665,258	22,892	688,150
BY-104	9/16/12	258	6/1/13	1,200,000	16,378	1,216,378
A-101	10/6/12	569	4/28/14	2,800,000	5,605	2,805,605
T-112	11/24/12	74	2/6/13	82,227	2,698	84,925
TX-105	11/27/12	355	11/17/13	2,300,000	2,844	2,302,844
BX-105	11/29/12	70	2/7/13	61,370	1,485	62,855
B-101	1/10/13	99	4/19/13	246,742	5,532	252,273
TY-104	1/13/13	93	4/16/13	65,347	1,913	67,260

Table 4.3-1. Initial Retrieval Sequence With As-Retrieved Volumes. (5 Sheets)

Tank	Retrieval start date	Retrieval duration	Retrieval end date	Retrieved liquid vol. (gal)	Retrieved solids vol. (gal)	Total retrieved vol. (gal)
T-102	2/6/13	58	4/5/13	126,729	4,394	131,123
BX-111	2/7/13	122	6/9/13	673,376	4,708	678,084
SX-102	2/9/13	349	1/24/14	1,700,000	16,612	1,716,612
U-103	2/12/13	261	10/31/13	1,400,000	2,840	1,402,840
S-108	3/17/13	371	3/23/14	2,000,000	3,978	2,003,978
T-103	4/5/13	62	6/6/13	130,873	4,402	135,275
TY-106	4/16/13	69	6/24/13	23,959	700	24,659
B-201	4/19/13	18	5/7/13	66,526	2,093	68,619
B-105	5/7/13	190	11/13/13	809,777	3,220	812,997
BY-106	6/1/13	369	6/5/14	2,100,000	13,573	2,113,573
T-111	6/6/13	257	2/18/14	684,887	21,832	706,719
BX-101	6/9/13	69	8/17/13	90,776	2,810	93,586
TX-108	6/24/13	130	11/1/13	493,612	4,202	497,814
BX-110	8/17/13	142	1/6/14	490,194	15,124	505,317
U-108	10/31/13	257	7/15/14	1,300,000	8,495	1,308,495
TX-111	11/1/13	240	6/29/14	1,300,000	4,694	1,304,694
B-102	11/13/13	64	1/16/14	70,878	424	71,302
TX-106	11/17/13	280	8/24/14	1,700,000	2,766	1,702,766
BX-108	1/6/14	63	3/10/14	74,580	2,438	77,017
B-106	1/16/14	100	4/26/14	322,075	431	322,506
SX-108	1/24/14	141	6/14/14	729,485	25,101	754,586
T-105	2/18/14	92	5/21/14	173,337	5,479	178,816
BX-103	3/10/14	75	5/24/14	121,152	3,703	124,855
S-109	3/23/14	347	3/5/15	1,900,000	6,024	1,906,024
B-202	4/26/14	18	5/14/14	64,296	2,023	66,319
C-109	4/28/14	81	7/18/14	560,130	19,308	579,439
B-104	5/14/14	221	12/21/14	526,636	16,154	542,791
T-203	5/21/14	22	6/12/14	83,022	2,612	85,634
BX-109	5/24/14	138	10/9/14	1,600,000	46,760	1,646,760
BY-108	6/5/14	173	11/25/14	531,718	14,728	546,446
T-108	6/12/14	69	8/20/14	95,696	2,029	97,725
SX-105	6/14/14	422	8/10/15	2,200,000	15,350	2,215,350
TX-102	6/29/14	168	12/14/14	420,986	521	421,507
U-102	7/15/14	214	2/14/15	1,100,000	3,936	1,103,936
C-110	7/18/14	129	11/24/14	534,768	17,475	552,243

Table 4.3-1. Initial Retrieval Sequence With As-Retrieved Volumes. (5 Sheets)

Tank	Retrieval start date	Retrieval duration	Retrieval end date	Retrieved liquid vol. (gal)	Retrieved solids vol. (gal)	Total retrieved vol. (gal)
T-110	8/20/14	224	4/1/15	619,283	19,111	638,395
TX-113	8/24/14	352	8/11/15	1,900,000	21,436	1,921,436
C-104	11/24/14	198	6/10/15	1,600,000	52,466	1,652,466
BY-112	11/25/14	203	6/16/15	982,171	3,251	985,422
TX-101	12/14/14	105	3/29/15	431,600	14,567	446,167
B-107	12/21/14	124	4/24/15	472,278	15,453	487,731
U-109	2/14/15	256	10/28/15	1,300,000	8,466	1,308,466
S-112	3/5/15	331	1/30/16	2,100,000	5,197	2,105,197
TX-110	3/29/15	285	1/8/16	1,600,000	6,692	1,606,692
T-107	4/1/15	127	8/6/15	375,371	12,268	387,639
B-204	4/24/15	28	5/22/15	116,485	3,665	120,150
B-203	5/22/15	28	6/19/15	118,743	3,736	122,479
C-112	6/10/15	95	9/13/15	488,510	16,365	504,874
BY-107	6/16/15	191	12/24/15	715,527	10,088	725,615
T-204	8/6/15	23	8/29/15	90,187	2,837	93,024
SX-114	8/10/15	181	2/7/16	877,045	13,032	890,077
TX-112	8/11/15	374	8/19/16	2,400,000	5,837	2,405,837
T-202	8/29/15	15	9/13/15	49,946	1,571	51,517
T-201	9/13/15	18	10/1/15	66,526	2,093	68,619
C-102	9/13/15	214	4/14/16	2,700,000	92,173	2,792,173
U-107	10/28/15	224	6/8/16	954,266	12,116	966,383
BY-105	12/24/15	304	10/23/16	1,500,000	16,719	1,516,719
TX-104	1/8/16	99	4/16/16	197,389	765	198,154
S-111	1/30/16	348	1/12/17	1,600,000	18,230	1,618,230
SX-103	2/7/16	401	3/14/17	1,900,000	25,356	1,925,356
C-107	4/14/16	158	9/19/16	771,347	24,968	796,315
TX-114	4/16/16	318	2/28/17	2,000,000	3,268	2,003,268
TX-115	8/19/16	368	8/22/17	2,400,000	4,095	2,404,095
BY-111	10/23/16	282	8/1/17	1,500,000	4,647	1,504,647
S-106	1/12/17	303	11/11/17	1,700,000	10,709	1,710,709
TX-107	2/28/17	89	5/28/17	113,651	451	114,101
SX-109	3/14/17	211	10/11/17	992,730	20,703	1,013,433
TX-116	5/28/17	365	5/28/18	2,000,000	3,551	2,003,551
BY-102	8/1/17	196	2/13/18	1,100,000	3,186	1,103,186
TX-117	8/22/17	362	8/19/18	2,100,000	3,039	2,103,039

Table 4.3-1. Initial Retrieval Sequence With As-Retrieved Volumes. (5 Sheets)

Tank	Retrieval start date	Retrieval duration	Retrieval end date	Retrieved liquid vol. (gal)	Retrieved solids vol. (gal)	Total retrieved vol. (gal)
SX-104	10/11/17	396	11/11/18	1,600,000	35,772	1,635,772
S-104	11/11/17	211	6/10/18	1,900,000	63,883	1,963,883
BY-101	2/13/18	249	10/20/18	1,300,000	4,288	1,304,288
TX-103	5/28/18	140	10/15/18	586,672	739	587,411
S-101	6/10/18	275	3/12/19	1,400,000	44,767	1,444,767
BY-109	10/20/18	265	7/12/19	1,400,000	4,346	1,404,346
SX-101	11/11/18	307	9/14/19	2,000,000	67,033	2,067,033
S-110	3/12/19	256	11/23/19	1,000,000	23,786	1,023,786

4.3.3 Sludge Wash and Waste Transfer Dynamics

In-tank sludge washing is the assumed HLW feed preparation during Phase I privatization. It is assumed no additional sludge washing occurs during the rest of the time period before the start of Phase II privatization. This will maximize the amount of space available for SST retrieval, and will minimize the PHMC costs by transferring all pretreatment for Phase II processing to the Private Contractor. Out-of-tank sludge washing is assumed for all Phase II waste processing. Out-of-tank sludge washing is assumed to proceed at a rate that allows it to keep up with the LAW glass production. Washed solids are stored at 10 wt% in either the feed staging/feed tanks or in one of the DSTs which will be used for either retrieved waste storage/staging or washed solids storage. A figure showing the assumed DST functions is given in Appendix A, Section 11.

The waste transfer rate between tanks, the delay between transfers, and other dynamics assumptions are described in detail in Appendix A, Sections 3, 4, 6, 7, 8, and 11.

4.3.4 Impacts on Disposal Program Schedule Commitments

4.3.4.1 Processing End Dates for Low-Level Waste and High-Level Waste. All sequences using the attached assumptions meet the recently updated LLW processing Tri-Party Agreement milestone (M-60-00) for completion of processing by December 31, 2024, and the HLW milestone (M-51-00) for completion of processing by December 31, 2028. These milestones can be met with facilities that process waste at the baseline process rates assumed for this study. The selected sequence completed LAW processing in August 2020, and HLW processing in March 2025. The processing rates and assumptions are given in Appendix A, Sections 6, 7, and 11.

