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HANFORD TANK WASTE OPERATIONS SIMULATOR MODEL (HTWOS) VERSION 3.0 VERIFICATION AND VALIDATION REPORT

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Abstract: This test report describes the methodology and results of the verification and validation (V&V) of version 3.0 of the Hanford Tank Waste Operations Simulator (HTWOS) model. A team of modeling personnel and staff performed the verification and validation based on their area of expertise. The results of the V&V effort are discussed in section 3.0, and issues and future model improvements are discussed in section 4.0.

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HANFORD TANK WASTE OPERATIONS SIMULATOR MODEL (HTWOS) VERSION 3.0 VERIFICATION AND VALIDATION REPORT

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Executive Summary

This test report describes the methodology and results of the verification and validation (V&V) of version 3.0 of the Hanford Tank Waste Operations Simulator (HTWOS) model. Verification and validation of the model is necessary to ensure the model incorporates the intended basis, functionalities, features, and assumptions. Many model improvements and changes have been made to the model since earlier verification and validation efforts. The test plan for this V&V effort is documented in RPP-39524, *Hanford Tank Waste Operations Simulator Model Fiscal Year 2009 Verification and Validation Test Plan* and provided the general methodologies, test cases, assumptions, and acceptance criteria for the V&V effort.

This V&V effort focused on the following key areas:

- HTWOS core functions which have been modified since previous verification efforts (Liquid Specific Gravity, Reaction Definitions, Traceback Function, Wet Solids Calculation, and Glass Formulation),
- Key Model Calculations,
- Model Inputs
- Modeled Processes (eg. Waste Treatment Plant, 242-A Evaporator, Single Shell Tank Retrieval, etc.),
- All Model Assumptions,
- HTWOS to Excel data reporting and analysis,
- Mass Balance Totalizers and Summary Mass Balance Reporting, and
- Overall "Mission" analysis

In addition the final HTWOS version 3.0 was rerun on two computers to show repeatability of results.

The assumptions used to define HTWOS Version 3.0 were the same assumptions used in ORP-11242, Rev. 3A, *River Protection Project System Plan* with some changes that are identified in Section 1.3. The changes resulted from model development occurring after the completion of the River Protection Project System Plan Rev. 3A modeling effort.

A team of modeling personnel and staff performed the verification and validation based on their area of expertise. Preliminary model runs were performed to test the changes or to verify that assumptions were correctly incorporated, preliminary run results were checked, the model was changed to resolve issues or deficiencies, and new preliminary runs were performed. This continued until the modeling deficiencies were corrected or until it was determined that the remaining deficiencies were quantifiable and could be corrected in future model versions.

The results of the V&V effort are discussed in section 3.0, and issues and future model improvements are discussed in section 4.0.

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List of Terms

List of Terms

Assumption: The term "assumption" refers to engineering inputs or bases for the Hanford Tank Waste Operations Simulator (HTWOS) that are supplied by the facilities based on their future operational plans (e.g., determined by budget, U.S. Department of Energy directive, Tri-Party Agreement milestones [Ecology et al., 1996]). Typical assumptions include operating schedules, process flowsheets, waste generation rates, stream compositions, and modes of operation.

Chief Modeler. A qualified Process Engineer assigned the responsibility for maintaining, improving, and updating the HTWOS model. The Chief Modeler is the central point of contact for incorporating all version module changes.

Interim Model Version: An Interim Model Version is a verified version of the HTWOS model containing a minor amount of model changes (compared to the last reference version) that are anticipated to be incorporated into the next Major Model Version. The Chief Modeler and the manager of the Processing Engineering group together determine whether an HTWOS model change results in an Interim Model Version or a Major Model Version. Typically, the verification of an Interim Model Version is documented in an HTWOS model data package.

Major Model Version. A major model version is verified reference set of assumptions and model logic that define the retrieval, staging, and treatment of the Hanford tank waste. Typically, Major Model Versions have been thoroughly verified with the verification documented in a verification and validation test plan and report. The latest Major HTWOS Model Version is described in the *Hanford Tank Waste Operations Simulator Model Design Document* (RPP-17152).

Model Modification. A model modification is a change to the HTWOS model. A model modification may be as simple as changing the value of a single parameter or as complex as changing the model logic or adding new process workspaces.

Modeling Process Engineers. A process engineer within the Process Modeling Organization assigned to work on HTWOS modeling.

Model Run. A single execution of the model to simulate the retrieval, staging, and treatment of Hanford Tank waste.

Model Scenario: A series of HTWOS model runs performed to evaluate the impact of changed RPP mission assumptions on the cleanup of the Hanford tank wastes. The HTWOS model runs used to develop a model scenario can include preliminary runs performed to test and verify model changes, a final run configures with the desired assumptions, and "alternative" runs performed to test the impact of specific assumption changes on the final run results.

Released Model Version. A version of the model that has undergone verification and validation and has been released for project use. Release versions may be major model versions or interim model versions.

Validation. Validation is defined as the evaluation of the model to confirm that:

- The model meets the process design requirements,
- The data accurately reflects the process being simulated, and
- The model produces results in the range of its intended use.

Verification. Verification is defined as the review or testing performed at the completion of a model run or change implementation to confirm that the information has been correctly implemented and that the model executed properly. Verification is performed by a process modeling engineer to provide an independent check.

Abbreviations and Acronyms

BARD	Bases, Assumptions, and Requirements Document
BBI	Best-Basis Inventory
BV	Bulk Vitrification
CH	Contact Handled
CH-TRU	Contact Handled Transuranic
CsIX	Cesium Ion Exchange
DBVS	Demonstration Bulk Vitrification System
DST	Double-Shell Tank
G2	Modeling Software by Gensym, Corporation.
HGR	Hydrogen Generation Rate
HLW	High-Level Waste
HTWOS	Hanford Tank Waste Operations Simulator
HTWOS2XL	Hanford Tank Waste Operations Simulator to Excel Interface
LAW	Low-Activity Waste
MDD	Model Design Document
NLP	non-linear programming
ORP	U.S. Department of Energy, Office of River Protection
RH-TRU	Remote Handled Transuranic
RPP	River Protection Project
SBS	Submerged Bed Scrubber
SP	System Plan
SST	Single-Shell Tank
STP	Supplemental Treatment Plant
TFCOUP	Tank Farm Contractor Operation and Utilization Plan
TWINS	Tank Waste Information Network System
TOC	Tank Farm Operations Contractor
TRU	Transuranic

URID	Unique Run Identification Number
V&V	Verification and Validation
V&V'd	Verified and validated
VB	Visual Basic
WRPS	Washington River Protection Solutions
WTP	Waste Treatment and Immobilization Plant

1.0 INTRODUCTION

The purpose of this test report is to describe the methodology and results of the verification and validation (V&V) of version 3.0 of the Hanford Tank Waste Operations Simulator (HTWOS) model. Verification and validation of the model is necessary to ensure the model incorporates the intended basis, functionalities, features, and assumptions. Many model improvements and changes have been made to the model since earlier verification and validation efforts. The test plan for this V&V effort is documented in RPP-39524, *Hanford Tank Waste Operations Simulator Model Fiscal Year 2009 Verification and Validation Test Plan* and provided the general methodologies, test cases, assumptions, and acceptance criteria for the V&V effort.

1.1 BACKGROUND

The HTWOS model is a dynamic event driven simulation that is used to predict and track the movement of tank waste throughout the River Protection Project (RPP) mission and includes storage, retrieval, processing, and disposal of the Hanford tank wastes. The HTWOS model is used to predict the movements of waste through the RPP system to form the technical basis for project schedules and programmatic planning. The HTWOS model uses the [1]G2® software manufactured by Gensym, Corporation. Most results from the HTWOS model are downloaded into verified [2]Mircosoft®, Excel file templates via a custom developed software application named HTWOS to Excel Interface (HTWOS2XL), a Visual Basic (VB) application developed under [3]Visual Studio 2005® using the .NET[4] programming framework.

The HTWOS previous verification and validation has been completed and documented in separate efforts. The HTWOS model assumptions are formally verified as part of each formalized run in the associated report or data package (e.g., ORP-11242, *River Protection Project System Plan*). Many of the HTWOS technical bases were previously validated and described in detail in Appendix A of HNF-SD-WM-SP-012, *Tank Farm Contractor Operation and Utilization Plan* (TFCOUP). In addition, verification and validation of the nine core functions was performed in 2004 and documented in RPP-18592, *Hanford Tank Waste Operations Simulator Software Verification and Validation Plan and Results*. Also many of the model calculations and procedures have been informally verified in the past but those verifications were not always documented. This report is intended to document the overall verification and validation of the current HTWOS model.

A recent internal unpublished assessment of the HTWOS modeling procedures and configuration control found several deficiencies and misalignments between modeling practices and

[1]Gensym and G2 are registered trademarks of Gensym Corporation. All other trademarks are property of their respective owners.
[2] Microsoft® Excel is a trademark of Microsoft Corporation in the United States and other countries.
[3] Visual Studio 2005® is trademark of Microsoft Corporation in the United States and other countries
[4] The Microsoft .NET programming framework is a software framework that manages a program's runtime requirements to provide security, memory management, and exception handling. Visual Basic programs written under the .NET frame work are sometimes referred to as VB.NET programs.

procedures. It found that there is no specific baseline or "reference" version of the model against which changes can be made and documented. Currently, reference models are created for each formal run and the results are documented in published reports. Since the last formal run (that was made to support the preparation of ORP-11242, changes have been made to the model to improve and enhance its performance, prompting this effort to establish a reference version of the model. The major changes to the model since the System Plan Rev. 3A are discussed in the test plan, RPP-39524. Version 3.0 is "locked down" and archived. Future model scenarios will be built off this major released version of the model until a new major version is established which will prompt a new V&V effort.

1.2 VERIFICATION AND VALIDATION SCOPE

Figure 1 depicts the overall flowsheet modeled in HTWOS. The assumptions which define each process were verified and the overall systems were validated, except for the following processes:

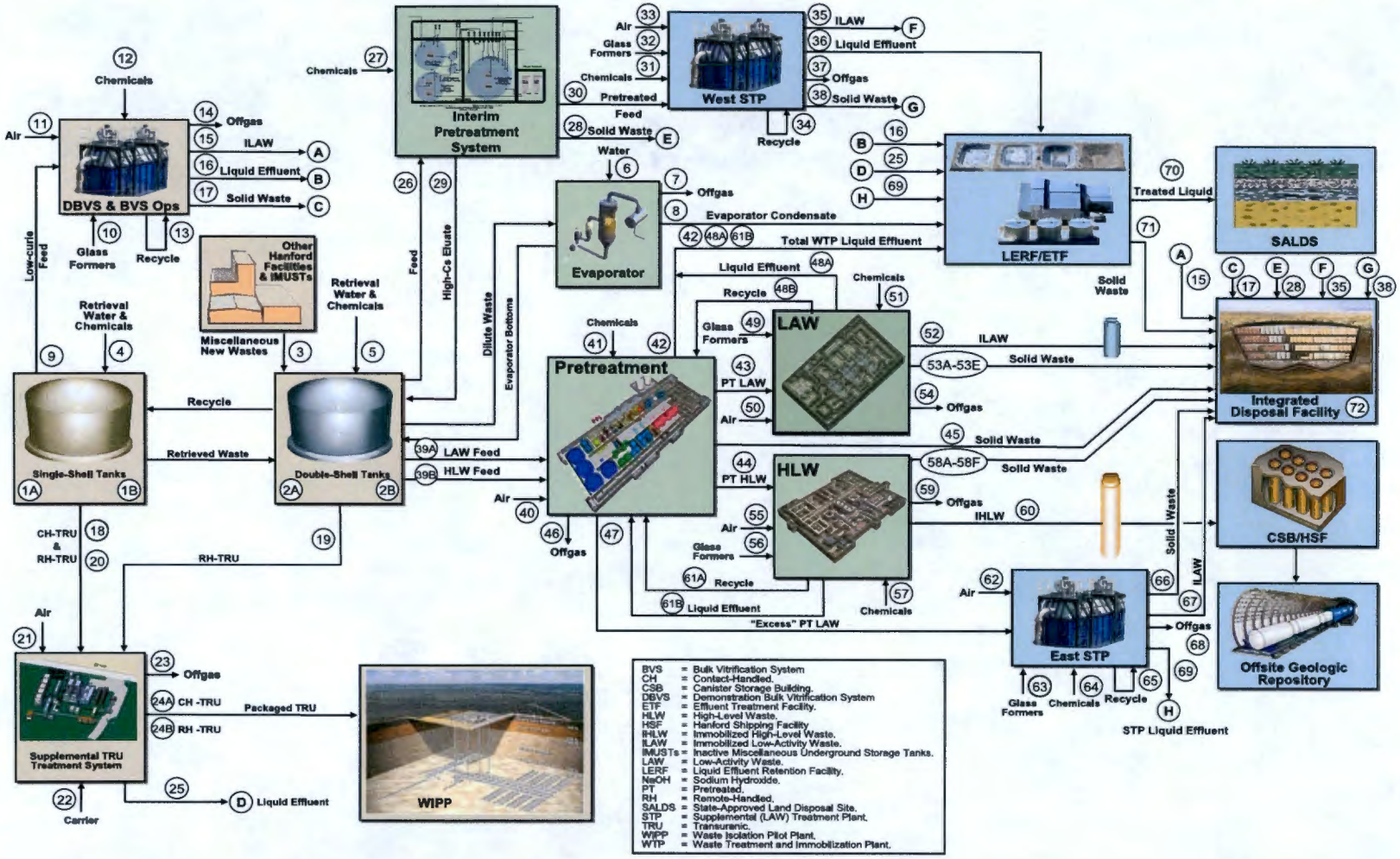
- Demonstration Bulk Vitrification System (DBVS) and Bulk Vitrification System (BVS).
- Remote Handled Transuranic (RH-TRU) Feed Staging
- East and West Supplemental Treatment Processes (STP)
- Selective Dissolution retrieval of SST was not verified or ran for Version 3.0.

These processes were excluded from the V&V due to RPP-mission baseline changes and anticipated future needs.

In addition, obsolete features built in the model which are no longer used, were not verified and validated (V&V'd). These features include unused legacy code, a complete Effluent Treatment Facility model, the original Waste Treatment and Immobilization Plant (WTP) model, old glass formulation models, the Fractional Crystalization Model, the Caustic Recovery Model, the Aluminum Lithium Precipitation Model and the detailed double-shell tank (DST) routings. If and when these process and features are used within the HTWOS, they will require V&V at that point.

Specific items included in the scope of this V&V activity are discussed in the subsections below.

Figure 1 HTWOS Flowsheet



1.2.1 Core Functions

Nine core functions have been identified through professional judgment as being essential to the HTWOS model (See Table 1). These core functions were previously verified in 2004 and that verification was documented in RPP-18592, *Hanford Tank Waste Operations Simulator Software Verification and Validation Plan and Results*. Five of these core functions; Liquid Specific Gravity, Reaction Definitions, Glass Formulation, Traceback Function, and Wet Solids Calculation have been changed during recent model upgrades so these five core functions were verified as part of this effort.

Table 1. HTWOS Core Function.

HTWOS Core Function	Included in this V&V
Liquid Specific Gravity	Yes
Reaction Definitions	Yes
Mass Balance	No
Concentrator Procedure	No
Pump Procedure	No
Glass Formulation	Yes
Radionuclide Decay	No
Traceback Function	Yes
Wet Solids Calculation	Yes

1.2.2 Model Calculations

The major model calculations listed below were verified and validated to ensure that the model correctly performed the calculation. These calculations have been informally verified in the past but those verifications were not documented. The calculations are being verified and documented under this effort. Details about the verification and validation of these calculations can be found in Section 3.2.

- Total Blend/No Blend Calculation
- WTP Feed Specification 7 Parameters
- WTP Feed Specification 8 Parameters
- WTP Feed Hydrogen Generation Rate (HGR) Parameters
- Split Calculations for Selected Model Objects

1.2.3 Model Inputs

Data used as input to the HTWOS model was verified to ensure that the values in the model accurately reflected the source documentation. The specific model inputs that were verified were:

- Initial Waste Inventory
- Water Wash and Caustic Leach Factors

- Physical Constants (Molecular Weight [MW], Liquid Specific Gravity [SpG] Factors, Half life, and Specific Activity).
- Process Split Factors
- Tank Volumes
- Reactions and Extent of Reactions

Details about the verification and validation of these model input data can be found in Section 3.3.

1.2.4 Modeled Processes

Specific processes within the model were examined to verify that HTWOS is correctly simulating the process operation. Processes were also validated to ensure that they were modeled representatively. The processes which were reviewed are as follows:

- WTP Pretreatment
- WTP LAW Submerged Bed Scrubber (SBS)
- WTP LAW Glass Formulation
- WTP LAW Melter
- WTP HLW Glass Formulation
- WTP HLW Melter
- 242-A Evaporator
- In Tank Sr/TRU Pretreatment
- SST Retrieval
- DST Waste Feed staging and Delivery
- Contact Handled (CH) TRU

Details about the verification and validation of these modeled processes can be found in Section 3.4.