4.3.4.2 Single-Shell Tank Retrieval Completion Date. None of the SST retrieval sequences run at the baseline conditions (see Appendix A, section 2, 3, 4, 6, 7, 8, and 11) met the September 30, 2018, Tri-Party Agreement interim milestone (M-45-05) for completing retrieval of all SSTs. Previous studies (Certa 1995) (Penwell 1996) showed that if in-tank sludge washing is used, it is the limiting factor because of the time needed to settle the solids after each wash. Therefore, out-of-tank sludge washing was used for this study. However, in this study, the assumed retrieval and tank farm infrastructure appears to limit retrieval, and delay retrieval completion. Therefore, further studies should be performed to determine what infrastructure changes are needed to allow the SST retrieval completion interim milestone to be met. Since the best basis inventory used for this study contains approximately 30 percent less sodium than previous studies, which results in less feed to the ILAW facility. Therefore, if the retrieval infrastructure allows, it may be possible meet the retrieval completion milestone while assuming the baseline LAW processing rates. Future studies should determine if this preliminary evaluation is correct, and how many simultaneous retrievals will be required to allow it to be met.

4.3.4.3 Single-Shell Tank Retrieval Schedule and Milestones. Tri-Party Agreement Milestones M-45-05-T01 through M-45-05-T15 specify the number of SSTs (additional) for which retrieval must be initiated. An SST retrieval schedule (not sequence) can be derived from these and other milestones (i.e., M-45-03-T01, M-45-03-T02, and M-45-03A related to demonstrating SST retrieval technology and tank 241-C-106). The schedule derived from Tri-Party Agreement retrieval milestones is considered tradeable and is not used as a modeling constraint.

SST Retrieval before Phase II privatization (before 2011) does not meet the Tri-Party Agreement schedule of 35 tanks to be retrieved during that time period. The amount of space in the DSTs available for retrieval of SST waste during the Phase I time frame restricts the total amount of waste that can be retrieved before the start of 2011.

Ramp-up of plant operating capacity is not assumed. Assuming ramp-up delays completion of retrieval because space is not available to retrieve at rapid rates during the ramp-up period. However, assuming ramp-up of the plants as they start processing is a realistic assumption, and will be incorporated into future studies.

4.3.4.4 Retrieval and Processing Rates versus Single-Shell Tank Retrieval Schedule. The FY 1996 study (Penwell 1996) determined the retrieval rates and processing rates needed to meet the 2018 retrieval end date milestone. It showed that unprecedented retrieval rates and transfer complexity associated with retrieval would be required to meet the 2018 retrieval date. The FY 1996 study showed that 92 percent of the waste would need to be retrieved during Phase II. However, the FY 1997 integrated Phase I study discussed under the LAW and HLW feed staging sections of this document showed that even less space would be available for retrieval during that period than was estimated by the FY 1996 study. Therefore, approximately 95 percent of the SST waste must be retrieved during Phase II. Because of lack of time to perform a similar study, and because of the similarity in retrieval requirements, a detailed study was not performed during FY 1997 to determine updated rates needed to meet the 2018 retrieval enddate milestone. Future work will update the previous study to determine the effect of updated assumptions and inventory updates.

The FY 1996 study also showed that large ILAW and HLW processing rates would be needed to allow completion of SST retrieval by the 2018 retrieval enddate milestone. As discussed above, the best-basis inventory used for this study contains approximately 30 percent less sodium than previous studies, which results in less feed to the ILAW facility. Therefore, if the retrieval infrastructure allows, it may be possible meet the retrieval completion milestone while assuming the baseline LAW processing rates. Future studies should determine if this preliminary evaluation is correct, and how many simultaneous retrievals will be required to allow it to be met. Since the modeling of DST space utilization for storing solids is better in this study, preliminary results indicate that the baseline HLW processing rate should not be a bottleneck even though the best basis inventory, and sludge wash factor changes indicate that there are more solids to be processed than previously estimated. This should also be confirmed by future studies.

4.4 DISPOSAL PROGRAM PROCESS SUMMARY

The very detailed TWRS Process Flowsheet (composite feed stream) has been rolled up into the high-level diagram depicted in Figure 4.4-1. This section provides an abbreviated description of these operations. The primary purpose of this exercise is to provide Phase II immobilized waste volume projections incorporating the very latest inventory and enhanced sludge washing data. Phase II Private Contractors will develop their own detailed flowsheets in time.

4.4.1 Results

DOE will procure all retrieval and treatment services from Private Contractors during Phase II. Guidance with respect to feed envelopes, separation requirements, product specifications is amorphous at this time. The general approach calls for retrieval of all remaining tank waste, interim storage in and staging from the DSTs, and all pretreatment/immobilization operations in contractor-provided facilities.

The HTWOS dynamic model, which uses the best-basis inventory, provides the tank farm contents at any point in time. The HTWOS tank farm contents as of the end of Phase I defines the composite feed stream required by this ASPEN[1]-based TWRS Process Flowsheet simulation. However, the tank farm contents are re-distributed between phases to be consistent with 1997 mass-weighted wash factors (Colton 1997). This simulation with new inventory updates the previous TWRS Process Flowsheet simulation of Phase II (Orme 1996).

Although the architecture of the Private Contractor's out-of-tank sludge pretreatment process is unknown, there is no reason to believe that their chemical additions and sludge leaching/washing efficiencies will be radically different from those determined by Hanford's previous modeling and ESW laboratory programs. While the Private Contractor's flowsheet may differ from the TWRS Process Flowsheet at the unit operations level, both should generate reasonably similar estimates of ILAW and IHLW product volume.

A dramatically improved chromium leach factor offset the effect of increased inventory. This simulation of Phase II produces 37,000 MT (13,900 m^3) of chromium-controlled IHLW and 396,000 MT of ILAW.

4.4.2 Tank Waste Remediation System Process Flowsheet Simulation of Phase II

All discussion of the Phase II disposal process is in reference to the upper-level flow diagram in Figure 4.4-1. Material balances are provided in Appendix F.

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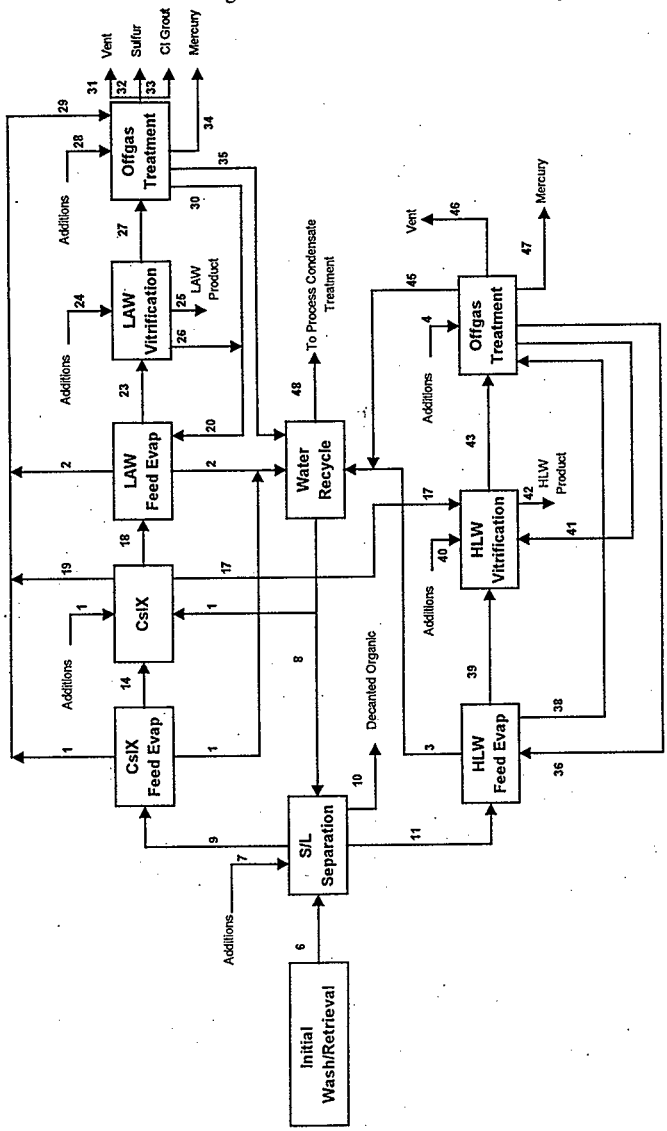
[1]ASPEN is a tradename of Aspen Technology, Inc., Cambridge, MA.

Figure 4.4-1. Phase II Waste Processing.



4.4.2.1 Initial Wash. The retrieval of waste from SSTs and DSTs with water or dilute caustic constitutes an initial wash. This wash occurs during retrieval, as insoluble solids are mobilized and salts are dissolved and dispersed in the slurry. The output from several simultaneous retrieval operations is accumulated in million-gallon staging tanks. Incidental blending occurs when slurries from different sources are combined. The energy and turbulence imparted to the slurries by sluicers, mixer pumps, transfer pumps, and the ensuing temperature rise are factors that promote the dissolution of water-soluble species. All of these operations are transparent to this simulation, which sees only the composite stream (Stream #6) resulting from initial wash (i.e., retrieval). The distribution of components between liquid and solid phase is determined by overall mass-weighted wash factors.

4.4.2.2 Solid/Liquid Separations. The SOLID/LIQUID (S/L) SEPARATION process block includes the established TWRS Process Flowsheet steps of (1) initial separation of waste liquids from solids, (2) leaching of caustic soluble components, and (3) adjustment of the interstitial liquid concentration by washing with dilute hydroxide/nitrite solution. Previous flowsheets implemented this treatment in DSTs, but Phase II contractors will select their own process architecture in new facilities. To prevent adverse effects on downstream operations from organic phases that might be retrieved from some SSTs, the S/L process block incorporates continuous decanter capability to separate organics from decanted supernates, leachates, and wash solutions. The amount of separable organic has been difficult to estimate and the assumed flowsheet value is 78 MT (Klem 1996).

The enhanced sludge-washing process utilizes leaching washes with 3*M* caustic solution which non-selectively removes components (primarily aluminum, chromium, phosphorus, sulfate, and sodium) from the tank waste sludges, followed by dilute caustic washes to remove the interstitial dissolved components. The process is based on experience at the Savannah River Site, and ESW experimental results which have been evaluated to derive mass-weighted leach factors (Colton 1997). The large increase in IHLW volume anticipated last year was offset by dramatically improved chromium leach factors

The retrieved slurries are on the average 3 wt% solids, although wide variations in solids loading can be expected in actual practice. For the purposes of this model, solids are thickened to 20 wt% solids prior to separating solids and liquids.

The flowsheet calculations do not reflect a second caustic leach at this time. As more information about the leaching process becomes available, it may be advisable to add a second leach cycle, or permanganate oxidative leach for specific wastes. This second cycle of leaching can be added with little impact to the flowsheet.

Colton's (1997) updated pretreatment chemistry evaluation provides revised caustic leach factors that have been applied in the S/L SEPARATION process block. Table 4.4-1 shows the components and revised mass-weighted leach factors. The caustic leach factor is the fraction of the water-insoluble component removed by caustic leaching. Enhanced sludge-washing results for a total of 30 SSTs are incorporated into the leach factor projection.

Table 4.4-1. Old and New Single-Shell Tank Caustic Leach Factors.

Component	Old single-shell tank leach factors (Colton 1996)	New single-shell tank leach factors (Colton 1997)
Al	0.60	0.88
Bi	0.003	0.003
Ca	0.02	0.03
Cr	0.14[1]	0.78
Fe	0.002	0.007
Na	0.45	0.46
P	0.70	0.75
Si	0.13	0.36
U	0.002	0.02

Caustic leach data for Phase II DST waste are currently limited to 241-SY-103 and 241-AN-104. Most of the aluminum and phosphate in DSTs is either already in solution or easily removed by ESW. Only 5 percent of the chromium in 241-SY-103 sludge was water soluble, and only 8 percent of the water washed chromium was removed by caustic. Since an appreciable amount of recalcitrant chromium resides in DSTs, an additional 36 percent oxidative leach factor has been applied to DST waste.

4.4.2.3 Cesium Ion Exchange Feed Evaporation.[2] The combined supernatants (Stream 9)[3] of the enhanced sludge-washing operation are evaporated and filtered in the CsIX FEED EVAPORATION process block before ion exchange. For sizing the evaporator load, a bottoms concentration of 7*M* sodium is assumed. In actual practice, the chemistry of the waste supernatants will control the extent of evaporation to a point short of precipitating salts. The evaporation is done early in the process to concentrate the waste prior to cesium ion exchange

[1]Reported last year incorrectly as 10 percent.

[2]The Phase II Private Contractor could elect to forego evaporation if that is conducive to their process. However, since the evaporator in question is assumed to replace the 242-A Evaporator, TWRS would have to evaluate how to provide evaporation for tank farm volume control.

[3]It is assumed that facility wastes that are currently evaporated in the 242-A Evaporator will be added to the feed for the pretreatment process (i.e., facility wastes are included in the filtrates).

and to decrease the load on the LLW melter and offgas system. The evaporator also reduces volume in the event that the bottoms are returned to in-process storage. Evaporator bottoms returned to in-process storage may require chemical adjustment to ensure tank farm specifications for OH^- and NO_2^- are satisfied.

4.4.2.4 Radionuclide Separations. All feeds to ion exchange will be processed through a deep-bed filter of glass frit or similar material, to remove solids that could adversely affect ion exchange column operations. Under normal conditions, the evaporator bottoms proceed to clarification through a glass frit deep-bed filter. Evaporated supernatants are likely to contain small amounts of solids that were entrained during decanting, that precipitated during evaporation or storage, or that were entrained during pipeline transfers to and from in-process storage.

Spent filter material is periodically flushed out and replaced with fresh frit. The spent filter bed is added to the cesium-depleted ion exchange effluent in the LLW evaporator feed tank.

The CsIX process block houses a three-cycle operation in which an organic ion exchange resin is loaded with cesium, eluted with nitric acid, and regenerated with caustic. The eluate, containing approximately 98 percent of the cesium, is concentrated to reduce its acid content and volume. Approximately 89 percent of the volume and 70 percent of the acid in the eluate is recycled for use in subsequent elutions. The cesium-depleted effluent, flushes, and regeneration streams feed forward to the LAW treatment process to be mixed with other miscellaneous LAW recycle streams.

The absence of TRU/Sr and Tc removal from the Phase II flowsheet should not be construed to mean that these separations will not be required for any portion of the Phase II waste. The approach to Phase II has been to model Phase II with the existing *TWRS Process Flowsheet* model because (1) it still provides a reasonable projection of product volume even if special separations for particular wastes are not included, (2) there was no guidance for Phase II other than it entails treatment of the balance of the waste, and (3) selection of additional separations technology is now a Private Contractor responsibility.

Phase II is also based on a composite feed stream. Cs removal is the only separation that would be widely applied during Phase II. TRU/Sr and Tc separation would undoubtedly be required for only a small subset of the Phase II feed. These special treatments will not be shown until there is a differentiation of Phase II feed into volumes that require special treatment (as there is in Phase I), nor until Private Contractors have proposed technology to make the separations.

4.4.2.5 Low-Activity Waste Feed Evaporation. The effluent from ion exchange (Stream 18) is combined with miscellaneous streams from offgas treatment (Stream 30), filter wash liquids, recycled glass product, and other dilute process recycle streams (Stream 26), before evaporation to a 10*M* sodium slurry (Stream 23) in the LAW FEED EVAPORATION process block.

4.4.2.6 Low-Activity Waste Vitrification. The LAW VITRIFICATION process block treats LAW slurry (Stream 23) in a melter of unspecified design. The glass formulation constraints are listed in Table 4.4-2.

Table 4.4-2. Low-Level Waste Glass Formulation Constraints (Orme 1996).

Al_2O_3	= 12 wt%
B_2O_3	= 5 wt%
CaO	= 4 wt%
Na_2O	= 20 wt%
SiO_2	> = 50 wt%

The dry glass formers (contained in Stream 24) are tailored to the waste feed to obtain the desired glass formulation.

Glass that does not meet acceptance requirements for disposal is routed to a crusher for size reduction. Crushed out-of-specification rework is slurried back to evaporation and recycled to the melter for remelting. For a flowsheet assumption, approximately 1 percent is reworked.

The Phase II Private Contractor's plan will address strategy for compliance. The Private Contractor may elect to qualify the treatment process rather than providing for rework of off-specification material. In general, a qualified process would require a long period of feed validation, while a process with recycle would have less stringent feed characterization requirements as long as the product could be sampled, analyzed, and reworked if found to be out of specification.

The ILAW package for the TWRS Process Flowsheet was a 32-m^3 rectangular container intended specifically for the sulfur polymer concrete waste form. The maximum size of a rectangular container for a glass monolith has not been analyzed. Since no specific guidance is provided for Phase II ILAW packaging, the Phase I standard package is used. This is the 2.6-m^3 package filled to a net volume of 2.08 m^3 (equivalent to 80 vol%). Phase II produces approximately 85,000 ILAW packages.

4.4.2.7 Low-Activity Waste Offgas Treatment. The OFFGAS TREATMENT process block consists of a quench tower, venturi scrubber/separator, demister, CuO SO_2 absorber, NO_x catalytic reactor, and high-efficiency particulate air (HEPA) filtration. The quench tower, venturi scrubber, and demister are included to remove particulates entrained in the offgas. These devices also cool the offgas, condense water vapor, and condense and scrub semi-volatile waste components like technetium. There are currently no provisions to recover

technetium from the decanted wastes, so the scrub will become enriched with technetium over time. Recirculated nitric acid is used as the scrub medium, so it is not effective for removal of the NO_x and SO_2, both of which are criteria air pollutants.