1.2.5 HTWOS2XL Data Reporting and Analysis

The HTWOS2XL application is a VB.NET program written to transfer data from objects within the HTWOS model to verified Excel spreadsheets to speed up the reporting and analysis of data from the model. Currently, HTWOS2XL creates twelve Excel spreadsheets when it is called by the HTWOS model at the end of a model run. The HTWOS2XL application was tested during its initial development but that testing was not documented so the HTWOS2XL application was verified and the verification documented as part of this effort. Selected data downloaded to the Excel template files by the HTWOS2XL application was compared to the same data reported from the model by an alternate reporting method. Details about the verification and validation of the HTWOS2XL application can be found in Section 3.5. The Excel template files that are used by the HTWOS2XL application were developed and verified per procedure (TFC-ENG-DESIGN-C-32, *Spreadsheet Development and Verification*) and did not require a repeat of the verification. Any changes made to the Excel template files during the course of this V&V effort were verified in accordance to TFC-ENG-DESIGN-C-32.

1.2.6 Mass Balance Summary, Reporting, and Results

The mass balance reporting of activity, mass balance data, and stream number assignments were verified during this V&V. The mass balance results were examined and significant imbalances are discussed. Details about the verification and validation of the mass balance reporting can be found in Section 3.6.

1.2.7 Overall Model Validation and Repeatability

Model results from various preliminary runs and from the final model run were compared against the results from ORP-11242, Rev. 3A to provide insight during the V&V effort and for information about the difference between the model runs, respectively. A summary of major insights obtained from comparing results from the preliminary and final V&V model runs to the ORP-11242, Rev. 3A model run can be found in Section 3.7, along with a tabular comparison of the results from the final model run to the ORP-11242, Rev. 3A model run. In addition the final model run was rerun on two different computers to confirm that the model can produce repeatable results. Details about the results from the repeat of the model run can be found in Section 3.8.

1.3 SUMMARY OF ASSUMPTIONS

The assumptions used to define Version 3.0 were the same as the assumptions used in ORP-11242 with the changes shown in Table 2, which changes evolved from model development occurring after the completion of the RPP System Plan Rev. 3A modeling effort.

Table 2. Assumption Variations from RPP-System Plan Rev. 3A.

Assumption	Change	Reason for Changing
Minimum DST Levels	Changed the minimum DST levels to 12 inches above the bottom of the tank or above a settled solids layer.	Only one DST attribute is available to control how far down pumping is allowed when removing waste from a tank or when decanting liquids above a settled solids layer.
SST retrieval history and status & Near-term retrieval sequence	Changed the assumptions to match the HTWOS model which resulted from schedule updates.	Near-term schedules were updated.(RPP-21216, *Single-Shell Tank Retrieval selection and Sequence*, Rev. 3A)
SST waste residuals	Revised the assumptions to match the Ecology case (RPP-RPT-39276, *HTWOS Model Data Package for M45-02N Ecology Case*); 12 ft^3 (90 gallons) for the 200-series SSTs and 290 ft^3 (2,169 gallons) for the 100-series SSTs.	The V&V runs branched from the Ecology case and it was more efficient to update the assumption values than to modify the values in the model.
242-A Evaporator shutdown and Availability	Deleted the evaporator outages.	The near-term schedule was updated and the new schedule conflicts with the assumed outages so the outages were removed as a constraint.
HLW feed delivery	Deleted the requirement to deliver 90% of the AY-102 solids for hot commissioning.	The actual requirement is to provide enough HLW feed to keep the melter operating at full capacity during the hot commissioning period.

The resulting detailed assumption set is presented in Appendix A.

2.0 VERIFICATION AND VALIDATION STRATEGY

Verification and validation of HTWOS ensures that functional requirements of the model are satisfied and that the model represents the assumed mission. Figure 2 depicts the overall V&V process. The V&V process is an iterative process, in which deficiencies or errors are identified, than the model is corrected, and than the model is rerun. This continues to the point where it is determined that the model is accurate and representative. Not all issues were corrected within the schedule of this V&V and some issues or deficiencies identified during this effort will be addressed in the future (Section 4.0). A team of engineers participated in the V&V; Table 3 shows the scope and personnel assignments. Details of the V&V activities, results, and conclusions are discussed in Section 3.0.

2.1 MODEL RUNS

As shown in Figure 2, preliminary runs were performed to test the changes or to verify that assumptions were correctly incorporated, preliminary run results were checked, the model was changed to resolve issues or deficiencies, and new preliminary runs were performed. This continued until the modeling deficiencies were corrected or until it was determined that the remaining deficiencies could (and should) be corrected in future model runs. Table 4 below lists the progression of the preliminary and final model runs. The final model run was V and V-3.0-8.4r0-2009-01-16-at-00-40-11, completed on January 16, 2009. Two additional runs were completed after that for the repeatability study portion of the test.

2.2 MODEL OUTPUT

Nine of the spreadsheets generated by the HTWOS2XL application were formally verified to support the V&V of the model. In addition, a mass balance graphic file was created to facilitate the presentation of results. These ten verified spreadsheets are listed below:

- SVF-1641, *Balance_Graphic_V and V-3.0-8.4r0-2009-01-16-at-00-40-11.xls*
- SVF-1642, *DST_Plots_V and V-3.0-8.4r0-2009-01-16-at-00-40-11_M1.xls*
- SVF-1643, *Mass_Balance_V and V-3.0-8.4r0-2009-01-16-at-00-40-11_M1.xls*
- SVF-1644, *Product_Plots_V and V-3.0-8.4r0-2009-01-16-at-00-40-11_M1.xls*
- SVF-1645, *SST_Retrieval_V and V-3.0-8.4r0-2009-01-16-at-00-40-11_M1.xls*
- SVF-1646, *Transfers_V and V-3.0-8.4r0-2009-01-16-at-00-40-11_M1.xls*
- SVF-1649, *WTP_HGR_Limits_V and V-3.0-8.4r0-2009-01-16-at-00-40-11.xls*
- SVF-1650, *WTP_Spec_7_V and V-3.0-8.4r0-2009-01-16-at-00-40-11_M1.xls*
- SVF-1651, *WTP_Spec_8_V and V-3.0-8.4r0-2009-01-16-at-00-40-11_M1.xls*
- SVF-1652, *WTP_Traceback_V and V-3.0-8.4r0-2009-01-16-at-00-40-11_M1.xls*

Figure 2. Overall Verification & Validation Activities

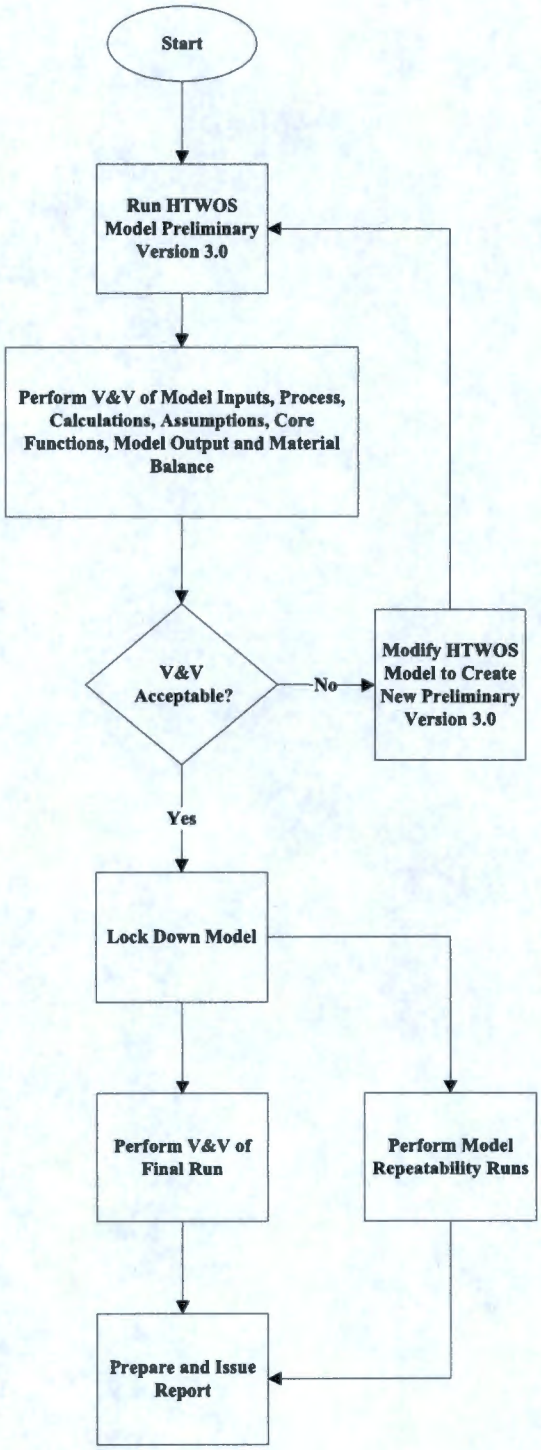


Table 3. Verification Responsibility Assignments. (2 Sheets)

Item/Object Being Verified	Verification Scope/Notes	Assigned To
	Core Functions	
Liquid Specific Gravity	Verify the calculation of the liquid specific gravity.	T. M. Hohl
Reaction Definitions (RSTOIC)	Verify that the RSTOIC procedure correctly implements reactions when called.	G. K. Allen
Traceback Function	Verify that the Traceback function correctly tracks waste from its source tank to a particular WTP feed batch.	R. L. Lytle
Wet Solids Calculation	Verify that the wet solids procedure correctly calculates a bulk settled solids volume.	G. K. Allen
	Model Calculations	
Total Blend/No-Blend Calculation	Verify the user interface, proper application of pretreatment operations, proper aggregation of the total blend, and inspect a series of test cases for consistency.	P. J. Certa R.L. Lytle G.K. Allen
WTP Feed Specification 7 Parameters	Verify that the model correctly calculates the parameters.	M.J. Rogers
WTP Feed Specification 8 Parameters	Verify that the model correctly calculates the parameters.	M.J. Rogers
WTP Feed Hydrogen Generation Rate (HGR) Parameters	Verify that the model correctly calculates the parameters.	M.J. Rogers
Representative Model Objects	Verify that the split calculations are correctly performed for selected classes of model objects using data from several time steps for each object, when possible.	R. L .Lytle
Model Inputs		
Initial Waste Inventory	Verify that input data is correctly input to the model by comparing the input data files to data reported from the model. Verification needs to check that each tank's inventory is correct.	T. M. Hohl
Wash and Leach Factors	Verify that input data is correctly input to the model by comparing the input data files to data reported from the model. Verification needs to check that each tank's wash and leach factors are correct.	T. M. Hohl
Molecular Weight, Liquid Specific Gravity Factor, Half-Life, and Specific Activity Table	Verify that the correct atomic masses (molecular weights), liquid specific gravity factors, half-lives, and specific activities are used in the model.	T. M. Hohl
Process Split Factors	Verify that the splits being used are consistent with the cited source.	R. M. Lowy
Tank Volumes	Verify that the maximum, minimum, and heel volumes are correct.	R. M. Lowy
Reactions and Extent of Reactions	Verify that the reactions and extents of reactions being used are consistent with the cited sources.	R. M. Lowy
	Modeled Processes	
WTP Pretreatment Process	Verify correct calculation of the existing unit operations	J. G. Reynolds
WTP LAW Melter (including Glass Formulation)	Verify correct calculation of the existing unit operations including spent melters.	P. J. Certa T. M. Hohl Mike Thien
WTP HLW Melter (including Glass Formulation)	Verify correct calculation of the existing unit operations including spent melters.	P. J. Certa Mike Thien

Table 3. Verification Responsibility Assignments. (2 Sheets)

Item/Object Being Verified	Verification Scope/Notes	Assigned To
242-A Evaporator	Verify correct calculation of the existing unit operations	R. A. Kirkbride
In-Tank Sr/TRU Pretreatment	Verify correct calculation of the existing unit operations	J. N. Appel
SST Retrieval	Verify assumptions: use of Na and Solid Sort Lists, retrieval durations, and as-retrieved volumes	L. M. Bergmann
DST Waste Feed Staging & Delivery	Verify correct calculation of the existing operations	M. W. Leonard
Model Calculations and Reporting		
Mass Balance Totalizers/Summary Mass Balance Reporting	• Verify correct assignment of HTWOS streams for the purpose of reporting system and subsystem mass and activity balances. • Verify the correct reporting of activity and mass balance data.	R. A. Kirkbride
HTWOS2XL Data Reporting and Analysis	• Verify that the latest HTWOS2XL version has completed acceptance testing. • Verify that the template spreadsheet files have been verified. • Verify that the different types of data being obtained from the model are correctly provided to template spreadsheets by the HTWOS2XL application.	R. A. Kirkbride and T. M. Hohl
"Mission" Analysis (results)	Evaluate model results for mission anomalies	R. A. Kirkbride and P. J. Certa

Table 4. HTWOS Version 3.0 V&V Runs.

Iteration	Unique Run Identifier (URID)
1	Version 3.0-8.4r0-2008-11-11-at-07-41-37
2	Version 3.0-8.4r0-2008-11-15-at-05-04-53
3	Version 3.0-8.4r0-2008-11-16-at-07-34-28
4	Version 3.0-8.4r0-2008-11-18-at-07-18-03
5	Version 3.0-8.3r1-2008-11-18-at-10-02-54
6	Version 3.0-3.0-8.4r0-2008-11-19-at-00-06-08
7	V and V-3.0-8.4r0-2008-11-22-at-00-03-19
8	V and V-3.0-8.4r0-2008-12-02-at-00-55-41
9	V and V-3.0-8.4r0-2008-12-03-at-00-52-58
10	V and V-3.0-8.4r0-2008-12-06-at-15-06-24
11	V and V-3.0-8.4r0-2008-12-07-at-15-51-35
12	V and V-3.0-8.4r0-2008-12-15-at-07-26-08
13	V and V-3.0-8.4r0-2008-12-15-at-19-30-16
14	V and V-3.0-8.4r0-2008-12-16-at-04-55-02
15	V and V-3.0-8.4r0-2008-12-17-at-07-18-14
16	V and V-3.0-8.4r0-2008-12-18-at-07-00-01
17	V and V-3.0-8.4r0-2008-12-18-at-16-55-58
18	V and V-3.0-8.4r0-2008-12-19-at-01-56-35
19	V and V-3.0-8.4r0-2008-12-19-at-23-47-59
20	V and V-3.0-8.4r0-2008-12-30-at-01-08-09
21	V and V-3.0-8.4r0-2008-12-30-at-19-56-09
22	V and V-3.0-8.4r0-2009-01-02-at-23-55-28
23	V and V-3.0-8.4r0-2009-01-07-at-01-08-46
24	V and V-3.0-8.4r0-2009-01-08-at-01-08-54
25	V and V-3.0-8.4r0-2009-01-09-at-15-02-12
26	V and V-3.0-8.4r0-2009-01-10-at-02-24-25
27	V and V-3.0-8.4r0-2009-01-13-at-01-11-44
28	V and V-3.0-8.4r0-2009-01-14-at-00-50-31
29	V and V-3.0-8.4r0-2009-01-14-at-10-42-46
30	V and V-3.0-8.4r0-2009-01-14-at-15-12-30
31 (Final)	V and V-3.0-8.4r0-2009-01-16-at-00-40-11
1 (Repeatability)	V and V on RL Machine-3.0-8.4r0-2009-01-21-at-01-59-08
2 (Repeatability)	V and V on GKA Machine-3.0-8.4r0-2009-01-22-at-01-02-12

3.0 RESULTS

The results of each specific assumption are presented in the Assumption Matrix in Appendix A. The subsections below discuss the methodology and results for each general part of the V&V corresponding with Table 3.

3.1 CORE FUNCTIONS

3.1.1 Liquid Specific Gravity

The liquid specific gravity algorithm used in HTWOS is based on a calculation method documented in RPP-14767, *Hanford Tank Waste Operations Simulator Specific Gravity Model – Derivation of Coefficients and Validation*. The liquid SpG calculation was originally validated by comparison with actual measured densities (RPP-14767). Since the last verification and validation of the core functions (RPP-18592), changes in HTWOS have been made to the liquid SpG calculation procedure to improve the efficiency of the calculation. The actual SpG equations within the model have not changed; therefore the previous validation (RPP-14767) is still valid; however the changes in how the model performs calculations warrant that the operation of the SpG core function be verified.

The liquid SpG calculation performed in HTWOS was verified by an independent spreadsheet calculation. The independent external spreadsheet used to perform this verification is documented in SVF-1602, *HTWOS SpG Algorithm V&V 2008-12-03.xls*.