Sulfur dioxide is removed from the gas stream by the Shell Flue Gas Desulfurization process. Nitrogen oxides are removed by selective catalytic reduction with NH_3. A combination of washable-metal HEPA filters and paper HEPA filters are used to filter the offgas before discharge to a stack. Liquid condensates from the offgas system are routed to the LAW evaporator.

Sulfur Recovery. SO_2 is removed from melter offgas by trapping on a CuO bed (as $CuSO_4$) at 400 °C. The CuO beds are approximately 90 percent effective at removing SO_2. After loading, the $CuSO_4$ is reduced with H_2, which releases the sulfur as H_2S. The CuO bed is regenerated by purging with air.

The H_2S released from the CuO bed is burned to a stoichiometric mixture (2 H_2S to 1 SO_2) in a combustion chamber. The stoichiometric mixture is reduced to elemental sulphur in a two-stage Claus reactor. The overall conversion efficiency of the Claus reactors is 99 percent. The tail gas from the Claus reactor is recycled to the inlet of the CuO bed.

The recovered sulfur is poured into 55-gal drums while still molten, allowed to cool, and packed out as a secondary waste (Stream 32).

Chloride and Fluoride Control. The quench tower and venturi are effective at scrubbing volatile chlorine and fluorine from the melter offgas, so the scrub solution becomes enriched in chloride and fluoride. Offgas treatment includes an operation to recover and discharge chloride as a secondary solid-waste grout. Fluoride is returned to the melter in a non-volatile CaF_2 form.

The chloride recovery operation consists of diverting a side stream of the recirculating scrub solution to a series of evaporators and distillation columns. A nitric acid product stream (containing all of the entrained solids, most of the nitric acid, 90 percent of the fluorine, and 35 percent of the chlorine) is neutralized with 10 percent excess $Ca(OH)_2$, to precipitate CaF_2 before recycling to the LLW evaporator in Stream 30. The CaF_2 will not re-volatilize from the melter. The calcium added in this operation reduces the amount of calcium added directly to the melter.

HCl concentrate (containing 65 percent of the chlorine and 10 percent of the fluorine) is neutralized, evaporated to reduce volume, grouted, and packed out in 55-gal drums as a secondary waste (Stream 33).

Mercury Recovery. The OFFGAS TREATMENT process block currently does not contain a separation for the mercury. Most of the mercury carried in the melter offgas (Stream 27) is recovered in the nitric acid scrub medium and recycled. Stream 34 is provided

strictly as a convenience to quantify how much mercury is available for separation from the chloride side stream.

4.4.2.8 High-Level Waste Feed Evaporation. The HLW FEED EVAPORATION process block combines offgas condensates and recycled scrub liquid (Stream 36) with pretreated solids (Stream 11), and dewaters the slurry by a combination of centrifugation and evaporation to reduce the evaporative load on the HLW melter. Process condensate (Stream 37) and condenser vent (Stream 38) result from dewatering.

The dewatered solids (Stream 39) are ready for feed adjustment.

4.4.2.9 High-Level Waste Vitrification. The HLW VITRIFICATION process block combines Stream 39 with recovered cesium (Stream 17) and a concentrated spent scrub solution (Stream 41), performs the feed adjustment, and vitrifies the solids.

Feed Adjustment. For feed adjustment, glycolic acid (included in Stream 40) is added to adjust the pH to approximately 6 and provide sufficient reductant (organic carbon). An addition of 6.4 g-mol glycolic acid per kg of waste oxides is expected to provide a sufficient excess for redox/oxidation control in the melter.

The organic acid digest is followed by the dry addition of glass-former chemicals such as silica, boric oxide and lithium oxide (included in Stream 40). The feed slurry is then concentrated by evaporation to a total oxide concentration of approximately 500 g/L and transferred to one of the melter feed tanks.

High-Level Waste Vitrification. The melter is assumed to be a low-temperature, joule-heated, slurry-fed ceramic melter. Scaling up of the Defense Waste Processing Facility (DWPF) joule-heated melter will be necessary to provide the required throughput rate if that design is selected. The number and sizing of melters is a Phase II Private Contractor decision.

For the flowsheet, the adjusted feed slurry from the melter feed tank is continuously fed to a joule-heated melter where slurry water is evaporated and calcination reactions proceed in the "cold cap" over the molten glass pool. Water and other volatile feed components are driven off, while nonvolatile components oxidize and melt into the glass. The molten borosilicate glass product flows (by pressure differential) from the melter into stainless-steel canisters, where the product cools to form a monolithic glass.

The process model predicts glass composition from the glass formulation ranges stated in Table 4.4-3. These ranges are for low-temperature (1150 °C) melting (Hrma et al. 1994).

Table 4.4-3. High-Level Waste Glass Formulation Ranges (CVS AT 1150 °C). (Hrma et al. 1994)

Component	Glass	
	Lower	Upper
Single-Component Ranges[a]		
Al_2O_3	0.0%	15.0%
B_2O_3	5.0%	20.0%
CaO	0.0%	10.0%
Fe_2O_3	2.0%	15.0%
Li_2O	1.0%	7.0%
MgO	0.0%	8.0%
Na_2O[b]	5.0%	20.0%
SiO_2	42.0%	57.0%
ZrO_2	0.0%	13.0%
Multi-Component Ranges[c]		
$Al_2O_3+ZrO_2$	<=16.0%	
$Al_2O_3+ZrO_2+Fe_2O_3$	<=24.0%	
MgO+CaO	<=10.0%	
Solubility Limits		
Cr_2O_3	<=0.5%	
F	<=1.7%	
P_2O_5[d]	<=3.0%	
$Rh_2O_3+Ru_2O_3+Ru_2O_3$	<=0.25%	
SO_3	<=0.5%	

[a]The sum of all components not listed may range from 1% to 10%.

[b]Includes K_2O.

[c]Attempts to eliminate formulations with poor processability by the application of multiple component constraints have been "only partially successful" per Hrma 1994. Multi-component constraints are ignored in the model.

[d]This limit differs from the 1% ceiling used for HWVP formulations as shown in Hrma 1994. It is an engineering judgment that TWRS composite glass can solubilize up to 3% P_2O_5.

With the current formulation ranges and HLW waste feed, the waste loading in IHLW is 37 percent (including sodium and silicon). The reduced caustic leach factor for chromium, discussed in Section 3.2.2.1, is responsible for chromium controlling the volume of IHLW.

Final Packaging. When sufficiently cooled, the filled canisters are sealed with an inner canister closure plug. A preliminary decontamination is performed by a low pressure water spray that removes loose contamination. Final decontamination is accomplished by a frit-blasting process. A final canister seal is provided by a welded closure.

A variety of canisters containing somewhat different net waste volumes are available for consideration, including the DWPF canister (0.62 m^3), the West Valley Demonstration Project canister (0.8 m^3), or a 4.5 m tall contractor-proposed standard canister (1.08 m^3) filled to 90 percent. Phase II produces 12,890 contractor-proposed standard canisters.

4.4.2.10 High-Level Waste Offgas Treatment. Offgas from the feed adjustment evaporation step is condensed and collected. Reduced mercury contained in the condensate is accumulated in a mercury sump built into the condensate collection tank. A total of 70 kg mercury (5 L) is expected to accumulate over the life of the plant.

Melter offgases (included in Stream 43 with feed adjustment vapors) flow to a quench tower and venturi scrubber to cool and condense the offgas, and separate entrained particulates from the gas stream. The offgas then passes through a chiller, demister, and HEPA filter. Levels of sulfur in the HLW melter feed will probably not require a reactor (CuO bed) for SO_2 abatement; likewise, the amount of nitrate in HLW is small so NO_x abatement is not an issue. Melter offgas exiting the HEPA filter will be combined with building ventilation exhaust air and released to the atmosphere via the plant stack.

Spent scrubber solution collected from the quench tower and venturi scrubber is evaporated in the secondary waste evaporator and recycled to the feed collection tank.[1]

Because of the potential for contamination, condenser vent gases in the HLW process are all scrubbed through the condenser vent scrubber. The condenser vent scrub solutions are combined with feed adjustment condensate and returned to the HLW FEED EVAPORATION process block.

4.4.2.11 Water Recycle. The TWRS flowsheet recycles process condensates extensively where the use of condensates is acceptable. The WATER RECYCLE process block shows where recycled water is used. Excess process condensates from the TWRS flowsheet are routed to the Liquid Effluent Treatment Facility for conditioning before release to the environment. Condensate treatment is an Environmental Restoration function outside of the scope of the TWRS Process Flowsheet.

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[1]The portion of the spent scrub that was previously routed to the salt waste adjustment tank purged the melter system of halides and other volatile compounds not soluble in the glass. In Revision 1, the HLW process operates beyond the completion of pretreatment and LLW treatment, and it is assumed that routing purges out of the facility is discouraged. Further study will determine if HLW scrub solution treatment similar to the LLW scrub solution treatment is required.

4.4.3 Issues and Caveats

The underlying caveat of this Phase II flowsheet is that it is not a product of the future Private Contractor(s) who will design and operate Phase II facilities. It is unlikely that future Private Contractors will propose drastically different flowsheets or come to drastically different conclusions about the final product volume unless DOE's long-term strategy undergoes major changes. Those volumes are driven by a relatively small number of parameters that are for the most part understood and not expected to change.

4.4.4 Recommendations

When the HTWOS model has been updated with the latest wash factors and leach factors, future Phase II (and Phase I) top-level flowsheets should be extracted from the HTWOS database. Use of this ASPEN-based flowsheet is recommended for small case studies where it would be inconvenient and time-consuming to use HTWOS.

5.0 HANFORD TANK WASTE OPERATION SIMULATOR MODEL OVERVIEW

The Hanford Tank Waste Operation Simulator (HTWOS) is a computer simulation that models the dynamic operation of the tank farm systems within the 200 East and 200 West areas. HTWOS simulates operational waste volume projection (OWVP) activities, LLW feed staging activities, HLW feed staging activities, Phase I SST retrieval activities, and Phase II SST retrieval activities providing a common assumption basis for all activities as well as showing operational impacts of each activity on the other activities. Tank farm operational constraints as well as physical equipment capacities are also modeled.

HTWOS is programmed in G2[1], an object oriented artificial intelligence software package commercially available through the Gensym Corporation. Using an object oriented programming language greatly enhances programming speed. In addition, G2 is a high-level graphical programming language which uses natural language phrases making it much easier for general program maintenance. G2 also provides a rich suite of graphical objects allowing developers to easily specify graphical user interfaces both for initial model input as well as displaying model results.

HTWOS is a chemical/radionuclide component based model which maintains a dynamic inventory of liquid and solid components in tanks. The original starting inventory and the components carried in the model are defined in Appendix C. The tank, the basic building block of the model, maintains a dynamic inventory of liquid and solids; the inventory changes as material is transferred to and/or from a tank. When transfers to the tank are complete, the tank goes through a settling period where solids transferred into the tank are settled as a distinct layer of solids on top of any pre-existing solids in the tank. Liquid is trapped within the solid layer during the settling period as interstitial liquid. This liquid has the same composition as the bulk liquid at the beginning of the settling period.

When material is pumped from the tank, a liquid-solid mixture is removed based upon one of three general scenarios: (1) the tank can be mixed into a homogeneous liquid-solid slurry, (2) the liquid in the tank can be decanted leaving the existing solid layers intact, (this process can occur with or without entraining solids), (3) a fraction of the total solids in the tank can be entrained with the liquid (the solid fraction starting at the top layer and working down depending what percentage of the total solids is specified). At the end of the pumping period, the tank again goes through a settling period where any transferred solids are settled into a distinct solid layer on top of any pre-existing solid layers in the tank.

Unlike the OWVP model, volume is not conserved in HTWOS. Both liquid and solid volumes are calculated values based upon the dynamic tank chemical inventory. If chemical reactions occur or solids dissolve a volume change may occur. In addition, sludge volume is

[1]G2 is a tradename of Gynsym Corporation, Cambridge, MA.

not conserved because it is based upon an assumed settled solids density which may change as tank conditions change.

5.1 DESCRIPTION OF SPECIFIC ACTIVITIES

The paragraphs below describe the basic programming used in the HTWOS model to simulate the programs/projects that were listed in the first paragraph. These activities include the following:

- OWVP
- Phase I LLW Feed Staging
- Phase I HLW Feed Staging
- Phase I SST Retrieval
- Phase II SST Retrieval.

5.2 OPERATIONAL WASTE VOLUME PROJECTION

The data from Revision 23 of the OWVP (Strode and Boyles 1997) were incorporated into the HTWOS model. This included waste additions from outside the tank farm system, tank to tank transfers, and evaporator runs. However, HTWOS had to have specific dates to perform its operations, not ranges like what is in the OWVP. To do this, it was assumed that tank to tank transfers and evaporator runs would be initiated on the start date listed in the OWVP output and would be transferred at the overall average rate used in HTWOS. Waste additions from outside of the system were handled differently because the date range for many of the additions spanned an entire year. Therefore it was decided that the additions would be made to a tank 15 days before a transfer out of that tank was initiated. This simplifies the operation of the model, but may underestimate the tank demand. If a transfer was not scheduled to be made out of a tank, the start date for the addition was used. For evaporator runs, the degree of evaporation was set equal to the volume reduction given in the OWVP output.

The data described above did not include transfers required specifically for Phase I processing. The Phase I data were obtained primarily from the HTWOS model and integrated into the OWVP model. The few major exceptions that exist between the two models are discussed below.

The tank transfer and utilization data from the two models compare very well from September 30, 1996, into 2006. For example, the transfer dates pertinent to HLW pretreatment and LAW treatment match exactly. However, the duration of 241-C-106 retrieval is extended in the OWVP model (July 1998 through December 1998, compared to July 1998 through June 1999). This is due to the different assumptions used in the models. This should not impact the overall results because 241-C-106 and 241-AY-102 remain idle until well after June 1999.

From 2006 until 2011 the models begin to show minor differences due to the retrieval of SSTs during Phase I. However, the Phase I processing transfers are nearly the same. One major exception is that the OWVP uses 241-AP-107 as the LAW contractor return tank until 241-AZ-101 becomes empty. From that point on, 241-AZ-101 is used as the contractor return tank. This was done so that 241-AP-107 becomes free earlier for SST retrieval. The HTWOS model, on the other hand, uses AP-107 as the contractor return tank through Phase I. This is how the tanks were designed to be used according to the assumptions in Appendix A. This will be rectified in the next revision of this document.

From 2011 (the end of Phase I) to the end of Phase II the HTWOS model employs different SST retrieval assumptions. Future planning states that the output from the HTWOS model from 2011 on will be used as the basis for the OWVP with the exception that the HTWOS will include facility generated waste transfers defined in the OWVP from 2011 to 2015. Presently these transfers are not included in the model. They will be included in the next version.

5.3 PHASE I LOW-LEVEL WASTE FEED STAGING

The double shell tanks (DSTs) that will be used for the LLW staging and the order that they will be processed is outlined in Section 3.1. Also defined was the start date for the staging activities to commence. However the start dates for each individual activity is determined in the model based on the availability of the tanks and conflicts with other activities. The input to the model allows the user to define:

- What tanks are to be retrieved and to where
- Percentage of tank retrieved
- If solids are retrieved
- Retrieval pump rate
- Type of retrieval
- Dilution ratio
- Batch percentage
- Early start date
- Any delay.

The user specifies the tanks to be retrieved. If the tanks are being retrieved into a staging tank (241-AP-102 or 241-AP-104), then a dummy value is used. In this way the model will transfer the retrieved tank contents into whichever staging tank is ready. Percentage of tank retrieved is set up so the user can specify the percentage retrieved or the metric tons of sodium retrieved. If the percentage is greater than 1.0 then the model assumes that the value applies to the amount of sodium retrieved. A trigger is used in order for the model to determine if solids are to be retrieved or not. At this time it is not set to a percentage, but rather 100 percent of the solids are mobilized and retrieved, or no solids (except entrained solids) are mobilized and retrieved. The type of retrieval determines if retrieval water is to be added and where. The dilution ratio sets the amount of retrieval water

(if any) added on a volume ratio basis. The batch percentage determines the amount of staged waste that will be transferred to the contractor tanks as a batch. Like the percentage of tank retrieved, this value is assumed to be a volume percentage if less than or equal to one or a metric ton amount of sodium if greater than one. The early start date can limit when a transfer occurs. If the model date is less than the early date then the model will delay the transfer until the early date. The delay value can be used to delay an operation a certain number of days before initiating.

The model performs each transfer in the order given in the file. Simultaneous operations can occur if the transfers do not conflict with one another.

5.4 PHASE I HIGH-LEVEL WASTE FEED STAGING

The DSTs that will be used for the HLW staging, the order that they will be processed, and the need date for the first batch of pretreated waste is outlined by the user. The length of time allotted for each of the pretreatment steps and the HLW processing rate can be changed within the model, but for this version uses the information outlined in Section 3.2. From this information and user input (defined below) the model calculates the start dates for the pretreatment of the HLW feed tanks. The input to the model allows the user to define the following:

- The order of tank processing
- Number of washes
- Percentage of tank solids mobilized
- Any delay
- Early start date
- Solids/wash solution ratio
- Wash solution volume
- If a caustic wash is performed.

As mentioned above, the tank order is given by the user. The number of washes determines the starting date for pretreatment of the first tank based upon the allotted time for each operation as defined by the staging plan author and the initial need date. Subsequent starting times are calculated by subtracting the calculated processing time for the previous tank, adding it to the processing start date, and then subtracting off the calculated allotted time for pretreatment. Percentage of tank solids mobilized affects the processing time of each batch and therefore affects the pretreatment start times for subsequent tanks. The delay time and early start date act identical to what was described previously for the LAW input. The wash solution ratio can be used to determine the amount of wash solution to be added based upon the amount of waste in the tank. However the wash solution volume can also be used to set the amount of wash solution added to the tank. A delimiter is used in the input file to determine which method will be used. Caustic washing will only be employed if the caustic wash trigger is set to "yes."