The comparison between the specific gravities calculated by HTWOS and those calculated independently by a spreadsheet shows that the two independently calculated values agree with each other to fifteen significant digits. Equality across the board verifies that HTWOS is correctly calculating the liquid SpG.

3.1.2 Reaction Definitions

The HTWOS model simulates chemical reactions that will occur during the retrieval, transfer, and treatment of the Hanford tank wastes. Reactions within HTWOS are stoichiometric with an assumed extent of reaction defining the reaction completion. Reaction kinetics are not modeled. HTWOS defines a reaction using special objects called reaction-definitions. A reaction-definition contains all the attributes to completely define the stoichiometry of a single chemical reaction. To minimize errors defining the attributes of each reaction-definition, standard procedures are used to load the desired reaction into a reaction-definition object. Chemical reactions are modeled by calling a standard procedure, RSTOIC, which performs the reaction defined by the reaction-definition provided to it. Multiple reactions are modeled by calling RSTOIC for each reaction-definition inside a separate calling procedure. RSTOIC calculates the desired reaction until one of two outcomes takes place. If enough reactants are present to satisfy the reaction-definition, the reaction is completed to the assumed extent of reaction. If any of the reactants are completely consumed before the extent of reaction is reached, the reaction stops based upon the limiting reactant. The chemical reactions for a given unit operation are performed in the order they are listed in the calling procedure.

HTWOS has a reaction checking tool that checks to see that each reaction is balanced. This tool also completes the reaction calculation based upon the set reaction conversion to see that the reaction conversion is correct. Checking all reactions can be done by selecting the "Check all reaction definitions" menu choice in the tools pop down menu at the top of the HTWOS screen. When selected, this tool iterates over all reaction-definition objects performing the defined reaction. If the starting mass before the reaction is not the same as the resulting mass after the reaction, an error message is logged identifying the problem reaction-definition and the mass difference between the start and the completion of the reaction. In addition, the checker records the comparison of the actual extent of reaction with the defined extent of reaction and enters an error message if these two numbers are not identical.

The reactions within the HTWOS model were checked using the reaction checking tool and the results from the reaction checker can be found in Table B-1 of Appendix B. This test confirmed that HTWOS is applying all reaction definitions correctly during the run. As shown there is one reaction-definition that is unbalanced out of 253 checked. HTWOS-OXIDATIVE-LEACH-CR-REACTION is a reaction used to approximate the oxidative leaching of chromium. It is off by two moles of oxygen in the product side of the reaction because the current permanganate compound that HTWOS carries for oxidative leaching is not the correct ionic form.
The test results verify that HTWOS performs the reaction-definitions correctly throughout a model run. HTWOS-OXIDATIVE-LEACH-CR-REACTION is used when oxidative-leaching in the WTP part of the model, but the reaction imbalance has no significant effect on results.

3.1.3 Traceback Function

The purpose of the HTWOS traceback function is to identify the origin of waste from any SST or DST during a simulation. The information traced is an array of the liquid and solid mass (kg) contributions from each of the 177 waste tanks. The starting conditions are the total washed solids mass and non-water liquid mass for each starting tank. The masses are updated during every transfer between tanks by the procedure 'start-pump' and by transfer between settled layers by the procedures 'mix_solid_layers', 'mix_top_solid_layer', 'make-next-solid-layer ' and 'mix_part_top_solid_layer. The updated traceback masses M'_{t1} and M'_{t2} for the sending array and receiving array respectively are calculated for each mass transfer according to

$$M'_{t2} = M_{t2} + M_{t1} M_p / M_1 \tag{1}$$

$$\text{and} \quad M'_{t1} = M_{t1} - M_{t1} M_p / M_1 , \tag{2}$$

where M_1 is the current total (solid or non-water liquid) mass in the sending array, M_p is the mass transferred, and M_{t1} and M_{t2} are the current sending array and receiving array traceback masses. The index "t" refers to one of the 177 tanks that contribute some fraction of its original mass across all other tanks present in a simulation. A separate array of traceback masses are tracked for both the solid and non-water liquid phase. Therefore, separate applications of equations (1) and (2) are made for both the solid and non-water liquid masses involved in a transfer. Conservation of the traceback mass is built in to equations (1) and (2). Additionally, it is assumed that the traceback mass phases are set after any initial dissolution and do not change for the remainder of the simulation. This is considered to be a reasonable approximation for *identifying* the sources of wastes contributing to a given tank.

The traceback function assumes that no significant phase changes occur as the wastes are transferred from the SSTs to the DSTs and to the treatment facilities. If the model is modified to improve the simulation of the waste chemistry (i.e., the precipitation or dissolution of solids as wstes are mixed) and a more accurate *quantification* of the traceback mass is required, the traceback function will need to be updated. For the application of flowsheet reporting, only the *identification* of contributing tanks is required to determine which transfers should be reported for specific tank retrieval and/or staging flowsheet. The traceback masses also serve as a guide for trouble shooting waste composition problems when a specific tank can be identified as the source.

Wash and leach factors are treated as a property of the waste and follow the waste during transfers. When two or more layers of waste are combined by mixing or transfer, the resulting wash and leach factors are the mass weighted average, by component, of the individual layers. For the combination of two layers the resulting property is calculated by the following

$$P_i = (P_{i1}M_{i1} + P_{i2}M_{i2})/(M_{i1} + M_{i2}) \quad (3)$$

Where P_i is the resulting property value for a component, P_{i1} and P_{i2} are the property values of the individual layers and M_{i1} and M_{i2} are the component masses for the component.

A test of the Traceback function should; 1) insure that the staring traceback masses for each tank equals the starting water-washed solids and non-water liquid phase masses, 2) insure that the traceback masses from each source tank are conserved, 3) verify that the traceback masses for a series of example activities (including waste transfers, solids settling, and tank mixing) correctly implement the conservation equations described above.

Test 1 was made by recording the snapshot data of each tank after the wash factors were applied. Test 2 was made by recording the snapshot data of each tank at two arbitrary simulation times. Test 3 was accomplished by recording the snapshot data of the relevant tanks immediately prior and immediately after waste transfers, solid settling, and tank mixing.

The results of the tests described in the previous sections are reported in Table B-3 through Table B-17. The tests confirmed that HTWOS is reliably applying the traceback function to the typical transfers selected. The test results verify that HTWOS performs the traceback function with sufficient accuracy to identify the source tank contents of a given tank during the simulation. The total liquid and total solid traceback masses for a given source were shown to be conserved during a simulation, even though contributions can be distributed over many tanks. Additionally, the results verify that the wash and leach factors are properly calculated during waste transfers and settling and mixing operations.

3.1.4 Wet Solids Calculations

The HTWOS model calculates tank solids volume using two methods that can be user selected for each tank. The first method is based upon a dry solids model, the second method is based upon a wet solids model. The dry solids model calculates solids volume assuming a constant solids density of 3 gm/cc for all solids. During a pumping operation between two tanks, the

unsettled solids volume is simply the volume of dry solids in the tank based upon a constant 3.0 gm/cc density. After a pumping operation is complete, the pumped solids in the destination tank are settled as a distinct layer on top of any existing solids. This solids layer consists of the volume of dry solids calculated based upon a constant 3.0 gm/cc density and an interstitial liquid mass calculated assuming a constant solids weight fraction (current HTWOS value is 0.4). The total settled solids volume is then the addition of the dry solids volume and the interstitial liquid volume associated with the settled solids layer. This method of solids volume calculation can over or under predict the pumped solids volume for certain tanks. Because of this situation, a second method of calculating solids volume was developed based upon a wet solids volume.

The wet solids volume method assumes that the wet solids volume is the volume associated with the solids mass plus the volume associated with the interstitial liquid of the solids mass. An initial wet solids volume is set for the source tank. As the source tank is pumped into a destination tank, a wet solids volume pumped is added to the current wet solids volume of the destination tank. At the completion of the tank transfer, the pumped solids in the destination are settled into a distinct layer above existing solid layers, but the volume of the layer is based upon the wet solids volume that was pumped into the downstream tank. The volume of dry solids is still calculated based upon the assumption of 3 gm/cc solids density, but the amount of interstitial liquid associated with this solids layer is the difference between the dry solids volume and the wet solids volume of the tank; the total solids volume for the settled solids layer becomes the new wet solids volume for that tank.

All pump procedures in HTWOS call the same procedure that calculates the solids volume of the source and destination tank after each time step during a tank transfer, so the wet solids calculation verification was checked for a single transfer of material from one tank to another. Two checks were completed; the first check assumed the solids volume was based upon the original dry solids calculation method, the second check assumed the solids volume was based upon the wet solids volume calculation. Both checks simply mixed the liquid solid mixture of the source tank and pumped the homogeneous mixture into an empty destination tank. At the end of the transfer the solids in the destination tank were settled as a solids layer covered with the free liquid that was transferred from the source tank and the resulting volumes reported.

The results of the tests described in the previous sections are shown in Table B-2. The first two paragraphs in the table show the results of using the original dry solids calculation method. As seen, the total volume of dry solids transferred was the same and the solids settled in the destination tank were settled to 0.4 wt fraction solids which produced a total solids + interstitial liquid volume of 63721.989 gallons. The last two paragraphs show the results of using the new wet solids volume calculation method. The initial wet solids volume of the source tank was 30644.9 gallons. After pumping this into the downstream tank and settling the mixture, the destination tank did receive the solids which created a new solids layer of 30644.9 gallons of wet solids mixture. In this case the settled solids weight fraction was 0.652, as this number is now a calculated number based upon the actual values rather than a set number that is used by the dry solids calculation method.

The verification results presented show that HTWOS performs the solids calculation correctly based upon the calculation method specified by the user.

3.1.5 Glass Formulation

The V&V of the HLW and LAW glass formulation is discussed below.

LAW Glass Formulation

The WTP LAW Glass Formulation was verified by completing an independent spreadsheet calculation. The spreadsheet used to perform this verification is documented in SVF-1622, Rev. 0, *LAW_WTP_Glass_Formulation_V&V_6_(manual calc after HTWOS code fixed).xls*. Verification included a review of HTWOS procedures used to formulate LAW glass and comparison against source documents.

The DOE-BNI LAW glass formulation calculation in the HTWOS model was checked for the purpose of verifying the correct calculation of frit required and total LAW glass produced. The scope of this verification is only for the DOE-BNI (20 wt% Na_2O max, 0.8 wt% SO_3 max) glass formulation. No other LAW glass model was verified at this time.

Results from several model runs were reviewed and inconsistencies were fixed by the HTWOS modeler. Fixes to these inconsistencies included; minor changes to the glass and frit procedures, adjustment to the output files, and correction of frit calculation errors. Details of the iterations and corrections are discussed in SVF-1622, Rev. 0. Data from the final V & V run confirmed that the LAW glass formulation and the model worked correctly.

HLW Glass Formulation

The HTWOS model determines the glass formulation for a set of HLW feed oxides by minimizing the total mass of the added glass formers while producing an acceptable glass. In this context, an acceptable glass is one that is projected to meet specified glass property constraints and satisfies simple solubility and model domain constraints. The model domain constraints are intended to keep the glass formulation within a region of known acceptable glasses and to keep the glass properties models within regions of their applicability. The glass properties constraints insure that a glass has the physical properties required for processing and for high durability as a final waste form. The simple solubility constraints are used to insure acceptable glasses when the glass property models do not adequately constraint some components.

Mathematically, the HLW glass formulation model is a constrained non-linear programming (NLP) problem. The technique that the HTWOS model uses to solve the NLP problem is to iterate over a linearized version of the problem. This approach is described in more detail in RPP-18592, Rev 2, along with the basis for each of the constraints.

The specific HLW glass formulation model used by HTWOS has been historically called the "Glass Properties Model", or GPM for short. There are two variants of that model, depending upon the limits used for certain constraints that are called the "Relaxed GPM" and the "Default

GPM". The "Relaxed GPM" incorporates potential improvements in the HLW waste oxide loading by relaxing the glass viscosity, Cr_2O_3 solubility, and the spinel liquidus temperature constraints. The "Default GPM" is a more conservative model that had been used for HLW glass projections up until 2002. In either case, the melter is assumed to operate at a nominal temperature of 1150 °C. The "Relaxed GPM" is the current baseline model for system planning purposes.

The glass property constraints are shown in Table 5.

Table 5. High-Level Waste Glass Property Constraints.

Property	Lower Limit	Upper Limit
Liquidus Temperature (Spinel)	850 °C	1100 °C (relaxed) 1050 °C (default)
Liquidus Temperature (Zircon)	None	1050 °C
Melt Viscosity at 1150 °C	4.5 Pa·s	10 Pa·s (relaxed) 5.5 Pa·s (default)
PCT (B, Li, Na)	None	2 g/m^2
Nepheline precipitation rule	0.62	None

Additional constraints (Table 6) were also applied to either limit the glass composition to the approximate region of validity (domain) of the various property models, or to limit the allowable concentration of components that impact the waste oxide loading in the resulting glass. The limits in should not be confused with those in Table TS-1.1 of the WTP contract (DE-AC27-01RV14136), which establishes minimum component limits in HLW glass for contractual purposes.

Table 6. High-Level Waste Glass Composition Constraints.

	Component	Minimum (wt %)	Maximum (wt %)	Allowed as glass forming chemicals?[a]
Model Domain	SiO_2	38.0	57.0	Yes
	B_2O_3	5.0	20.0	Yes
	Na_2O	5.0	20.0	Yes
	Li_2O	1.0	4.0	Yes
	Al_2O_3	None	17.0	Yes
	Fe_2O_3	2.0	15.0	Yes
	CaO	None	10.0	No
	MgO	None	8.0	No
	ZrO_2	None	15.0	No
Solubility	Cr_2O_3	None	0.5 (default) 1.0 (relaxed)	No
	P_2O_5	None	3.0	No
	SO_3	None	0.5	No
	$Rh_2O_3 + Ru_2O_3$	None	0.25	No

Notes:

a. For modeling purposes, the glass forming chemicals are assumed to be pure oxides rather than impure minerals.

The WTP HLW Glass Formulation was verified by the following activities which are documented in SVF-1623, Rev 0, *HLW_Glass_Formulation_Verify_v_0.xlsm*.

1. Alternate calculation of a set of example melter batches derived from a full mission run and specific Total-Blend / No-Blend Calculations.
2. Comparison of both hard-coded and user adjusted constraints against the assumptions in ORP-11242, Rev 3A, Assumption B2.3.3.6, Tables B-1 and B-2.
3. Testing that changes to the user adjusted assumptions are actually used by the glass formulation model and reflected in the model output.

Minor discrepancies found during verification were fixed by the Chief HTWOS modeler (specifically, the "hard-coded" upper and lower limits for the various constraints in the headers for the glass output report were linked to the user-specified inputs and the values actually used by the glass formulation model).

The HLW Glass Formulation Model in HTWOS has been verified to work properly. Additionally, the values of the user-adjustable constraints (plus the values of the hard-coded constraints) reflect the assumptions for the "Relaxed Glass Properties Model", the current baseline for system planning purposes. Changes to the user adjustable constraints are properly used in the model and reflected in the output.

It is anticipated that the HLW Glass Formulation Model will be updated sometime after the next System Plan (Rev. 4) to reflect a completely new model currently being developed by Pacific Northwest National Laboratory personnel. When that change is made, provisions should be made for flagging any batches that have not fully converged, either in HTWOS or in the glass output spreadsheet.

3.2 MODEL CALCULATIONS

3.2.1 Total Blend/No Blend Calculation

The total blend/no-blend calculations are performed to establish bounding values for the amount of HLW glass that could be produced during the RPP mission. The total blend calculation represents the amount of glass that would be produced if all of the tank waste could be mixed and made into glass at a uniform blend. The no-blend calculation represents the amount of glass that would be produced if each tank of waste were made into glass by itself with no blending with any other wastes. Comparison of the realized blend (the quantity of glass projected to be produced during the RPP mission) to the total blend and no-blend values gives an indication of the degree of incidental blending of waste achieved during retrieval and staging for delivery to the WTP. Total blend and no-blend calculations may be performed with a subset of the tanks for evaluating different mission scenarios or to match a particular set of processing assumptions.

The total blend/no-blend calculations are controlled by a new user interface that defines a blend/no blend case to be calculated. The new user interface is shown by going to the "Tools" menu choice at the top of the HTWOS window and selecting the menu choice "Show blend/no blend/glass matrix calcs". Verification of these calculations fall into three areas.

1. Verify that the user interface is creating the desired case and executing the sequence of calculations necessary to complete the calculations correctly.
2. Inspecting the results of a case for consistency.
3. Comparing the results of a case using this new user interface with the results of the same case using the original calculation method.