The model performs each set of pretreatment operations (caustic wash/number of water washes) on the tanks given in the input file. The tanks will be pretreated in the order given. Only after the previous tank has been pretreated will the start date for the pretreatment of the next tank be calculated. Therefore, at this time, no simultaneous pretreatment operations can occur. If the calculated start date for a tank is less than the actual date, pretreatment of that tank will commence immediately after the conclusion of pretreatment on the prior. This may need to be rectified in the future versions of the model.

5.5 PHASE I SINGLE-SHELL TANK RETRIEVAL

As the DSTs defined for use by either Phase I HLW or LLW feed staging complete their mission, they are either "released" for use in SST retrieval or are given another role in the tank farms. For example, after 241-AN-105 has been retrieved for feed for the first batch of LLW, it then becomes the dilute receiver tank for east area. This means that it will not be used for SST retrieval until it is defined to no longer be the dilute receiver. Other tanks that will not be used for SST retrieval are as follows:

241-AW-102 - Evaporator Feed Tank
241-AW-106 - Evaporator Catch Tank
241-AW-101 - DSSF Accumulation Tank
241-AY-101 - Spare.

All other tanks are released after they have performed their missions in the staging plans. Tanks 241-AP-102, -104, -106, and -108 are not released until the end of Phase I (June 1, 2011) even though in the model they are through processing (approximately September 2008). This allows for additional processing above what is modeled. Tanks that do not take part in feed staging are released so that they will be available to receive retrieved SST waste starting December 31, 2003. The SST retrieval follows the guidelines outlined in Section 5.6, Phase II Single-Shell Tank Retrieval.

The order of SST retrieval is given by a file exterior to the HTWOS model. The model checks the SSTs in order to see which tank to retrieve next. The selection of a SST for retrieval will only occur if all of the system checks are met (i.e., limit on the total number of retrieval machines, limit on retrieval machines per farm or quadrant, downstream tank availability, etc.). Therefore, the order in which the SSTs are retrieved may not match the order specified in the exterior file.

5.6 PHASE II SINGLE-SHELL TANK RETRIEVAL

Phase II retrieval operations include retrieval of the SST contents, staging the waste for feed delivery to the solids washing facility, solids dissolution during the solids washing process, partitioning into a LAW and HLW fraction, and processing these fractions through a LAW and HLW vitrification plant. During Phase II retrieval, HTWOS moves material

through groups of tanks organized into specific activities. When a tank becomes full, the model searches for another tank to pump to and either initiates the transfer or waits until a tank becomes available. The calculational method automatically stops transfer operations to upstream tanks when downstream tanks become full. Operations are automatically resumed when downstream tanks are pumped out and can receive material. The specific equipment capacity, timing, and general operating assumptions are identified in Appendix A.

5.7 VERIFICATION AND VALIDATION STRATEGY FOR THE HANFORD TANK WASTE OPERATION SIMULATOR MODEL

It is expected that the initial Verification and Validation (V&V) work will be completed in parallel to approval and issuance of this document. The strategy for this V&V is summarized by two broad activities:

1. Assure the HTWOS model is programmatically and computationally "sound" in its present state for performing current TWRS operations analysis and

2. Remains sound for future revisions.

The soundness of the model is being assessed through a systematic testing and evaluation of the model's functionality, and through comparisons with the programmatic and technical assumptions as given in Appendix A. Additionally, the technical basis driving the model's treatment of transfer equipment, process chemistry and waste properties will be reviewed by the appropriate subject experts.

The model functions currently being tested are the tank waste properties calculations, the caustic leaching chemical reactions, and the material balance during waste transfer operations. These functions are necessarily related---for example: material balance depends on the correct evaluation of chemical reactions; also, the transfer times depend on the correct computation of waste volume given the known composition. The interwoven nature of the way functions impact the model allows many of the initial programming inconsistencies to be identified by the model developers themselves during the debugging and running of the model. This also means that certain functions must be tested both exclusively and in combination. Specifically, the testing is conducted by running various parts of the HTWOS model and comparing the model results with hand calculations or with the results from an independent program written in FORTRAN. Additionally, the logic and coding for a selected set of HTWOS procedures is being examined.

The V&V will also contain a checklist comparing HTWOS data with appropriate Appendix A assumptions. This will ensure that the accepted data are used by the model to specify quantities such as size and rates of processing facilities, the efficacy of caustic leaching, the assignment of DST processing or storage function, etc.

Some of these tests and comparisons will be built-in to the HTWOS model. Therefore, replication of the V&V benchmarks will be, in part, automated for future revisions of the model. Also, to more efficiently monitor and update the accepted assumptions, an interactive version of the Appendix A assumptions can be maintained directly within the HTWOS model.

5.8 FUTURE USE OF HANFORD TANK WASTE OPERATION SIMULATOR

HTWOS is used to integrate and provide a common assumption base for OWVP activities, law feed staging activities, HLW feed staging activities, Phase I SST retrieval activities, and Phase II SST retrieval activities. The integration of the HTWOS OWVP activities with the official OWVP model run by the Models and Inventory group this year consisted of incorporating past and future transfers defined by the OWVP model into HTWOS, adding the Phase I feed staging activities to HTWOS, and then transmitting HTWOS operating information to the Models and Inventory Group and having them incorporate this information into their existing OWVP model. This scenario posed many challenges as the basic model operation and the modeled detail is vastly different for the two models. Next fiscal year, the HTWOS model will be released to the Models and Inventory Group to be used in parallel with their official OWVP model. When the two models calculate similar results, the HTWOS model will become the official OWVP simulator providing the full integration of the five activities discussed above.

The HTWOS model will be placed under configuration control. A configured model will be validated and verified against known results and will be complete with operating documentation. This configured version will be the official model until a new revision is released.

The configured HTWOS model will physically run on a Unix workstation because of its size. This configured model will be accessed and operated by the Modeling and Inventory Group from their local personal computers through an interface called Telewindows.[1] Telewindows allows operation of a remotely running model from a local computer. Operation in this manner assures that the user is accessing the current verified version of HTWOS. When the next version of HTWOS is available, it is loaded on the host Unix workstation and the user will automatically access it when initiating a Telewindows connection.

5.9 FUTURE FEATURES OF THE HANFORD TANK WASTE OPERATION SIMULATOR MODEL

The additions described below are features that are planned to be added to the HTWOS model for the next revision of this document. These are features that are presently not in the model; they are not modifications to existing features.

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[1]Telewindows is a tradename of Gensym Corporation, Cambridge, MA.

OWVP Input. Presently the tank to tank transfers, facility additions, and evaporator runs outlined in Section 5.2 for the OWVP are "hardcoded" into the model. Hardcoded means that the transfers are specific (specific dates, tanks, volumes, waste reduction factors, etc.). They are not calculated by the model. In order for the model to generate realistic results for different scenarios, these transfers will need to be "softcoded" (the model determined the date, amount, and destination of transfer based on parameter within the model). This will require significant interaction with the OWVP author. These changes, or at least modeling of the OWVP transfers/actions that occur during pre-Phase I (FY 2000), will be implemented.

Impacts on Other Schedules. The rate at which products are produced at the processing facilities will define the need for storage and disposal space. Data that need to be obtained include the following:

Phase I	Cesium packages from LAW only contractor LAW packages from both LAW contractors HLW canisters
Phase II	LAW product from both LAW contractors LAW storage vaults HLW canisters

The above data will need to be obtained from the model on a daily basis. Presently the model can calculate the number of items produced and average their daily production based on the average processing rate. However, if processing facility and equipment reliability are added, this has the potential to disrupt the average.

The additions described below may be implemented into the next version of the model depending on need and priorities.

Facility Downtime. Presently the processing facilities in the model operate at average processing rates. These processing rates include allowances for facility downtime (due to equipment failures, routine maintenance, etc.) and for not running at full capacity. The average processing rate assumption works well for steady-state models, but it does not for dynamic models. For example if a facility can process the contents of one tank in a year with a 50 percent total operating efficiency, a steady-state model would have the facility processing for the entire year and the tank would not become empty until the end of the year. However in a dynamic model, it could be programmed that the facility processes the entire tank in 6 months and is down the other 6 months. In this scenario the tank becomes empty 6 months sooner and upstream processes from the tank can utilize its space. This can alter the entire processing schedule.

Equipment Reliability. Programming unscheduled failure of pumps (mixer, decant, transfer, etc.) and transfer lines will be added to the model as information becomes available. This will be a feature that can be toggled on/off as the user desires. This will need to be done because if random failures of equipment are programmed into the model, obtaining reproducible results will become impossible.