Verification of item 1 was completed by inspecting the code called when using the new user interface to define and run a blend calculation. Inspection of the code shows that the correct calculation steps are being called in the correct order. The new calculation method was compared to the original calculation method and found to be equivalent.

Verification of item 1 also tested the model code to verify that the proper operations are performed in the proper order and the waste from the individual tanks is properly aggregated for the appropriate TOTAL-BLEND/NO-BLEND calculations.

Verification of item 2 was completed by performing a test which compared spreadsheet calculations and HTWOS export data on a three tank system for all of the operations performed on the tanks/blends prior to processing by the glass model calculations. The spreadsheet calculations agreed with the intermediate tank/blend compositions exported from the HTWOS.

Verification of item 3 was completed by calculating the glass for an identical set of tanks using the original calculation and the new calculation. This resulted were compared in a spreadsheet and an overall 4.16e-6 % difference was found in the total glass calculated by each method.

The completion of the verification discussed in this section showed that the total-blend/no blend calculation is performing correctly.

3.2.2 WTP Feed Specification 7 Parameters

Composition data for each batch of waste delivered to the WTP were taken from the feed vector file reported from the final V&V run and used to perform an alternate calculation of the WTP feed specification 7 parameters and limits. The parameters calculated from the feed vector file data were compared to the parameters calculated by the HTWOS model and reported in a comma-delimited file named spec-7-output.csv and found to agree. The spreadsheet used to perform the alternate calculation and comparison of results (SVF-1655, Rev. 0, *Verify_HTWOS_WTP_Feed_Spec_Calcs.xls*) was configured to allow the user to select individual feed batches to see the comparison and to iterate around all the feed batches to identify batches where the alternate calculation disagreed with the data in the spec-7-output.csv file.

3.2.3 WTP Feed Specification 8 Parameters

Composition data for each batch of waste delivered to the WTP were taken from the feed vector file reported from the final V&V run and used to perform an alternate calculation of the WTP feed specification 8 parameters and limits. The parameters calculated from the feed vector file data were compared to the parameters calculated by the HTWOS model and reported in a comma-delimited file named spec-8-output.csv and found to agree. The spreadsheet used to perform the alternate calculation and comparison of results (SVF-1655, Rev. 0) was configured to allow the user to select individual feed batches to see the comparison and to iterate around all the feed batches to identify batches where the alternate calculation disagreed with the data in the spec-8-output.csv file.

3.2.4 WTP Feed Hydrogen Generation Rate (HGR) Parameters

Composition data for each batch of waste delivered to the WTP were taken from the feed vector file reported from the final V&V run and used to perform an alternate calculation of the WTP HGR parameters and limits. The parameters calculated from the feed vector file data were compared to the parameters calculated by the HTWOS model and reported in a comma-delimited file named hgr-output.csv and found to agree. The alternate calculation and comparison of results are documented inSVF-1656, Rev. 0, *Verify_HTWOS_WTP_Feed_HGR_Calcs.xls*.

3.2.5 Representative Model Objects (Split Calculation Procedure)

Unit operations in HTWOS are executed through the use of procedures representing the operation of their respective equipment. Since all members of a class have an identical representational structure, validation of a split calculation for a given procedure acting on a particular model object (piece of equipment) can be extended to validate the split calculations for objects (equipment) of the same class using the same procedure.

The split calculations were checked for six representative HTWOS model objects. Time step data were recorded for the six objects immediately prior to and immediately after the implementation of the split factors. Calculations were performed in Excel on the initial equipment component mass vectors to determine the final equipment component mass vectors. The calculated final equipment component mass vectors were then compared to the HTWOS final equipment component mass vectors.

The results of the tests confirm that the split calculations are performing properly for the six representative model objects. The results of the tests on these six representative objects can be extended to confirm that the split calculations are performing properly for an additional 43 model objects (for a total of 49). Table B-18 provides a list of the pump procedures, equipment classes, and equipment names verified.

3.3 MODEL INPUTS

3.3.1 Initial Waste Inventory

Data reported from the HTWOS model was compared to the input data files. The spreadsheet used to perform this verification is documented in SVF-1604 Rev. 0, *HTWOS Inventory Input V&V 2008-11-21.xls*.

Of the approximately 42,460 data values in the inventory input files only two values in the inventory data reported from the HTWOS model did not match the values in the input data files. The two values that disagreed were the ^{90}Y in the solid phase from two waste generator sources. The values disagreed because the HTWOS model appropriately calculates ^{90}Y values based on secular equilibrium with ^{90}Sr. This is not a significant issue because the ^{90}Y values should be based on secular equilibrium with ^{90}Sr. The inventory data for the two waste generators should be revised in the future to base the two ^{90}Y values on secular equilibrium with ^{90}Sr.

Based on these findings, it has been verified that the input data is correctly inputted into the HTWOS model and that each tank's inventory is correct.

3.3.2 Wash and Leach Factors

Wash and leach factor data reported from the HTWOS model was compared to wash and leach factor data downloaded from the Tank Waste Information Network System (TWINS) on March 7, 2007. The TWINS data downloaded on March 7, 2007 was the data source for the wash and leach factor data in the HTWOS model. The comparison is documented in SVF-1605 Rev. 0, *Wash & Leach Factors V&V 2008-11-25.xls*.

The wash and leach factor data from TWINS matched the data written out of the model except for the wash factor values for ^{90}Y. The TWINS data shows non-zero wash factor values for ^{90}Y and HTWOS has zero wash factor values for ^{90}Y. When the wash factor data were prepared for input to the model, the wash factor values for ^{90}Y from TWINS were intentionally left out of the input data file because of how the model handles ^{90}Sr and ^{90}Y. There are no wash factor values for ^{90}Sr in TWINS and in the HTWOS model because HTWOS uses a solubility correlation to predict the ^{90}Sr and Sr distribution between the liquid and solid phases instead of wash factors. Because the model determines ^{90}Y based on secular equilibrium with ^{90}Sr, wash factor values for

^{90}Y are not needed and would not be used if provided. The comparison of wash and leach factor data verified the data in HTWOS to be correct.

3.3.3 Physical Property Values

The HTWOS model carries physical property values for the atomic mass (molecular weight; MW), a liquid specific gravity (SpG) factor, half-life, and specific activities of various radionuclides elements and chemical species. The values in the molecular weight (MW) table in HTWOS were compared against the values held in the most recent Specific Activities (SpA) workbook (SVF-1286, Rev. 1, *HTWOS Specific Activities 06-29-2008.xls*,) and it's sources which are as follows:

- SpG coefficients – HNF-SD-WM-SP-012, Rev. 6 for inorganics. Some organic compounds (12) tracked (but not currently used) in the model have SpG coefficients, but they were not checked against any source.
- Half-lives – Chart of the Nuclides, 16th edition, documented with any adjustments in the EZDK spreadsheet[5] –SVF-1259, Rev. 0, *EZDK_generic_FY 2007.xls*.
- Integrated Gamma Energy in MeV –SVF-1152, Rev. 0, *Cesium_Gamma_Equivalents_v_0.xls*.
- Molecular Weight and Specific Activity – SVF-1286, Rev. 1

The two sets of values were compared by a logical IF in Microsoft Excel to see if they were equal. The spreadsheet used to perform this verification is documented in SVF-1603 Rev. 0, *MW_SpG_Half-Life_SpA Table V&V 2008-12-03.xls*. All the values compared were equal within an acceptable tolerance with minor discrepancies due to a difference in the number of significant digits being reported

3.3.4 WTP Process Split Factors

The WTP process splits were verified against the source documentation. The evaluation was completed by opening individual objects in the HTWOS model and using the "show/set attributes" selection from the menu for each process unit and "show/edit splits" for units whose operation includes a split factor. The split factors from HTWOS model were compared to the reference values. Three sources were reviewed for the split factors in the model:

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[5] The Tank Farm Inventory group is responsible for maintaining reference values for molecular weight, half-life, and specific activity. The EZDK spreadsheet (SVF_1259, Rev. 0) is a source file used by the HTWOS modeling team. All of the molecular weight and half-life data are from the 16th Edition of the Chart of the Nuclides with the exception of three half-life values; ^{69}Ni due to an uncertainty with regard to the reported half-life value, ^{242}Cm to compensate for a lack of information about the parent isotope (^{242m}Am), and ^{227}Ac because the value in the 16th Edition of the Chart of the Nuclides was so close to the value in the 15th Edition that a change was not considered necessary. The half-life of ^{242}Cm (~163 days) is short compared to the half-life of the parent isotope (~141 years) and ^{242m}Am is not tracked in the BBI so the longer of the two half-life values is used for ^{242}Cm to approximate the secular equilibrium of ^{242}Cm with ^{242m}Am.

- 24590-WTP-MDD-PR-01-002, Rev 8, *Dynamic (G2) Model Design Document*, for offgas configuration and splits, unless otherwise noted.
- 24590-WTP-RPT-PT-02-005, Rev. 3, *Flowsheet Bases, Assumptions, and Requirements* (BARD) for;
  - ^{129}I (PT Waste Feed Evaporator),
  - ^{129}I, ^{99}Tc, Hg (PT Feed Evaporator Condenser),
  - ^{129}I (LAW Melter),
  - ^{129}I, ^{99}Tc (LAW SBS),
  - ^{129}I (HLW Melter),
  - ^{129}I, ^{99}Tc, Hg (HLW WESP),
- CCN150375 - ^{99}Tc (LAW Melter)

Corrections identified in the preliminary runs were implemented and a review of the final run (*V and V-3.0-8.4r0-2009-01-16-at-00-40-11)* showed that all of the corrections had been made, except for the two exceptions described below;

1. HTWOS-HLW-SBS - ^{129}I split was incorrectly entered as 0.51503 and needs to be changed to the BARD value of 0.52632
2. HTWOS-HLW-WESP – ^{129}I, ^{99}Tc, and Hg+ split factors should be changed to "1" instead of the fractional values currently in the model.

The inconsistencies noted above will be corrected in the next major model.

3.3.5 Tank Volumes

The maximum, minimum, and heel volumes were verified against the source documentation. The evaluation was completed by opening individual vessel/tank objects in the HTWOS model and using "Table" from the menu for each process units to review volume attributes. Vessel/tank capacities were evaluated for SST, DST, PT, LAW, HLW, OFFGAS, ETF, DBVS/BVS, West STP, and East STP.

Tank and Vessel volumes within WTP were checked against 24590-WTP-MDD-PR-01-002 Rev 6 and SST and DST parameters were checked against the information in SVF-1452, Rev. 0, *HNF-EP-0182 Rev 238.xls*.

In general, maximum capacities are agree with WTP and Tank Farm information except where values have been consciously changed to simulate a desired process operation. The heel volumes match the assumptions for residual waste in tanks.

Preliminary runs were evaluated and inconsistencies were identified to the Chief Modeler.

After the changes were implemented, the changed values were reviewed using the HTWOS V&V final run (*V and V-3.0-8.4r0-2009-01-16-at-00-40-11)*. Except for the two exceptions described below, all changes were successfully completed (the tank designation listed first is from the HTWOS model and the second designation refers to the cited reference value).
:

1. HTWOS-V12011A (27125 gal) vs (55307 gal) for UFP-VSL-00001A
2. HTWOS-V12011B (26551 gal) vs (55307 gal) for UFP-VSL-00001B

The remaining inconsistencies will be addressed in future model runs.

3.3.6 Reactions and Extent of Reactions

The reactions and extents of reactions used in the model were verified against the source documentation. The WTP process chemistry was compared to 24590-WTP-MDD-PR-01-002 Rev 6. The review included comparison of conversion factors (extent of reaction), stoichiometry, and treatment of organic chemicals. Reactions describing BV demonstration use some but not all WTP technical basis.

Preliminary runs were evaluated and inconsistencies were identified to the Chief Modeler. After the changes were implemented, the changed values were reviewed using the HTWOS V&V final run (*V and V-3.0-8.4r0-2009-01-16-at-00-40-11)*. The review showed that all issues had been resolved and the HTWOS model of the WTP and BV chemistry were consistent with the cited sources.

3.4 MODELED PROCESSES VERIFICATION AND VALIDATION

3.4.1 WTP Pretreatment

Key features of the WTP pretreatment were examined to check the validity of the WTP pretreatment model. Specific items verified are as follows:

- Checked the sodium molarities of the two evaporators against 24590-WTP-RPT-PT-02-005 (BARD).
- Checked the ultra-filter flux rate using the filter feed volume plots and solids concentration as a function of time.
- The chromium concentration of the solids in the ultrafiltration system was checked to ensure that it was 5,000 ppm Cr after oxidative leaching for cases where it was known that oxidative leaching was applied to the sludge.

The average volume decrease of the ultrafilter feed vessel as a function of time was found to be 16.4 gpm. Some of these volumes are solids, and the flowrate is set at 15.6 gpm liquid flowrate. Using the average solids density of 3g/mL and the average supernatant density of 1.27 gpm, the 16.4 gpm of slurry was transformed into volume of supernatant versus time. This average value came to be 15.4 gpm, however there was a lot of scatter around the mean because the average

solids content changed a lot as the feed was filtered. Consequently, the 15.4 average flowrate is approximately equal to 15.6 target gpm for supernatant and is considered valid.

The solids in the ultrafilter feed vessel were found to always be 5,000 parts per million (ppm) Cr (to 4 significant figures) in all cases checked where oxidative leaching had been applied.

3.4.2 WTP LAW Submerged Bed Scrubber (SBS)

An alternative calculation of the operation of the LAW SBS using a spreadsheet was completed in order to verify the HTWOS WTP LAW Submerged Bed Scrubber (SBS) calculation. The alternative calculations and results are documented in SVF-1620, Rev 0, *LAW_SBS_Verify_v_0.xlsx*. The following items were specifically verified:

- Verified that both the total mass balance and activity balance around the LAW SBS close.
- For components not involved in reactions, verified that the component mass and activity balance close.
- Verified that the splits in HTWOS match the reference assumptions.
- Verified that the reactions and extents in HTWOS match the reference assumptions.
- Using the alternative calculations compared the spreadsheet estimate of the SBS offgas stream to the values reported by HTWOS. The compositions match, with the exception that ^{3}H is about 4% different than expected. This is probably due to limitations of the accounting used in the spreadsheet, and should be revisited the next time that the HTWOS model is realigned with WTP assumptions (after SP4). Note that the HTWOS model saturates the offgas stream with water using a relative humidity calculation, while the WTP G2 MDD makes a simplifying assumption of a constant mole fraction.

Discrepancies found during the verification were fixed by the HTWOS modeler and as a result the LAW SBS was found to function properly and is setup with the proper splits and reactions.

3.4.3 WTP LAW Melter

The WTP HLW Melter was verified by the steps listed below, which are documented in SVF-1629, Rev 0 *HTWOS LAW Melter Verification.xls*.

Verified the WTP LAW Melter splits in HTWOS are consistent with the source documentation, 24590-WTP-RPT-PT-02-005, *Flowsheet Bases, Assumptions, and Requirements*.

1. Calculated material added to the melter.
2. Calculated melter constituents by applying the reactions.
3. Calculated off-gas components and compared to HTWOS output.
4. Confirmed the total mass in the system is equivalent to the input mass.

5. Calculated and added the mass of radionuclides to the LAW glass mass from chemicals and calculated amount of failed melters and LAW containers and compared to HTWOS calculations.

The results of the verification were as follows:

- The splits were verified as consistent with the source documentation.
- The total mass and individual components in the off-gas all agreed to within 0.001% and therefore the off-gas calculations are considered validated.
- Calculated LAW container glass mass was within 0.02% of HTWOS calculations.
- Calculated LAW container count was within 0.03% of HTWOS calculations.
- Calculated spent melter glass was within 1.3% of HTWOS calculations.
- Comparison of the spreadsheet calculated total mass of LAW glass was less than 0.001% different than the equivalent HTWOS calculation.

The results of the verification showed that the WTP LAW Melter model in HTWOS is working properly.

3.4.4 WTP HLW Melter

The WTP HLW Melter was verified by the steps listed below which are documented in SVF-1628, Rev. 0, *SVF-1628 Rev. 0.xls*.

1. Verified the WTP HLW Melter splits in HTWOS are consistent with the source documentation, 24590-WTP-RPT-PT-02-005, *Flowsheet Bases, Assumptions, and Requirements.*
2. Calculated material added to the melter.
3. Calculated melter constituents by applying the reactions.
4. Calculated off-gas components and compared to HTWOS output.
5. Confirmed the total mass in the system is equivalent to the input mass.
6. Calculated and added the mass of radionuclides to the HLW glass mass from chemicals and calculated amount of failed melters and IHLW containers and compared to HTWOS calculations.

The results of the verification were as follows:

- Discrepancy in ^{134}Cs, ^{137}Cs, and ^{137m}Ba were corrected for the final run from 0.02982 to 0.02892.

- The total mass balance difference between the spreadsheet and the HTWOS output of less than 0.0001% the HTWOS off gas stream calculations are considered validated.
- Calculated spent melter glass was within 0.4% of HTWOS calculations.
- Calculated IHLW glass mass was within 0.04% of HTWOS calculations.
- Calculated IHLW canister count was within 0.03% of HTWOS calculations.
- Comparison of the spreadsheet calculated total mass of HLW glass was less than 0.0001% different than the equivalent HTWOS calculation.

The results of the verification showed that the WTP HLW Melter model in HTWOS is working properly.

3.4.5 242-A Evaporator

The assumptions for the 242-A evaporator can be found in Section A4.3 of the Assumptions Matrix table (Table A-1) in Appendix A. In summary, the assumptions were compared to model parameters or model logic, to results from the model, or to alternate calculations performed to check the calculations performed by the model. The comparisons indicated that the assumptions are implemented in the final model and that the HTWOS model is correctly performing the calculations. Details about the verification and results of the verification can be found in Table A-1.

3.4.6 In Tank Sr/TRU Pretreatment

Specific assumptions associated with In-Tank Sr/TRU Pretreatment were verified and documented in section A2.3.2 of the Assumption Matrix in Appendix A. In general the transfer file was examined to verify that each of the steps for the in-tank Sr/TRU Pretreatment was completed in AN-102 and AN-107. The following errors were found and will be addressed in future HTWOS modeling.

- The model adds water prior to conducting the $KMnO_4$ strike based on the maximum of 10% solids or 5.5 Molar Na. The model should only use the 5.5 Molar Na criteria based on the assumptions. It is believed that this logic was carried over from SST transfer logic and is incorrect.
- The model applies a $^{Sr}90/Sr$ solubility correlation just prior to adding the $SrNO_3$ for isotopic dilution of the $^{Sr}90$. This application reduces the $^{Sr}90$ because of solubility and then reduces the $^{Sr}90$ because of the reaction with CO_3. Only the reaction with its 94 % conversion should be applied.
- The model applies a $^{Sr}90/Sr$ solubility correlation just after the use of $SrNO_3$ for isotopic dilution of the $^{Sr}90$. This correlation is no longer applicable since there is significant Sr added relative to the amount already present in the waste liquid. The correlation was developed based only on $^{Sr}90$ and was good for the ratios of $^{Sr}90/Sr$ that exist in the tanks. This application also affects the $^{Sr}90$ concentration after the 94 % conversion is applied.

3.4.7 SST Retrieval

The verification of specific assumptions associated with SST retrieval are documented in section A3.0 of the assumption matrix. In most cases the assumptions were found to be correctly modeled with the following exceptions:

- The selective dissolution of waste from tanks S-105 and S-109 and operation of the DBVS/BVS facility was turned off for the final model run in order to avoid waste staging issues in the West Area. This assumption change was made to simplify the current V&V effort because the DBVS/BVS facility is not assumed to operate in the next major modeling effort and the West Area waste retrieval and staging will be changed significantly. The use of the DBVS/BVS and the selective dissolution assumptions will need to be verified when they are included in future model runs. This change led to a need to correct the residual waste volumes for S-105 and S-109. This in turn underestimated the volume of retrieved waste from S-109 as compared to the value in the assumption (SVF-1283, Rev. 2, *Single-Shell Tank Retrieval Assumptions for Mission Modeling, SVF-1283 Rev 2.xls*). This discrepancy should be corrected in future model revisions by either revising the assumption or the model.
- The constraint to limit the maximum number of simultaneous retrievals to seven was not correctly implemented. Data in the ACTIVE-SST-RETRIEVALS-LOGGER object from the final run show that the number of simultaneous retrievals remains below the maximum of seven for most of the mission with occasional spikes to eight or nine simultaneous retrievals. The number of simultaneous retrievals exceeded the total constraint of seven for short part of the mission (about 1.5% of the duration of retrieval operations; 231 days out of approximately 43.5 years of retrieval operations). Examination of the model used for some of the preliminary runs revealed that not all of the SST waste retrieval operations were assigned retrieval machines and since the accounting of retrieval machines is used to track and limit the number of simultaneous retrievals, some model logic written to accomplish specific retrievals effectively bypasses the simultaneous retrieval constraint. Examples of specific retrievals whose logic or code bypassed the simultaneous retrieval constraint are the TRU waste retrievals, the retrieval of wastes from S-105 and S-109 for feed to the DBVS/BVS, and the early retrieval of low-insoluble-solids wastes in the West Area to provide feed to the West Cs IX system and to the West STP. Resolution of this issue was deferred to the future because assumption changes to the mission planned for the next modeling effort could resolve the issue or negate the benefit of any work done now.

3.4.8 DST Waste Feed Staging and Delivery

Specific assumptions associated with DST waste feed staging and delivery were verified and are documented in section A4.2.6 and A4.4 of the assumption matrix. For the waste feed staging the transfer files were reviewed against the assumptions. Not all of the constraints in the assumptions agreed with the model output. Specific discrepancies are discussed in section A4.2.6 of the assumption matrix.

3.4.9 Contact Handled Transuranic Waste Delivery and Packaging

Specific assumptions associated with delivery and packaging of Contact Handled (CH) TRU were verified and details of the verification documented in section A.2.3.1 of the assumption matrix. A summary is provided here. The CH-TRU waste retrieval schedule assumptions were compared to parameters in the model and to results reported in the transfer file (SVF-1646, Rev. 0) and found to agree. The process flowsheet in the model was compared to the assumption text to determine that the model is correctly configured so nothing is recycled from the packaging facility back to the tank farms. The process flowsheet in the model compared to the assumption text and to source documents about the packaging facility to determine that the model is correctly configured to simulate the process according to the assumptions and source documents, with one exception. The one exception is that no split factor was specified for ^{99}Tc in the TRU dryer. A value of 0.0010031 should be provided in the model for splitting ^{99}Tc in the solid and liquid phases to the overheads within the SUP-TRU-DRYER. Not having a split factor specified for the TRU dryer very slightly over estimates the ^{99}Tc in the TRU product and very slightly under estimates the ^{99}Tc that will go to the condensate and to the stack. This will need to be corrected in future model runs.

3.5 HTWOS2XL DATA REPORTING AND ANALYSIS

The correct functioning of the HTWOS2XL application (i.e., the ability to create the spreadsheets) was verified before the application was implemented in fiscal year 2007 and has been demonstrated repeatedly by the successful creation of Excel files when writing results from approximately 190 HTWOS model runs performed between August 2007 and February 2009. The verification performed under this effort focused on verifying that data was transferred correctly from HTWOS into the Excel spreadsheets. The verification of the correct data transfer was performed by checking the transfer of data from a few HTWOS model objects. The model objects and data selected represent the transfer of the same type of data from other objects in the same class, taking advantage of the object-oriented programming used within the model. Selected data written by HTWOS2XL into the four spreadsheet template files used to create the product plots file, the SST retrieval file, the DST plots file, and the residual waste inventory file were compared to the same data within the HTWOS model (single data values) or to the same data reported from the model by an alternate method. The alternate reporting methods used included emailing the contents of internal-write objects from the model or opening comma-delimited text files written by the model at the end of the run.

The comparisons showed that the values for data written into the spreadsheet templates by the HTWOS2XL application agree with the values of data in the model or agree within acceptable tolerances with the values of data reported from the HTWOS model using alternate reporting methods. The data comparisons are documented in:

- SVF-1611, Rev. 0, *Verify_HTWOS2XL_DST_Plot_Data_Rev_0.xls*
- SVF-1612, Rev. 0, *Verify_HTWOS2XL_Product_Plot_Data_Rev_0.xls*
- SVF-1613, Rev. 0, *Verify_HTWOS2XL_SST_Retrieval_Data_Rev_0.xls*
- SVF-1614, Rev. 0, *Verify_HTWOS2XL_Waste_Residual_Data_Rev_0.xls*,

3.6 MASS BALANCE TOTALIZERS/SUMMARY MASS BALANCE REPORTING

The mass balance totalizers and summary mass balance reporting was verified by reviewing the stream number assignments within the HTWOS model and reviewing the summary balance spreadsheets produced by the HTWOS2XL application for activity or mass imbalances and performed alternate calculations to check the accounting in the chemical additions to the DSTs and SSTs.

Several corrections in stream number assignments are reflected in the final HTWOS model run V and V-3.0-8.4r0-2009-01-16-at-00-40-11. The HTWOS version 3.0 reflects the correct stream number assignments.

The summary balances generated for the final HTWOS model run (V and V-3.0-8.4r0-2009-01-16-at-00-40-11) showed the remaining imbalances;

- ^{227}Ac and Ac in the DBVS/BVS system,
- ^{134}Cs in the West Cs IX system,
- Hydrogen and oxygen in the tank farms and hydrogen around the RPP mission.

Resolution of the ^{227}Ac, Ac, and ^{134}Cs imbalances is deferred until after the System Plan, Rev. 4 modeling effort because those systems will not be modeled as part of System Plan, Rev. 4. These imbalances appear to be due to the separation of parent and daughter isotopes or to radionuclide data not being decayed as part of the annual decay calculation.

An imbalance of about 0.4% was observed for hydrogen and oxygen around the tank farms, which is acceptable. A summary mass balance for the RPP mission showed hydrogen and oxygen imbalances on the order of 0.26% and 0.10%, which are at or below the lowest mass balance tolerance of 0.25%. The template spreadsheet used by the HTWOS2XL application to create the summary balance file was revised to reflect the changes made to the balance accounting in the HTWOS model (SVF-1643, Rev. 0).

3.7 "MISSION" ANALYSIS

Table 7 provides a comparison of the results from the final V&V run to the results obtained from the HTWOS model run documented in ORP-11242, Rev. 3A (referred to in the table as the RPP System Plan, Rev. 3 Run). The duration of the RPP mission increased in the final V&V run primarily because of changes in the LAW glass formulation for the bulk vitrification facilities (the East and West STP facilities) and secondarily because more wastes were processed through the WTP LAW melter. No attempt was made to identify or resolve issues with WTP feed delivery that could be contributing to an increase in WTP melter feed outages because the main purpose of the effort was to verify the HTWOS model and not to develop a mission scenario.

An evaluation of the LAW feed delivered to the WTP against the contract specification 7 limits (see SVF-1650, Rev. 0) led to several observations. The observations of note are (1) that a significant volume of delivered feed falls above (12%) and below (17%) the allowable [Na] limits and (2) that about 5% of the delivered feed exceed the maximum TRU:Na limit. These behaviors are not unexpected given known limitations of this version of the model. The following model improvements are suggested:

1. DST utilization and feed staging logic needs to be improved to insure that dilute supernate is concentrated before delivery to WTP, use proper dilution water for the DSS/DSSF waste retrieval, and the 242-A Evaporator target SpG may need to be reduced for balance of mission to avoid over-concentrating feed.
2. The common features of the high-TRU batches appears to be very low [Na] and traceback to C-105 which has known error in the Am-241 waste feed in the test inputs used for this run.

Table 7. Summary of Key Results.

Mission Metric	RPP System Plan, Rev. 3 Run	Model Verification Run
C-Farm Retrieved	November 2016	September 2014
All SSTs Retrieved	March 2047	September 2050
Total LAW Glass, MT	384,164	520,492
Total LAW Glass Volume, m^3	146,388	198,186
WTP LAW Packages	33,065	41,282
WTP LAW Glass Mass, MT	195,745	244,398
WTP LAW Glass Volume, m^3	75,286	93,999
WTP LAW Na_2O Loading	18.1 wt%	17.8 wt%
Number of STP Boxes	4,423	6,478
STP Glass Mass, MT	188,419	276,094
STP LAW Glass Volume, m^3[a]	71,102	104,126
STP LAW Na_2O Loading	21.24 wt%	20.4 wt%
Total HLW Canisters	12,513	12,149
IHLW Mass, MT	40,042	38,871
WTP HLW Glass Volume, m^3	14,830	14,397
WTP HLW Waste Oxide Loading[b]	28.4 wt%	29.2 wt%
Total Dried TRU Waste Volume, m^3	3,488[c]	8,100
Waste Processing Completed	February 2049	December 2054

Terms:

DST	double-shell tank	SST	single-shell tank
HLW	high-level waste	STP	Supplemental Treatment Plant
LAW	low-activity waste	TRU	transuranic
ORP	Office of River Protection	WTP	Waste Treatment and Immobilization Plant

Notes:

a. The STP LAW glass data include data for the Demonstration of Bulk Vitrification System (DBVS) and the Bulk Vitrification System (BVS) Operation.
b. IHLW Waste Loading is determined as the mass of waste in an oxide form divided by the total mass of glass and expressed on a percentage basis.
c. Based on 5,581 MT of dried product having a bulk density of 1.6 MT/m^3.

3.8 REPEATABILITY OF RESULTS

The same configuration of the HTWOS version 3.0 was run on two different machines to demonstrate that the model results were repeatable. These two runs are identified as Iterations 1 (Repeatability) and 2 (Repeatability) in Table 4. Selected result files from the raw data folder[6] were compared using a program named ExamDiff[7], a freeware Windows tool for comparing files. All of the files compared using ExamDiff were flagged as identical in their content or were appropriately flagged as being different because the file contained different HTWOS model run name and numbers. The remainder of the file contents was flagged as identical. In addition, the wvp-taf-file.csv data from the final run and the two repeatability runs were compared (see SVF-1640, Rev. 0, *Verify_HTWOS_Repeatability-Transfer_Data.xls*). All of the 99,273 data values reported in the csv-taf-file.csv files from the two repeatability runs agreed, confirming that the model runs are repeatable.[8] This led to the conclusion that the model runs are repeatable

4.0 ISSUES AND FUTURE MODEL IMPROVEMENTS

After the completion of the V&V process the following issues were identified as needing addressed in future model revisions:

4.1 PROCESS SPLITS

The following two process split factors should be revised in future model modifications:

1. HTWOS-HLW-SBS - ^{129}I split was incorrectly entered as 0.51503 and needs to be changed to the BARD rev 3 value of 0.52632.
2. HTWOS-HLW-WESP – ^{129}I, ^{99}Tc, and Hg+ split factors should be changed to "1" instead of the fractional values currently in the model.

4.2 TANK VOLUMES

The following UFP tanks capacity should be modified to agree with the WTP model design document.

1. HTWOS-V12011A (27125 gal) vs (55307 gal) for UFP-VSL-00001A
2. HTWOS-V12011B (26551 gal) vs (55307 gal) for UFP-VSL-00001B

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[6] The raw data folder contains approximately 500 to 700 comma-delimited text files written by the model at the end of each run. These files contain mass-data-history data, model object accumulation data, and other model results.

[7] ExamDiff is available from PrestoSoft at http://www.prestosoft.com/edp_examdiff.asp.

[8] When comparing the data in the wvp-taf-file.csv file from the first repeatability run to the final run, 46 data values were found to be different. This was traced to a slight change made to the KBs for the final run after the final run was completed. The 46 values that are different are in a portion of the reported transfer data that was used to debug model operation and is no longer used because of the recently programmed procedure traceback.

4.3 IN TANK SR/TRU PRECIPITATION

The following issues with In-Tank Sr/TRU Precipitation should be addressed in future model modifications.

- The model adds water prior to conducting the $KMnO_4$ strike based on the maximum of 10% solids or 5.5 Molar Na. The model should only use the 5.5 Molar Na criteria based on the assumptions. It is believed that this logic was carried over from SST transfer logic and is incorrect. The immediate impact of using the 10% solids criteria is to add more water to the supernate from AN-102 or AN-107. This intern adds more $KMnO_4$ and $Sr(NO_3)_2$ to the supernate. The additional chemicals should not impact the programs estimation of LLW glass volume. It does impact the water balance.

- The model applies a $^{90}Sr/Sr$ solubility correlation just prior to adding the $SrNO_3$ for isotopic dilution of the ^{90}Sr. This application reduces the ^{90}Sr because of solubility and then reduces the ^{90}Sr because of the reaction with CO_3. Only the reaction with its 94 % conversion should be applied.

- The model applies a ^{90}Sr /Sr solubility correlation just after the use of $SrNO_3$ for isotopic dilution of the ^{90}Sr. This correlation is no longer applicable since there is significant Sr added relative to the amount already present in the waste liquid. The correlation was developed based only on ^{90}Sr and was good for the ratios of ^{90}Sr /Sr that exist in the tanks. This application also affects the ^{90}Sr concentration after the 94 % conversion is applied.

4.4 NEW WASTE RECEIPTS

The waste receipt schedules within the model and the projected waste receipts for the final run were compared to the assumed waste receipt schedules and found to agree with the following exceptions.