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6.0 ACTIONS PLANNED FOR FUTURE TANK WASTE REMEDIATION OPERATION AND UTILIZATION PLAN REVISIONS

The focus of the initial version (Rev. 0) of the TWRSO&UP and the HTWOS modeling effort was to use common bases and assumptions for analysis of the LAW feed staging, the HLW feed staging, the OWVP, and the SST retrieval sequence analysis and to issue one document that included the results of the feed staging and retrieval sequence analysis. This document is the result of that focus. Future revisions to this document will be prepared in response to new, significant data as it becomes available or to major programmatic changes. An example of new data are the recently completed FY 1997 SST enhanced sludge wash factors and an example of a programmatic change will be the May 1998 privatization contract award. The planned actions are summarized below.

The overall vision for the future revisions of the TWRSO&UP is to increase the scope of the HTWOS modeling to add other portions of the Disposal Program and to incorporate new data and programmatic changes as they occur, to provide additional flexibility in the HTWOS model to automate the analysis and make it easier to perform alternative evaluations, and to add features to the HTWOS model to provide outputs to support DOE-HQ information requests and future program planning. Revisions of the TWRSO&UP will be prepared as major changes occur in the data sources or in the Disposal Program, or to support major decisions being made within the Disposal Program. Presently, alternative evaluations using the HTWOS model are planned early in FY 1998 to support DOE's May 1998 privatization contract award. Revision 1 of the TWRSO&UP is planned late in FY 1998 to document the contract award. Annual updates are planned in FY 1999 and beyond. The frequency of future revisions is expected to change as more is known about the availability of new data and future decision points are established.

6.1 FIRST REVISION

The first revision to the TWRS O&UP will be completed by September 30, 1998, and is expected to incorporate the following data or changes.

- The best-basis inventory tank-by-tank inventory or Phase I tank-specific characterization data
- The SST ESW wash and leach factors developed from ESW laboratory data made available in FY 1997
- Additional detail on the sluicing of tank 241-C-106 into tank 241-AY-102 (over that presently modeled)
- Partitioning of the best-basis inventory tank -by-tank inventory into soluble and insoluble fractions using the ESP thermodynamic model

- Information from the recently developed ICDs (numbers 16, 19, 20, and 21) that affects the feed staging analysis (little in the ICDs is expected to change from Rev. 0 to Rev. 1)

- The results of the HLW Pretreatment Process AGA (Manuel 1997)

- Contract feed specification revisions

- Modeling of the storage and disposal facilities in HTWOS

- Automation of evaporator campaign planning. This feature will provide flexibility in the use of HTWOS to evaluate programmatic schedule changes on tank farms operations.

Other changes are described in Section 5.9.

6.2 FUTURE REVISIONS

Future revisions of the TWRSO&UP will include the following improvements to the HTWOS modeling as changes are made or information becomes available.

- The flexibility to shift the scheduling of waste transfers from outside sources into the tank farm system. Presently, transfers into the tank farm from outside sources are set by the program office controlling the outside source. The ability to shift the receipt schedule for outside-source wastes is needed to perform sensitivity studies to determine the impact of delaying or accelerating outside-source receipts on waste tank volumes.

- Provide the capability for the HTWOS model to provide output in a format that supports different DOE-HQ information requests. Examples of this are the inputs to the Integrated Database (IDB), the Project Baseline Summary (PBS), and the Baseline Environmental Management Report (BEMR).

- Add detailed information on the contractor's processes as it is made available.

- Improve the accuracy of the physical models used by HTWOS. Specific areas identified for improvement include the density correlations, charge balancing the streams (within the accuracy of the inventory estimates), modeling the percent water in the waste, detailed modeling of the solids behavior(solids density, voidage, and fluffed density), automating solubility calculations, and updating glass formulation models.

- The capability to sum HTWOS process streams to generate the process material balance.

- DST space allowance for the return of staged feed that does not meet the envelope criteria.

6.3 INTEGRATION OF MODELING EFFORTS

Future actions are planned to further integrate the use of the HTWOS model with the Operational Waste Volume Projection (OWVP) and to support programmatic planning, and to improve the accuracy and flexibility of the HTWOS model. These actions are described below.

The model and the capability to access the model using Telewindows is available to the Model and Inventory Group for their use in familiarizing themselves with the model. Next fiscal year the HTWOS model will be released to the Models and Inventory Group to be used in parallel with their official OWVP model. Numatec Hanford Corporation Process Development group personnel will work with OWVP personnel to support their use of the HTWOS model and to identify improvements to the model to make it easier to use for OWVPs. When the two models calculate similar results, the HTWOS model will become the official OWVP simulator providing full integration of the Feed Staging analysis with the OWVP analysis and the SST Retrieval Sequence analysis and producing the flowsheets and mass balances needed to communicate the results of the analyses.

The following actions are planned to support integration of these activities.

- Prepare a users manual for the HTWOS program. The manual will describe the features of the model, some of the bases for calculations performed by the model, and a summary of the verification and validation performed on the model.

- Automate the selection of waste transfer destination tanks.

- Place the model under configuration management. Some verification and validation (V&V) of the model has been performed this fiscal year and V&V will continue as changes are made to the model. Test cases will be prepared to support users needs.

- Continue to use consistent bases and assumptions for the analyses.

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7.0 REFERENCES

Agnew, S. M., P. Baca, R. Corbin, K. Jurgensen, and B. Young, 1995, *Tank Layer Model (TLM) for Northeast, Southwest, and Northwest Quadrants*, LAUR-94-4269 Revision 1, February, 1995, Los Alamos National Laboratory, Los Alamos, New Mexico.

Agnew, S. F., 1996, *History of Organic Carbon in Hanford High-Level Waste Tanks: Hanford Defined Waste Model Rev. 3*, LA-UR-96-989, Los Alamos National Laboratory, Los Alamos, New Mexico.

Barney, G. S., 1976, *Vapor-Liquid-Solid Phase Equilibria of Radioactive Sodium Salt Wastes at Hanford*, ARH-ST-133, Atlantic Richfield Company, Richland, Washington.

Berry, J. B., 1997, Compilation of Interface Control Documents, Recommendations to Resolve Open Issues, Plans to Resolve All Remaining Interface Issues, HNF-SP-1227, (DRAFT), Lockheed Martin Hanford Corporation, Richland, Washington.

Boston, H. L., 1997, *Subcontract Number 80232764-9-K001, Interim Issue of Waste Feed Delivery Mid-Level Logics,* letter to A. M. Umek, LMHC-9756006 (August 4), Lockheed Martin Hanford Corporation, Richland, Washington.

Brooks, K. P., J. R. Phillips, R. L. Meyers, K. G. Rappe, D. R. Rector, and P. A. Smith, 1996a, *TWRS Low-Level Waste Addback Program, Sludge Pretreatment Studies Using Hanford Tank C-107*, PNNL Letter Report to D. J. Washenfelder, (September 30), Pacific Northwest National Laboratory, Richland, Washington.

Brooks, K. P., R. L. Meyers, and K. G. Rappe, 1996b, *Bench-Scale Enhanced Sludge Washing and Gravity Settling of Hanford Tank C-106 Sludge*, PNNL-11432, Pacific Northwest National Laboratory, Richland, Washington.

Certa, P. J., W. H. Grams, C. M. McConville, L. W. Shelton, and E. J. Slaathaug, 1996, *Low-Level Waste Feed Staging Plan*, WHC-SD-WM-RPT-224, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Claghorn, R. D., J. D. Galbraith (NHC), T. B. Salzano, R. M. Marusich, E. L. Dalpiaz, and A. N. Palit (FDNW), 1996, *Alternatives Generation and Analysis for Double-Shell Tank System Phase I Waste Preparation Equipment*, HNF-SD-TWR-AGA-002, Rev. 0, Numatec Hanford Corporation, Richland, Washington.

Colton, N. G., 1996, *Status Report: Pretreatment Chemistry Evaluation - Wash and Leach Factors for Single-Shell Tank Waste Inventory*, PNNL-11290, Pacific Northwest National Laboratory, Richland, Washington.

Colton, N. G., 1997, *Status Report: Pretreatment Chemistry Evaluation FY 1997--Wash and Leach Factors for the Single-Shell Tank Waste Inventory*, PNNL-11646, Pacific Northwest National Laboratory, Richland, Washington.

DOE-RL, 1996, *Phase I Request for Proposal*, U.S. Department of Energy, Richland, Washington.

Ecology, EPA, and DOE, 1994, *Hanford Federal Facility Agreement and Consent Order*, as amended, Washington State Department of Ecology, U.S. Environmental Protection Agency, and the U.S. Department of Energy, Olympia, Washington.

Fowler, K. D., 1995a, *Data Quality Objectives for Tank Farms Waste Compatibility Program*, WHC-SD-WM-DQO-001, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Fowler, K. D., 1995b, *Tank Farm Waste Compatibility Program*, WHC-SD-WM-OCD-015, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Galbraith, J. D., T. B. Salzano, and J. R. Nicholson, 1996, *Decision Document for Phase I Privatization Transfer System Needs*, WHC-SD-WM-TI-750, Revision 0, Westinghouse Hanford Company, Richland, Washington .