- The current modeling of the aging waste tanks (AY/AZ) process condensate is not accurately being addressed in HTWOS. Resolution of this will be deferred until after the System Plan, Rev. 4 effort.
- The 222-S waste receipts were turned off for the final run to avoid conflicts with the West Cs IX system feed staging, which is not being verified at this time. The correct receipt of the 222-S laboratory wastes will need to be verified in future modeling modifications.

4.5 SST RETRIEVAL

The volume of waste retrieved from S-109 is underestimated, when compared to the assumption values found in SVF-1283, Rev. 2. This discrepancy is associated with the DBVS/BVS being turned off. This needs to be corrected in future model revisions by either revising the assumption or the model.

4.6 MASS BALANCE

The mass balance file shows imbalances around the WTP and around the east and west STP for various radionuclides and elements. There is an imbalance of ^{227}Ac, and Ac around the DBVS/BVS and an imbalance of ^{134}Cs around the West CsIX. If the radionuclide decay is turned off there are no imbalances. The resolution of this issue will be addressed in future modeling efforts when those systems are simulated as part of the RPP mission.

4.7 WASTE FEED DELIVERY

Model results were not consistent with all of the specific assumptions associated with DST waste feed staging as described in section A4.2.6 of the assumption matrix. These inconsistencies should be addressed in future model versions.

4.8 LAW FEED

The following model improvements are suggested to improve the in-specification feed deliveries to WTP (see section 3.8 for a more detailed description):

1. DST utilization and feed staging logic needs to be improved to insure that dilute supernate is concentrated before delivery to WTP, use proper dilution water for the DSS/DSSF waste retrieval, and the 242-A Evaporator target SpG may need to be reduced for balance of mission to avoid over-concentrating feed.
2. The common features of the high-TRU batches appears to be very low [Na] and traceback to C-105 which has known error in the ^{241}Am waste feed in the test inputs used for this run.

These enhancements are planned to be addressed in the next System Plan update.

4.9 LAW SUBMERGED BED SCRUBBER PARTITIONING

For the WTP LAW SBS, the partitioning of tritium (^{3}H) was demonstrated to fall within about 4% of the expected partitioning (^{3}H is supposed to follow the water). This may be due to limitations in the way the verification spreadsheet performed its alternative calculations, but should be revisited when the entire WTP model is realigned with the emerging WTP process flowsheet assumptions (probably MDD Rev 10 and BARD Rev 4).

5.0 REFERENCES

24590-WTP-MDD-PR-01-002, Rev 8, *Dynamic (G2) Model Design Document*, Bechtel Hanford Incorporated, Richland WA.

24590-WTP-RPT-PT-02-005, Rev. 3, *Flowsheet Bases, Assumptions, and Requirements.* Bechtel Hanford Incorporated, Richland WA.

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APPENDIX A

HANFORD TANK WASTE OPERATIONS SIMULATOR MODELING ASSUMPTIONS

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LIST OF TERMS

BCR	Baseline Change Request
BBI	Best-Basis Inventory
BNI	Bechtel National, Inc.
BNI/WGI	Bechtel National-Washington Group
Bq	Bequerels
CERCLA	Comprehensive Environmental Response Compensation Liability Act
CH2M HILL	CH2M HILL Hanford Group, Inc.
Ci	Curies
CSB	Canister Storage Building
DHR	decay heat rate
DOE	U.S. Department of Energy
DST	Double-shell tank
ETF	Effluent Treatment Facility
ft	feet
ft^3	cubic feet
FY	Fiscal year
g	grams
g/mL	grams per milliliter
g-mol	gram mole
GPM	Glass Properties Model
HEME	High Efficiency Mist Eliminator
HEPA	High Efficiency Particulate Air
HLW	High-level waste
HTWOS	Hanford Tank Waste Operations Simulator
ICD	Interface Control Document
IDF	Integrated Disposal Facility
IHLW	Immobilized high-level waste
ILAW	Immobilized low-activity waste
IMUST	Inactive miscellaneous underground storage tanks
IP	In progress
kg	kilograms
Kgal	kilogallons
L	liters
LAW	Low-activity waste
LERF	Liquid Effluent Retention Facility
LLW	Low-level waste
M	molarity or moles per liter
m^2	square meters
m^3	cubic meters
Mgal	million gallons
MRS	Mobile Retrieval System
MSD	Mission Summary Diagram
MT	metric tons

MTG/d	metric tons of glass per day
nCi/g	nanocuries per gram
NO_x	Nitrogen-Oxide
ORP	U.S. Department of Energy, Office of River Protection
OSD	Operating Specification Document
PFP	Plutonium Finishing Plant
PUREX	Plutonium-Uranium Extraction Plant
RCRA	Resource Conservation and Recovery Act of 1976
RL	U.S. Department of Energy, Richland Operations Office
RPP	River Protection Project
SBS	Submerged Bed Scrubber
SpG	Specific gravity
SST	Single-shell tank
SWL	Saltwell liquid
TFC	Tank Farm Contractor
TPA	Tri-Party Agreement
Tri-Party Agreement	Hanford Federal Facility Agreement and Consent Order
TRU	transuranic
TWINS	Tank Waste Information Network System
VOC	Volatile Organic Compounds
WESF	Waste Encapsulation and Storage Facility
WESP	Wet Electrostatic Precipitator
WSCF	Waste Sampling and Characterization Facility
WRF	Waste Retrieval Facility
WTP	Waste Treatment and Immobilization Plant
WVRF	Waste volume reduction factor
wt%	Weight percent

A1.0 OVERVIEW

This appendix documents the HTWOS model objects, calculations, inputs, assumptions, and results verified to establish HTWOS Version 3.0. Figure A-1 provides a schematic of the RPP mission. Table A-1 identifies the HTWOS model objects, calculations, inputs, assumptions, and results, the methods used to verify the items, and the results of the verification. Tables A-2 through A-4 provides additional details about specific assumptions.

A2.0 MODELER'S AND VERIFIER'S SIGNATURES

The signatures below document that the HTWOS model objects, calculations, inputs, assumptions, and results were verified.

Modeler's Names

G. K. Allen _____ Date 3/2/2009

Verifiers Names

J. N. Appel _____ Date 3/3/2009

L. M. Bergmann _____ Date 3/2/09

P. J. Certa _____ Date 3/2/09

T. M. Hohl _____ Date 03/02/2009

R. A. Kirkbride _____ Date 3/2/2009

M. W. Leonard _____ Date 3/3/2009

R. M. Lowy _____ Per Telecon RML Date 03/02/09

R. L. Lytle _____ Date 03/02/09

J. G. Reynolds _____ Date 03/02/09

M. J. Rogers _____ Date 03/02/09

M. G. Thien _____ Per Telecon MGT Date 03/02/09

Figure A-1. Simplified Schematic of the River Protection Project.

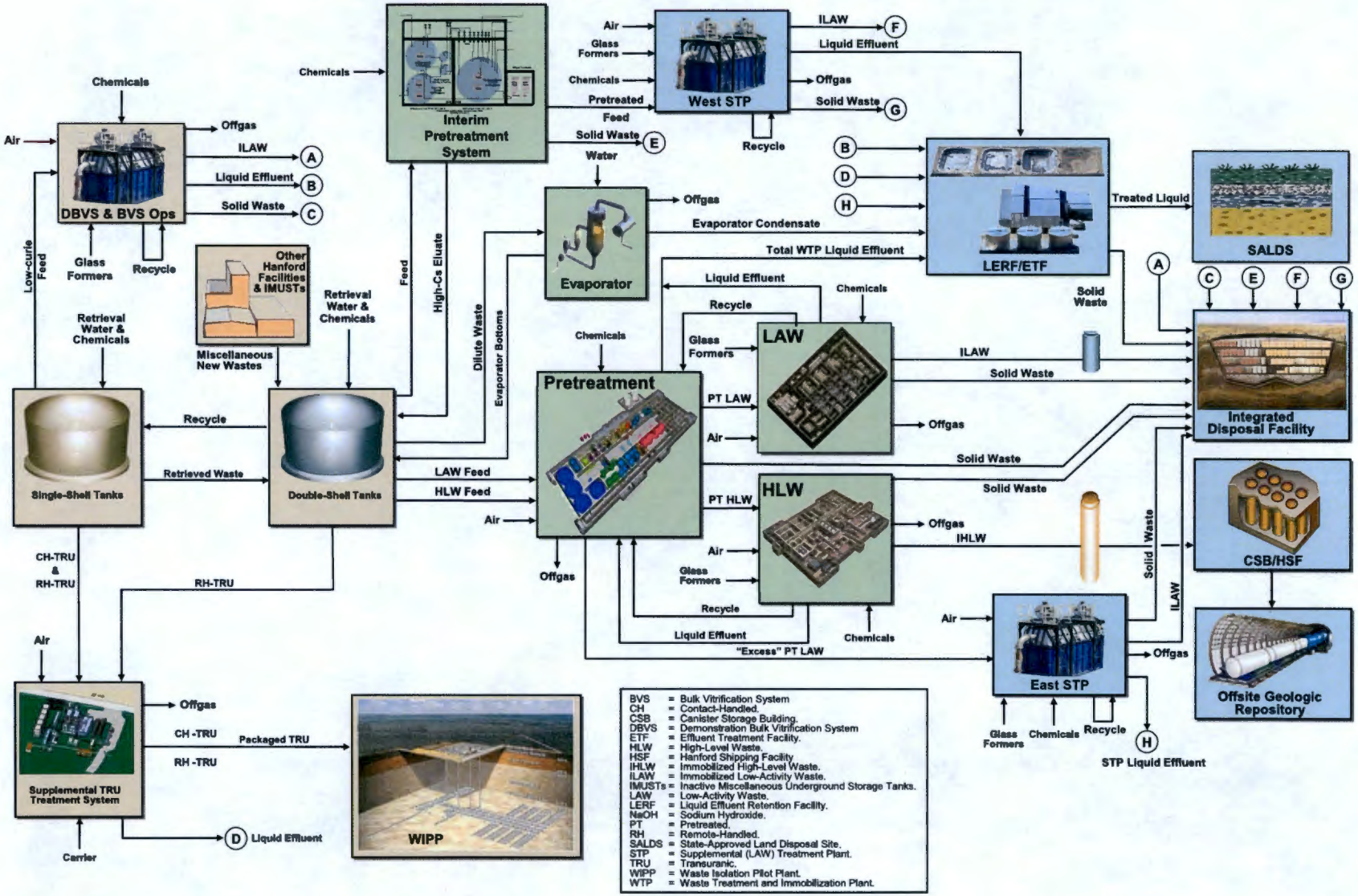

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
A2.1.1. New Waste Introduced Via Deactivation			
PUREX – Deactivation ~ 2025 Flush Volume Factor	15 Kgal 10%	R.A. Kirkbride	• Compared waste receipt schedule in East Waste Receipts block on Balance of Mission (BOM) Logic workspace to assumption values. • Examined transfer file data (SVF-1646, Rev. 0, *Transfers_V and V 8.4r0-2009-01-16-at-00-40-11_M1.xls*) for waste receipt and flush transfers.
T-Plant – Deactivation ~ 2025 Flush Volume Factor	15 Kgal 22%	R.A. Kirkbride	• Compared waste receipt schedule in East Waste Receipts block on BOM Logic workspace to assumption values. • Examined transfer file data (SVF-1646, Rev. 0) for waste and flush receipt.
A2.1.2. New Waste Introduced Via Operations			
222-S Laboratory – Receipt Rate: • FY 2007 through FY 2017[1] • FY 2018 through the end of waste processing • Flush Volume Factor	• 5 Kgal/year • 10 Kgal/year • 22%	R.A. Kirkbride	• Compared waste receipt schedule in West Waste Receipts block on Evaporator Logic workspace to assumption values. • Examined transfer file data (SVF-1646, Rev. 0) for waste and flush receipt.
A2.2. Waste Treatment Plant			
Key features for modeling	Key features of the WTP that will be modeled for purposes of mission planning and estimation of secondary waste streams include: • Feed Receipt Tanks (simplified and LAW tanks lumped) • Front End Evaporator (simplified – no feed tanks) • Ultrafilter System (with modified [OH^-] endpoint and oxidative leach) • Pretreated HLW Lag Storage and Blend Tanks (simplified – 81 Kgal lumped capacity)	Various personnel	The process graphics in the HTWOS model were compared to the process graphics in the 24590-WTP-MDD-PR-01-002, Rev 6 document. Addition details about the verification are provided in sections 3.4.1 through 3.4.4.

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
	individual melters) • LAW Melter Feed Preparation (simplified) • LAW Melter (model total capacity, not individual melters) • Off-gas treatment systems except for Pretreatment Facility off-gas system). • Recycle of both LAW SBS and WESP Condensate to Back End Evaporator. • Recycle of HLW Condensate (from SBS, WESP, and HEME – neglect canister wash water) to HLW Feed Receipt tank. • Discharge of LAW Caustic Scrubber effluent and evaporator condensate to the LERF/ETF via Pretreatment. • The WTP pretreatment facility will be configured so that a portion of concentrated pretreated LAW from the Treated LAW Concentrate Tank can be transferred to the Supplemental Treatment Plant (STP) in East Area as feed. This is downstream of the point to which LAW SBS condensate is recycled, so the STP feed will include a proportional fraction of SBS condensate.		
Technical Basis for Modeling	The basis for modeled chemical reactions and extents for estimating primary streams and secondary waste streams will be the 24590-WTP-MDD-PR-01-002, Rev 6, with flowsheet and operating mode modifications as needed to implement the other assumptions in this System Plan. Off-gas system configuration and updated split factors for all unit operations will be obtained from 24590-WTP-MDD-PR-01-002, Rev 8, with additional clarification provided by 24590-WTP-RPT-PT-02-005, Rev 3, "Flowsheet Bases, Assumptions, and Requirements."[2]	R. M. Lowy	This is discussed in Section 3.4.1 through 3.4.4.
	Cs partitioning in the WTP Cs IX system	R. A. Kirkbride	Reviewed the revised summary mass balance (SVF-1643, Rev. 0, *Mass_Balance_V and V-3.0-8.4r0-2009-01-16-at-00-40-11_M1.xls*) for th partitioning of Cs in the WTP Cs ion exchange (IX) system.

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
A2.2.1. Low-Activity Waste Processing Schedule			
LAW feed delivery dates	Start delivery of the first LAW feed batch on 5/1/2018.	R. M. Lowy	Compared the USER-DATA in the TANK-FARM-FEED-ANALZYER or WTP batch feed source workspace to the assumption value for the first fee delivery date.
	Start delivery of the first LAW feed batch on 5/1/2018. The first LAW feed batch will be provided by a decant transfer of about 150 Kgal of supernate from AY-102 to the LAW feed receipt tanks.	R. A. Kirkbride	Examined the transfer file data (SVF-1646, Rev. 0) for the first LAW feed and compared delivery date to the assumption value.
	Deliver remaining LAW feed as needed to keep the WTP operating within model constraints.	R.A. Kirkbride	Analyzed the projected ILAW production and ramp data (SVF-1644, Rev. *Product_Plots_V and V-3.0-8.4r0-2009-01-16-at-00-40-11_M1.xls*) to det the length of LAW melter outages and examined model results to identify source(s) of the outages.
LAW Pretreatment Ramp Up	Support the down-stream demand for pretreated LAW up to a maximum UF permeate rate of 15.6 gpm.	R. M. Lowy	Compared the USER-DATA2 value in the SET-UF-SOLIDS-AND-PERM RATE object to the assumption value.
LAW Vitrification Ramp Up	From - To MTG/d (net rate) 5/15/2018 – 9/30/2018 8.74[3] 10/1/2018 – 12/31/2019 9.0 1/1/2020 – 12/31/2020 18.0 1/1/2021 – end of mission 21.0	R. M. Lowy R. A. Kirkbride	Compared the ramp rates in the assumptions to the values in the HTWOS WTP-LAW-RAMP-RATE (by selecting "show initial ramp processing rat the object menu). Compared the ramp rates in the assumptions to the ramp rate data in the production plot file (SVF-1644, Rev. 0).
Complete Waste Processing	One goal of the run is to determine when waste processing completes with the stated assumptions.	R. A. Kirkbride	Examined the glass production data (SVF-1644, Rev. 0) for the last date w glass is produced.
A2.2.2. LAW Feed Receipt Tanks			
LAW Feed Receipt Tank Use	The WTP LAW feed receipt tanks will be capable of receiving 1 Mgal of LAW feed without interruption.	R. M. Lowy	Compared the maximum volume value for HTWOS object SPARE-101 to assumption value.
A2.2.3. LAW Pretreatment Process			
LAW WTP Process Model	• There will be approximately 300 gallons (2005 lb_m air-dried) of spent cesium ion exchange resin generated for every 300,000 gallons of supernate treated through the cesium ion exchange system.	R. M. Lowy	• Examined HTWOS procedure HTWOS-CSIX-PUMP-FSPLIT3 for t parameter values for the mass of resin and volume of supernate proce per bed of resin.

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
	being prepared for disposal.		ion exchange resin using data reported in the summary mass balance (SVF-1643, Rev. 0) and compared the estimated values to the target in Table A-2.
A2.2.4. LAW Melter Design and Operation			
LAW melter glass capacity	6,900 gallons	R. M. Lowy	Compared the set volume in the HTWOS-LAW-MELTER object to the assumption value. .
LAW melter operation	• One LAW melter is replaced every 2.5 years. • At the time of replacement, the contents of the melter (6,900 gallons) are sent to a "Spent" melter stream. • The glass remaining in the LAW melter at the end of the mission will be sent to the spent melter stream.	R. M. Lowy R. A. Kirkbride	• Compared the melter-failure-rate value in the HTWOS-LAW-MELT object to the assumption value. • Compared the melter failure gallons value in the HTWOS-LAW-ME 1 object to the assumption. • Compared the mass of glass reported in the spent LAW melter strean the Assumption Checks worksheet in SVF-1643, Rev. 0) to an estim the mass obtained by dividing the number of years of operation by 2. per melter and multiplying the by the volume of glass in a spent melt by the glass density.
A2.2.6. ILAW Formulation and Packaging			
ILAW Process	• The total sodium loading of LAW glass from pretreated feed will be determined using the DOE Model (D-03-DESIGN-004), which maximizes the sodium oxide loading in the LAW glass subject to the following constraints: $[Na_2O] \leq 20wt\%$ $[SO_3] \leq 0.8wt\%$ • The composition of the LAW glass will be	T.M. Hohl and R. A. Kirkbride	The HTWOS model code was compared to the source documents for the I model and for LAW glass formulation. Alternate calculations were perfor formulate the LAW glass and then to compare the results of the alternate calculation to the LAW glass formulation projected by the HTWOS model

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
A2.2.8. High-Level Waste Processing Schedule			
HLW feed delivery dates	Start delivery of the first batch group of HLW feed on 5/15/2018 and deliver remaining HLW feed as needed to keep the WTP operating within model constraints. The first batch group of HLW feed will be provided from AY-102 using existing supernate or by adding sufficient water to the decanted solids to obtain a slurry solids loading between 10 and 200 grams solids per liter of slurry.	R. A. Kirkbride	• Examined the transfer file data (SVF-1646, Rev. 0) for the first HL receipt and compared delivery date to the assumption value. • Analyzed the projected IHLW production and ramp data (SVF-164 0) to determine the length of HLW melter outages and examined m results to identify the source(s) of the outages. • Compared the projected solids loading of the HLW batches origina sourced in AY-102 (SVF-1651, Rev. 0, *WTP_Spec_8_V and V-3.0-2009-01-16-at-00-40-11_M1.xls*) against the assumption values.
HLW Vitrification Ramp-up	From - To HLW MTG/d (net rate) 5/15/2018 – 9/30/2018 1.44 10/1/2018 – 12/31/2019 3.0 1/1/2020 – 12/31/2020 4.0 1/1/2021 – 2/5/2024 4.2 2/6/2024 – end of mission 5.25	R. M. Lowy R. A. Kirkbride	Compared the ramp rates in HTWOS object WTP-HLW-RAMP-RATE (b selecting "show initial ramp processing rate" in the object menu) to the assumptions. Compared the ramp rates in the production plot file (SVF-1644, Rev. 0) to assumptions.
A2.2.9. HLW Feed Receipt Tanks			
HLW Feed Receipt Tank Usage	• Sufficient space to receive 160,000 gallons (600 m^3) without interruption.	R. M. Lowy	• Compared the maximum volume value in the HTWOS object OUT-(TANK-2 to the assumption value.
	• All HLW batches must be between 52,834 and 160,000 gallons (targeting an average of about 130,000 gallons in volume) and contain between 10 and 200 grams of unwashed solids per liter of slurry. • Deliver the HLW solids at a target nominal solid concentration of 8 wt% to facilitate more efficient WTP operations.[4]	R. A. Kirkbride	• Compared the volumes and solids loadings of all of the HLW batche: assumption values (SVF-1651, Rev. 0). • Evaluate the average HLW solids loading for all of the batches deliv the WTP.
A2.2.10. HLW Pretreatment Process			
HLW WTP Process Model	• The water wash factors in the TWINS on 3/7/2007 will be used for partitioning waste into solid and liquid phases during	T. M. Hohl	• The wash factors reported from the HTWOS model were compared t original input data files.

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
	• Sufficient caustic will be added to the waste during caustic leaching so that 3.0 M [OH^-] remains in solution after the leach reactions are complete.	R. M. Lowy	• Examined the truth-values for HTWOS-CAUSTIC-LEACH, and 3-MOLAR-CAUSTIC-ENDPOINT. Compared the initial value and recorded value in the CAUSTIC-ENDPOINT-MOLARITY float-par to the assumption. Examined the design specification in the HTWOS procedure CALCULATE-BNFL-CAUSTIC-VOLUME.
	• All solids delivered with the HLW feed and entrained solids delivered with the LAW feed will undergo caustic leaching, and caustic-leached solids containing more than 5,000 μg Cr / g dried solids will undergo oxidative leaching. The insoluble fraction remaining will be incorporated into HLW glass.		• Examined the truth-value for OXIDATIVE-LEACH.
	• An oxidative leach process that removes Cr from the HLW sludge without impact on cycle time or other species will be implemented in the ultrafilters. Reaction stoichiometry and endpoint (5,000 μg Cr / g dried solids) are described in RPP-15552.		• Examined the HTWOS-OXIDATIVE-LEACH-CR and the HTWOS-LOAD-OXIDATIVE-LEACH-REACTION procedures.
A2.2.11. HLW Melter Design and Operation			
HLW melter glass capacity	1,800 gallons	R. M. Lowy	Compared the set volume in the HTWOS-HLW-MELTER-1 object to the assumption value. .
HLW melter design	• One HLW melter is replaced every 2.5 years. • At the time of each melter replacement, 823 gallons of HLW glass are sent to a "Spent" melter HLW melter stream	R. M. Lowy	• Compared the melter failure rate value in the HTWOS-HLW-MELTI object to the assumption value. • Compared the melter failure gallons value in the HTWOS-HLW-MEI object to the assumption.
	• The glass remaining in the HLW melter at the end of the mission will be sent to the spent melter stream.	R. A. Kirkbride	• Compared the melter failure gallons value in the HTWOS-HLW-MEI object to the assumption. Compared the mass of glass reported in the melter stream to an estimate of the mass obtained by dividing the nur years of operation by 2.5 years per melter and multiplying the by the of glass in a spent melter and by the glass density.
A2.2.13. IHLW Formulation and Packaging			
Method for Estimating	Glass Properties Model modified as follows.	P.J. Certa/	• Compared the values for the Glass Properties Model limits (on the Gl

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
	• Use a maximum zircon liquidus temperature limit of 1050 °C. • Use a Product Consistency Test (PCT) upper limit of 2 g/m^2.		
IHLW Glass Density	2.7 MT/m^3	R. M. Lowy	Compared the SOLID-DENSITY value in the HTWOS-HLW-MELTER-1 and on the glass assumptions workspace to the assumption value. .
IHLW Canister Net Mass	3.2 MT (thin-walled canister)	R. M. Lowy	Compared the product of the value for glass volume per IHLW canister an IHLW SOLID-DENSITY to the assumption value.
A2.3. Supplemental Treatment			
A2.3.1. TRU Sludge Packaging			
Contact-Handled Sludge Packaging Feed Delivery	• The contact-handled Supplemental TRU Treatment and Packaging process will be available on 10/1/2013 to process waste from the 200-Series SSTs listed below. • The system will first be located near B-Farm and then moved to T-Farm. There will be a 10-day outage between tanks and 60-day outage to move equipment between farms. • Tanks [B-201, B-202, B-203, B-204], [T-201, T-202, T-203, T-204], T-111, T-110, and T-104 will be retrieved and sent for packaging as CH-TRU. The tanks will be retrieved and packaged in the stated order except that the tank order within the [brackets] can be changed. • The waste from the B-200 and T-200 series SSTS, T-104, T-110, and T-111 will be retrieved using the volume of retrieval water needed to achieve the as-retrieved volume given in Table A-4, without impact to DST space (i.e., no liquids are returned to the DST system). • There will be no water or waste sent to the DST system.	R.A. Kirkbride	• Compared the date for the analyzer associated with the B-200 SSTs c East Area workspace with the assumptions. • Reviewed the transfer file data (SVF-1646, Rev. 0) to identify which processed first, and to determine the lag between retrieval operations • Compared the simulated sequence from the transfer file to the assum • Compared the HTWOS-projected as-retrieved waste volumes reporte *SST_Retrieval_V and V-3.0-8.4r0-2009-01-16-at-00-40-11_M1.xls*, SVF-1645, Rev. 0, to the as-retrieved waste volumes in Table A-4 fo of the tanks. Examined the HTWOS process schematic for the destir of water and waste, and examined the transfer file for transfers from packaging facilities to the tank farms. • Examined the HTWOS process schematic for the destination of wate waste, and examined the transfer file for transfers from the packagin facilities to the tank farms.

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
	• The solids in tank SY-102 will be moved across the site as soon as the waste currently in tank AN-104 has been moved out and will be combined with the solids in tank AW-105 or AW-103 as space allows. • Supernatant liquid will be decanted from tank AW-103 when sufficient DST space is available after June 2024. The waste solids in tank AW-103 will be washed four times as DST space allows, using one gallon of 0.01 M NaOH solution for each gallon of the initial bulk settled solids for each wash. After each wash, the solids are settled to 40 wt% before decanting the wash solution for feed to the evaporator. The first wash of the waste solids in AW-103 is assumed to dissolve the saltcake portion. Existing water wash factors and the Sr solubility model will be applied to estimate the overall wash effectiveness. • Add enough 0.01 M NaOH to deliver an approximately 10 wt% solids slurry for packaging. • Supernatant liquid will be decanted from tank AW-105 after July 2025 and following the AW-103 washing as DST space allows. The waste solids in tank AW-105 will be washed four times over a nine-month period, or as DST space allows, using one gallon of 0.01 M NaOH solution for each gallon of the initial bulk settled solids for each wash. After each wash, the solids are settled to 40 wt% before decanting the wash solution for feed to the evaporator. The first wash of waste solids in AW-105 is assumed to dissolve the saltcake portion. Existing water wash factors and the Sr solubility model will be applied to estimate the overall wash effectiveness. • Add enough 0.01 M NaOH to deliver an		

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
	Complex WRF[6] using one gallon of 0.01 M NaOH solution for each gallon of the initial bulk settled solids for each wash. After each wash, the solids are settled to 40 wt% before decanting the wash solution for feed to the evaporator. The first wash of the waste solids will dissolve the saltcake portion. Existing water wash factors and the Sr solubility model will be applied to estimate the overall wash effectiveness. • Add enough 0.01 M NaOH to deliver an approximately 10 wt% solids slurry for packaging. • After packaging the RH-TRU waste from the B-Farm SSTs, the packaging facility will be located near T-Farm to wash and package the waste from tanks T-105, T-107, and T-112. The retrieved SST waste will be washed four times over a nine-month period in the T-Complex WRF using one gallon of 0.01 M NaOH solution for each gallon of the initial bulk settled solids for each wash. After each wash, the solids are settled to 40 wt% before decanting the wash solution for feed to the evaporator. The first wash of the waste solids will dissolve the saltcake portion. Existing water wash factors and the Sr solubility model will be applied to estimate the overall wash effectiveness. • Add enough 0.01 M NaOH to deliver an approximately 10 wt% solids slurry for packaging.		

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
Sludge Packaging Process	The process flowsheet for the contact-handled TRU sludge treatment is described in RPP-21970, Rev. 0. For modeling purposes, the two dryers may be lumped into one dryer of equivalent treatment capacity. For planning purposes, the same flowsheet will be used for processing the water-washed sludge from the RH-TRU Tanks.	R. A. Kirkbride	
	• The slurry will be transferred to the Feed Receipt Process System modeled as five tanks, each with a working volume of 7,200 gallons.		• Compared the HTWOS process graphic and the attributes of the feec to the stated assumptions.
	• The slurry, carrier and heat are continuously added to the dryer, while dried product is withdrawn to maintain a product with 10 wt% water and 80 wt% waste loading (both relative to waste, water and carrier).		• Compared the user data in the SUP-TRU-DRYER object to the statec assumptions, and compared the water and carrier loading in the packa CH-TRU to the stated assumptions.
	• The maximum capacity of the Sludge Packaging Process is a slurry feed rate of 5.6 gpm.[8] The slurry is fed to the dryer at the maximum of the stated dryer feed rate or the capacity of the retrieval technology being used to retrieve the TRU waste, whichever is most constraining.		• Examined the pump flow attribute of the SUP-TRU-FEED1 through TRU-FEED5 objects and the Feed rate, gpm attribute of the SUP-TR DRYER object, and calculated the average retrieval rate for the CH-T tanks.
	• Vermiculite is added to the dryer as a flowability agent and to the drum as a sorbent and sand is added to the dryer as a scouring agent. The total vermiculite and sand added during the packaging process will be modeled as the addition of SiO_2 to the dryer at a ratio of one mass of SiO_2 per eight masses of slurry feed, on a dry basis. (Note: Silica comprises 97.5 % of the total mass of the additive and the composition of vermiculite can vary widely so ignoring the non-SiO_2 constituents in vermiculite does not significantly increase the uncertainty in the packaged waste composition.)		• Calculated the ratio of the total mass of waste feed to TRU packagin water) to the mass of SiO_2 additive and compared the calculated ratic stated assumption.
	• Dryer retention factors (i.e., the fraction of		• Compared the split factors in the SUP-TRU-DRYER object to the dr

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
	• Liquid effluent will either be transferred to the LERF via Tank Truck or recycled to the Retrieval project. For planning purposes, it will be assumed that the liquid effluent is transferred only to LERF (no recycle) and modeled as a continuous transfer.		• Compared the HTWOS process graphic to the stated assumptions.
	• The dried CH-TRU waste product is packaged in 55-gallon drums containing 620 lb_m of product per drum.[9]		• Compared the user data in the CONTACT-SUPP-TRU-PKG-COUN' data-logging-sensor to the stated assumptions, and compared the num CH-TRU packages calculated from the reported mass of packaged C
	• The dried RH-TRU waste product is packaged in an RH-TRU Waste Canister containing 2,825 lb_m of product per canister. Each canister will be shipped to WIPP in an RH-TRU 72-B Shipping Package.[10]		• Compared the user data in the REMOTE-SUPP-TRU-PKG-COUNT logging-sensor to the stated assumptions, and compared the number TRU packages calculated from the reported mass of packaged RH-T
	• The washed solids will require remote handling for packaging, can be treated and packaged as remote-handled TRU for disposal at WIPP.		• N/A
A2.3.2. Supplemental LAW Processing			
Supplemental Treatment Demonstration	• A Demonstration Bulk Vitrification System (DBVS) will be located in the 200 West Area (west of S-Farm) and be operated at a net rate of 2.745 MTG/d[11] starting on 3/1/2011 to process 260 MT Na from the low-curie waste from tank S-109. The demonstration will be completed by 10/23/2012.	Defer[12]	N/A

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
	• The DBVS will be fed directly from S-109 with no solids entrained out of S-109. The feed will be delivered at 5 M Na. The S-109 waste retrieval will be controlled to limit the total activity in the retrieved waste to 0.0062 Ci per liter (at the 5 M Na feed concentration) for the demonstration.	Defer	N/A
Supplemental Treatment Demonstration Extension	• The Bulk Vitrification System (BVS) facility will be refurbished and re-permitted for extended operation after a one-year outage. The refurbished facility starts operating on 10/23/2013 at a net rate of 3.66 MTG/day and operates as long as low-curie feed from tanks S-109 and S-105 is available.	Defer	N/A

	• The feed to the BVS process for extended operation includes:
	  • Low-curie feed from the continued selective dissolution of tank S-109 waste. It is expected that continued selective dissolution of waste in S-109 will continue until the cumulative removal of waste reaches 90%. Partitioning of the waste components will be approximated using the selective dissolution factors in TFCOUP Table. About 80% of the Na, and 20% of the Cs currently in the tank will be sent to the DBVS or the BVS. The remaining waste will be retrieved later.
	  • Low-curie feed from the selective dissolution of tank S-105 waste. It is anticipated that selective dissolution will continue until the cumulative removal of waste reaches 90%. Partitioning of the waste
		Defer	N/A