Grams, W. H., 1995, *Double-Shell Tank Retrieval Allowable Heel Trade Analysis*, WHC-SD-WM-TA-162, Revision 0, Westinghouse Hanford Company, Richland, Washington.

Greenburg, A. E. 1992, *Standard Methods for the Examination of Water and Wastewater*, Procedure 2710E, 18th Edition, American Public Health Association, Washington, D.C.

Herting, D. L. and R. M. Cleavenger, 1983, *Solubility Phase Diagram - Final Report*, SD-WM-TI-078, Rockwell Hanford Operations, Richland, Washington.

Herting, D. L., T. Welsh, and D. A. Reynolds, 1986, *Gibbsite Equilibrium in Simulated Liquid Waste*, SD-WM-TI-211, Rockwell Hanford Operations, Richland, Washington.

Herting, D. L., 1990, *Process Aids 1985 Compilation of Technical Letters,* WHC-IP-0711, Volume 17, Westinghouse Hanford Company, Richland, Washington.

Hodgson, K. M., 1995, *Tank Characterization Report for Double-Shell Tank 241-AZ-101*, WHC-SD-WM-ER-410, Revision 0, Westinghouse Hanford Company, Richland, Washington.

Hodgson, K. M. and M. D. LeClair, 1996, *Work Plan for Defining a Standard Inventory Estimate for Wastes Stored in Hanford Site Underground Tanks*, WHC-SD-WM-WP-311, Rev. 1, Lockheed Martin Hanford Corporation, Richland, Washington.

Hrma et al., 1994, *Property/Composition Relationships for Hanford High-Level Waste Glasses Melting at 1150 °C*, PNL-10359, Pacific Northwest Laboratory, Richland, Washington

Kupfer, M. J., A. L. Boldt, B. A. Higley, K. M. Hodgson, L. W. Shelton, B. C. Simpson, and R. A. Watrous (LMHC), S. L. Lambert, and D. E. Place (SESC), R. M. Orme (NHC), G. L. Borsheim (Borsheim Associates), N. G. Colton (PNNL), M. D. LeClair (SAIC), R. T. Winward (Meier Associates), and W. W. Schulz (W^2S Corporation), 1997, *Standard Inventories of Chemicals and Radionuclides in Hanford Site Tank Wastes*, HNF-SD-WM-TI-740, Rev. 0, Lockheed Martin Hanford Corporation, Richland, Washington.

Lange, N. A., 1979, *Lange's Handbook of Chemistry*, Twelfth Edition, Edited by J. A. Dean, McGraw-Hill Book Company, New York, New York.

Lumetta, G. J., and B. M. Rapko, 1994, *Washing and Alkaline Leaching of Hanford Tank Sludges: A Status Report*, PNL-10078, Pacific Northwest Laboratory, Richland, Washington.

Lumetta, G. J., F.V. Hoopes, R. T. Steele, and M. J. Wagner, 1996, *Washing and Caustic Leaching of Hanford Tank C-106 Sludge*, PNNL-11381, Pacific Northwest National Laboratory, Richland, Washington.

Manuel, A. F., S. L. Lambert, and G. E. Stegen, 1996, *Phase I High-Level Waste Pretreatment and Feed Staging Plan*, WHC-SD-WM-ES-370, Rev. 1, Westinghouse Hanford Company, Richland, Washington.

Manuel, A. F., 1997, Alternatives Generation and Analysis for the Phase I High-Level Waste Pretreatment Process Selection, HNF-SD-TWR-AGA-003, Rev. 0, Numatec Hanford Corporation, Richland, Washington.

McCabe, W. L. and J. C. Smith, 1976, *Unit Operations of Chemical Engineering*, Third Edition, McGraw-Hill Book Company.

Orme, R. M., 1995, *TWRS Process Flowsheet*, WHC-SD-WM-TI-613, Revision 1, Westinghouse Hanford Company, Richland, Washington.

Orme, R. M., A. F. Manuel, L. W. Shelton and E. J. Slaathaug, 1996, *TWRS Privatization Process Technical Baseline*, WHC-SD-WM-TI-774, Revision 0, Westinghouse Hanford Company, Richland, Washington.

Papp, I. G., 1997, *Technical Baseline Description of High-Level Waste and Low-Activity Waste Feed Mobilization and Delivery*, HNF-SD-TWR-TM-001, Rev. 0, Numatec Hanford Corporation, Richland, Washington.

Patello, G. K., L. Lauerhass, R. L. Meyers, and K. D. Wiemers, 1996, *Low-Activity Waste Envelope Definitions for the TWRS Privatization Phase I Request for Proposal*, PNNL-11108, Pacific Northwest National Laboratory.

Penwell, D. L., C. E. Grenard, R. S. Wittman, 1996, *Initial Retrieval Sequence and Blending Strategy*, WHC-SD-WM-RPT-229, Revision 0, Westinghouse Hanford Company, Richland, Washington.

PHMC, 1997, *Unclassified Operating Specifications for the 241-AN, AP, AW, AY, AZ, and SY Tank Farms,* OSD-T-151-00007, Fluor Daniel Hanford, Richland, Washington.

Powell, M. R., G. R. Golcar, C. R. Hymas, and R. L. McKay, 1995, *Fiscal Year 1993 1/25-Scale Sludge Mobilization Testing*, PNL-10464, Pacific Northwest Laboratory, Richland, Washington.

Rapko, B. M., G. J. Lumetta, and M. J. Wagner, 1995, *Washing and Caustic Leaching of Hanford Tank Sludges: Results of FY 1995 Studies*, PNL-10712, Pacific Northwest Laboratory, Richland, Washington.

Rapko, B. M., and M. J. Wagner, 1997, *Caustic Leaching of Composite AZ-101/AZ-102 Hanford Tank Sludge*, PNNL-11580, Pacific Northwest National Laboratory, Richland, Washington.

Reynolds, D. A., 1995, *Practical Modeling of Aluminum Species in High-pH Waste*, WHC-EP-0872, Westinghouse Hanford Company, Richland, Washington.

Reynolds, D. A. and D. L. Herting, 1984, *Solubilities of Sodium Nitrate, Sodium Nitrate, Sodium Nitrite, and Sodium Aluminate in Simulated Nuclear Waste*, RHO-RE-ST-14P, Rockwell Hanford Operations, Richland, Washington.

Sasaki, L. M., 1996, *Tank Characterization Report for Double-Shell Tank 241-AY-102*, WHC-SD-WM-ER-454, Revision 0-A, Westinghouse Hanford Company, Richland, Washington.

Schreiber, R. D., 1995, *Tank Characterization Report for Double-Shell Tank 241-AZ-102*, WHC-SD-WM-ER-411, Revision 0-A, Westinghouse Hanford Company, Richland, Washington

Shelton, L. W., 1996a, Tank Waste Remediation System Baseline Tank Waste Inventory Estimates for Fiscal Year 1995, WHC-SD-WM-TI-784, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Shelton, L. W., 1996b, *Projected Double-Shell Tank Supernatant Compositions for Phase I Privatization*, WHC-SD-WM-TI-751, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Slaathaug, E. J., A. L. Boldt, and K. D. Boomer, 1996, *Tank Waste Remediation System Optimized Processing Strategy*, WHC-SD-WM-TI-694, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

Sloughter, J. P., and W. C. Miller, 1996, *Path Forward for Low Hydroxide Issue in Tank 241-AN-102*, Internal Memo to W. E. Ross, letter numbers 74A00-96-006 and 74F00-96-016, September 17, 1996, Westinghouse Hanford Company, Richland, Washington.

Sterner, S. M., J. R. Rustad and A. R. Felmy, 1996, *The Hanford Thermochemical Databank: v 1.00 With Parameters for the ESP and Pitzer Models*, Pacific Northwest National Laboratory, Richland, Washington.

Strode, J. N., and V. C. Boyles, 1997, Operational Waste Volume Projection, HNF-SD-WM-ER-029, Rev. 23, Lockheed Martin Hanford Corporation, Richland, Washington.

Temer, D. J., and R. Villarreal, 1995, *Sludge Washing and Alkaline Leaching Tests on Actual Hanford Tank Sludge: A Status Report*, LAUR-95-2070, Los Alamos National Laboratory, Los Alamos, New Mexico.

Temer, D. J., and R. Villarreal, 1996, *Sludge Washing and Alkaline Leaching Tests on Actual Hanford Tank Sludge: A Status Report*, LAUR-96-2839, Los Alamos National Laboratory, Los Alamos, New Mexico.

Temer, D. J., and R. Villarreal, 1997, *Sludge Washing and Alkaline Leaching Tests on Actual Hanford Tank Sludge: A Status Report*, LAUR-97-2889, Los Alamos National Laboratory, Los Alamos, New Mexico.

Wefers, K. and C. Misra, 1987, *Oxides and Hydroxides of Aluminum, Alcoa Technical Position Paper No. 19, Revised*, Alcoa Laboratories.

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