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
	Pretreatment System, leaving approximately 1% of the waste as a residual.		
East Area Supplemental Treatment Process	• A production facility, consisting of four melter lines, starts hot testing on 2/1/2019 and operates at 25% of full capacity (about 3.66 MTG/d) for eight months. • Full capacity operation starts on 10/1/2019 at a rate of 14.65 MTG/d.	Defer	N/A
West Area Interim Pretreatment System (IPS)	• Solid/liquid separation will be performed in tank SY-101 by the installation of two rotary micro filtration units, which will remove all entrained solids. • Waste pretreatment will be performed using a regenerable Cs IX resin contained in one of two new vaults. In one vault, two IX resin columns will be used to remove Cs; one as a lead column and as a one polishing column. Cs removal will proceed until breakthrough of Cs is observed, at which time the system will be shut down and the resin regenerated using an acid eluent. The acid eluent is collected in an eluate tank within the Cs IX vault, sampled and analyzed, neutralized with caustic, and transferred to tank SY-102 for subsequent transfer to an East Area DST. • Pretreated waste is sent to one of two new double-contained receiver tanks (DCRTs) located in the second of the two new vaults. Each new DCRT has a working volume of 41,400 gallons. Pretreated waste from the Cs IX system will be sent to one DCRT while the pretreated waste in the other DCRT is sampled and analyzed before being sent to the West Area Supplemental Treatment Plant. • Since the pretreatment system is being started before the West Area STP, pretreatment operations will start on 2/28/2014 and continue until the DCRTs	Defer	N/A

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
	pretreated waste is assumed to be 1.5 E-5 Ci per mole of sodium. • For planning purposes, the capacity of the IPS is assumed to exceed the capacity of the West Supplemental Treatment Plant. • Waste in tank SY-101 will be used as the first feed to the pretreatment system. Then the supernatant liquid in tank SY-103 will be transferred to SY-101 for solid/liquid separation and delivery to Cs IX. The salt solids in tank SY-103 will be dissolved, sampled and analyzed, and transferred to tank SY-101. After SY-103 has been emptied, it will be used to receive and sample wastes for staging into SY-101 and processing through Cs IX. • No estimate will be made of the loading of radionuclides or chemical species on the spent ion exchange resin.		
West Area Supplemental Treatment Process	• A production facility, consisting of four melter lines, starts hot testing on 7/2/2014 and operates at 25% of full capacity (about 3.66 MTG/d) for eight months. • Full capacity operation starts on 3/2/2015 at a rate of 14.65 MTG/day.	Defer	N/A
	• The West Area STP operates to process as much liquid waste from the West Area SSTs as practical.	Defer	N/A
WTP Process Considerations	The WTP pretreatment facility will be configured so that a portion of concentrated pretreated LAW from the Treated LAW Concentrate Tank can be transferred to the East Area Supplemental Treatment Plant (STP) as feed. This is downstream of the point to which LAW SBS and WESP condensate is recycled, so the STP feed will include a proportional fraction of the SBS and WESP condensate.	Defer	N/A
STP Process Basis (including DBVS)	• The bulk vitrification processes will be modeled using a simplified continuous flowsheet that implements the overall	Defer	N/A

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
	those two documents may be obtained from the process design criteria provided in 145579-A-DC-002, Rev 0F. However, the mixture of glass forming minerals specified in Table 1 of ST07.004 will be used instead of Hanford soil.		
	• The three DBVS/BVS feed receipt tanks will be modeled as one tank with a 45,000-gallon working capacity.	Defer	N/A
	• The twelve 15,000 gallon West STP feed receipt tanks will be modeled as one tank with an 180,000-gallon working capacity.	Defer	N/A
	• The twelve 15, 000 gallon East STP feed receipt tanks will be modeled as one tank with an 180,000-gallon working capacity.	Defer	N/A
	• The Na_2O loading in the product will be a nominal 21.24 wt% based on waste sodium.	Defer	N/A
	• Single-use box lids will be used in the DBVS/BVS system and each box with lid will retain 2.70% of the ^{99}Tc fed to the box melter as a non-glass waste form.	Defer	N/A
	• Multiple-use box lids will be used in the West STP system. Retention of ^{99}Tc will be modeled as a reduced retention due to the multi-use lids. Each box with lid will retain 0.39% of the ^{99}Tc fed to the box melter as a non-glass waste form.	Defer	N/A
Product and Packaging	Bulk vitrification is used as the supplemental treatment process to immobilize LAW. The following will be used to estimate bulk vitrification product volume and package count. • Glass density is 2.65 MT/m^3. • Packaged in 35 m^3 roll-off boxes, each	Defer	N/A

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
In-Tank Sr/TRU Precipitation			
In-tank Demonstration	• After 3/1/2020[13], if necessary, clean out AP-102 by decanting supernate down to 12 inches above any existing solids layer. • Sometime in April 2020, transfer 50 Kgal of supernate from AN-107 into AP-102, mixing it with a 10-inch liquid heel[14], and adding enough water to dilute the Na concentration to 5.5 M. • Add the necessary reagents [5.308 gallons of 3.83 M $NaMnO_4$ and 6.723 gallons of 3 M $Sr(NO3)_2$ each per 1000 gallons of diluted waste] and simulate the Sr/TRU precipitation by applying the reactions and removal factors given in Section A2.5 of TFCOUP, Rev. 6. • Simulate the reaction time and solids settling time by waiting 30 days. (Note that this may be considered conservatively long as the reaction requires a minimum of 4 hours [per RPP-24809] and the settling of C-Farm solids is assumed to occur within 3 to 5 days. Also, some time may be needed for sampling and analysis of the pretreated waste and evaluation of the results before declaring the demonstration was successful.)	J. N. Appel	• Examined a print out of the composition/volume information for AP- just prior to the first addition of AN-107. • Examined the transfer file for the schedule of transfers from AN-107 102 to verify the 50,000. Calculate the sodium molarity from a printc composition/volume information and the transfer file in a spreadshee • Examined the transfer file for the reagent additions. Had volume/composition files printed out. Used these files and the transf to create a spreadsheet that checked the material balance using the sp Section A2.5. • Examined the transfer file to ensure that at least 30 days past before a transfer in or out of AP-102.
In-tank Precipitation	After successful completion of the demonstration, the wastes in AN-102 and AN-107 will be transferred to AP-102 in four batches to precipitate Sr and TRU as outlined below. The pretreated supernate will be delivered to WTP as Envelope A feed. The Sr/TRU precipitate will be blended with other tank solids and delivered to WTP as HLW Envelope D feed. **For pretreatment of the AN-107 waste:** • Add 372 Kgal of waste from AN-107 to AP-102, mixing with the waste from the demonstration, and adding enough water	J. N. Appel	**AN-107 Pretreatment** • Examined the transfer file for the schedule of the second transfer fror 107 to AP-102. Calculated the sodium molarity from a printout of the composition/volume information and the transfer file in a spreadshee

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
	simulate the Sr/TRU precipitation by applying the reactions and removal factors.		to create a spreadsheet that checked the material balance using the sp Section A2.5.
	• Simulate the reaction time and solids settling time by waiting 30 days. • Decant the pretreated supernate to another DST for sampling before delivery to the WTP. • Add 422 Kgal of waste from AN-107 to AP-102, mixing with a 10-inch liquid heel. • Add about 100 Kgal of flush water to tank AN-107 to dilute remaining supernate heel and transfer to AP-102 for treatment with the second AN-107 Batch, adding enough water to dilute the Na concentration to 5.5 M. (Note that none of the solids in AN-107 are removed by the flush water.) • Add the necessary reagents (in the same ratio as used in the demonstration) and simulate the Sr/TRU precipitation by applying the reactions and removal factors. • Simulate the reaction time and solids settling time by waiting 30 days. • Decant the pretreated supernate to another DST for sampling before delivery to the WTP.		• Examined the transfer file to ensure that at least 30 days past before a transfer in or out of AP-102. • Examined transfer file data for the supernate decant. Examined the p outs of composition/volume data to confirm that supernate was pump • Examined the transfer file for the third transfer out of AN-107 to AP- • Examined the transfer file for the flush of the AN-107 heel to AP-10 examined the model code to determine if the waste is diluted per the assumptions. • Examined the transfer file for the reagent additions. • Examined the transfer file to ensure that at least 30 days past before a transfers in or out of AP-102. • Examined the transfer file for the transfer of the pretreated waste fro AP-102 to another DST.
	For pretreatment of the AN-102 waste: • Add 456 Kgal of waste from AN-102 to AP-102, mixing with a 10-inch liquid heel, and adding enough water to dilute the Na concentration to 5.5 M. • Add the necessary reagents (in the same ratio as used in the demonstration) and simulate the Sr/TRU precipitation by applying the reactions and removal factors. • Simulate the reaction time and solids		**AN-102 Pretreatment** • Examined the transfer file for the first transfer out of AN-102 to AP- Calculated the sodium molarity from a printout of the composition/v information and the transfer file in a spreadsheet. • Examined the transfer file for the reagent additions. Had volume/composition files printed out. Used these files and the transf to create a spreadsheet that checked the material balance using the sp Section A2.5.

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
	• Add about 100 Kgal of flush water to tank AN-102 to dilute remaining supernate heel and transfer to AP-102 for treatment with the second AN-102 Batch, adding enough water to dilute the Na concentration to 5.5 M. (Note that none of the solids in AN-102 are removed by the flush water.) • Add the necessary reagents (in the same ratio as used in the demonstration) and simulate the Sr/TRU precipitation by applying the reactions and removal factors. • Simulate the reaction time and solids settling time by waiting 30 days. • Decant the pretreated supernate to another DST for sampling before delivery to the WTP, or deliver from AP-102 (by decanting the supernate) depending on the availability of DST space.		• Examined the transfer file for the transfer of the pretreated waste fro AP-102 to another DST. • Examined the transfer file for the second transfer out of AN-102 to A • Examined the transfer file for the water addition to AN-102 and the transfer out of AN-102 to AP-102. • Examined the transfer file for the reagent additions. • Examined the transfer file to ensure that at least 30 days past before transfers in or out of AP-102. • Examined the transfer file for the transfer of the pretreated waste fro AP-102 to another DST.
A2.4. Waste Disposal Sites			
IHLW Facility Need Dates (Project W-464)	• The IHLW interim storage facility (the Canister Storage Building), being upgraded by Project W-464, will be operational on 9/29/2015 and provide interim storage for up to 880 IHLW canisters. • The need date for the Canister Storage Building will be the date on which the first IHLW is produced (estimated to be 5/17/2018). • For planning purposes, the first 880 IHLW canisters will be stored in the CSB.[16] • The shipping rate is up to two canisters of IHLW per day – first priority given to shipping newly created IHLW canisters beyond the 880 stored at the CSB – second priority is given to emptying the	R. A. Kirkbride	• Examined the glass production plot file (SVF-1644, Rev. 0) for consistency with the assumption values. • Examined the glass production plot file (SVF-1644, Rev. 0) for consistency with the assumption values. • Examined the glass production plot file (SVF-1644, Rev. 0) for consistency with the assumption values. • Compared the maximum canister production rate based on the WTI melter capacity against the assumed shipping rate.

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
A3.0. Retrieval and Closure			
A3.3. SST Retrieval Progress			
SST retrieval history and status	As of 4/1/2007, retrieval actions have been completed or are in progress (IP) for the following tanks[17]: Tank / Start Date / End Date/Status C-103 / 11/06/2005 / 8/23/2006[18] C-106 / 11/18/1998 / 12/31/2003 C-108 / 12/20/2006 / IP C-201 / 10/25/2005 / 3/23/2006 C-202 / 6/30/2005 / 8/11/2005 C-203 / 6/30/2004 / 3/24/2005 C-204 / 7/23/2006 / 2/11/2006 S-102 / 12/16/2004 / IP S-112 / 9/28/2003 / 3/28/2007	R. A. Kirkbride	Examined the SST retrieval data in the HTWOS model, and examined the retrieval results file (see SVF-1360, Rev. 1) for the model run.
A3.4 SST Retrieval Sequencing			
Near-term retrieval sequence (into FY 2019)	Retrieve SST wastes from the C-Farm, S-102, S-105, and S-109 tanks, starting after the dates given below when DST space becomes available[19], retrieving at the rates derived using the minimum durations in Table A-4, and proceeding as the available DST space and model logic allows:[20] Source Tank / Receiver Tank / Start Date C-108 / AN-106 / 12/20/2006 C-109 / AN-106 / TBD C-104 / AN-101 / 6/1/2008 C-107 / AY-101 / 9/1/2008 C-110 / AN-106 / 1/1/2011 C-112 / AN-101 / TBD C-101 / AY-101 / TBD C-105 / AY-101 / TBD C-102 / AZ-101 / 4/4/2013 C-111 / AN-101 / TBD	R. A. Kirkbride	Compared the start dates projected by the model to the start dates stated in assumptions.
Long-term retrieval sequence (FY 2019 and beyond)	The life-cycle priorities for sequencing the retrieval of SST waste are to minimize mission duration, by: • Balancing feed to WTP, STP, and TRU	L.M. Bergmann	Compared the Solid Sort and Na Sort lists used by the model to lists in the file used to generate the lists (SVF-1100, Rev. 0, *Relaxed_SST_Seq_Input_08-11)_v_1.xls*) and examined the glass production plots (SVF-1644, Rev. outages

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
	• Providing for incidental blending		
A3.7. Waste Retrieval Facilities			
Waste Retrieval Facility (WRF) Availability Dates	B-Complex WRF: 6/21/2018 T-Complex WRF: 6/21/2019 Wastes retrieved from tanks in the B or T complexes before the WRFs are available will be at lower insoluble solids loadings as defined in the Retrieved Waste Composition assumptions (see Section A3.8 of HNF-SD-WM-SP-012, Rev. 6).[21] Compliant transfer lines will be constructed to support retrievals from B and T complex before the WRFs are made available; one line for each complex.	R. A. Kirkbride	Examined the transfer file data (SVF-1646, Rev. 0) for the first transfers ir WRF tanks, and for the solids loading in transfers directly from B- or T-C SSTs to a DST.
A3.9. Constraints on Simultaneous Retrievals			

Simultaneous retrieval	The most limiting condition(s) resulting from application of the following constraints:
	• Retrieval and transfer systems in the NE and NW quadrants can support a maximum of 6 simultaneous retrievals in each tank farm and a total of six simultaneous retrievals in each quadrant (after the WRFs are constructed).
	• Retrieval and transfer systems in the SE and SW quadrants can support a maximum of 2 simultaneous retrievals in each tank farm and a total of two simultaneous retrievals in that quadrant.
	  o SE - A, AX, and C farms
	  o NE - B, BX, and BY farms
	  o SW - S, SX, and U farms
	  o NW - T, TX, and TY farms
	• A maximum of 7 total simultaneous retrievals can be performed at one time. (This assumes that labor resources are available.)
		R.A. Kirkbride	Examined the logic blocks controlling simultaneous retrievals and examin internal to the HTWOS model that shows the maximum number of simult retrieval machines.

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
	going directly from SSTs to supplemental treatment processes.		
A3.10. Retrieval Rates			
SST Waste Retrieval Rates	The SST waste retrieval rates are based on the retrieval technology that is planned to be used for each tank. Table A-4 identifies the assigned retrieval technology and the minimum retrieval duration based on the assigned technology. The HTWOS model uses an average retrieval rate based on the initial inventory and the minimum retrieval duration.	LM Bergmann	Compared the reported minimum retrieval durations to the data in Table A
A3.11. Retrieved Waste Volume & Composition			
Retrieval Solution Requirements	Table A-4 provides an estimate of the as-retrieved volume generated during the retrieval of wastes from the various SSTs. The HTWOS model will add water and supernate (for the C-Farm tanks) as needed to generate the as-retrieved volumes, after the application of water-wash factors.	LM Bergmann	Compared the reported as-retrieved waste volumes to the data in Table A-
A3.13. Single Shell Tank Waste Residuals			
SST Waste Residuals	• 200 Series SSTs: Best Basis Inventory (BBI) data for tanks where retrieval actions have been completed, when available, or 12 ft^3 of slurry containing water-washed solids and 24 wt% water as interstitial liquid.[22] • 100 Series SSTs: BBI data for tanks where retrieval actions have been completed, when available, or 290 ft^3 of 35 wt% water-washed solids with liquids at ½ the concentration of bulk as-retrieved supernate.[22] Determination of the as-retrieved supernate composition is described in Assumption A3.11.	R. A. Kirkbride	• Examined the second page of the Initial Inventory Assumptions in th HTWOS model for the value of the residual volume of waste to be le 200-Series SSTs, and examined the residual waste volumes reported end of the model run. • Compared the residual waste volume attributes in the HTWOS mode few 100-series SSTs and examined the residual waste volumes report the 100-series SST at the end of the run (in SVF-1645, Rev. 0).

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
A4.0. Waste Feed Operations			
A4.1. Initial Waste Inventory			
Starting tank inventory (DSTs+SSTs)	Starting tank inventories represents the contents of the tanks as of 1/1/2007[23], [24] (documented in RPP-33715). This is identified as the "FY 2007" inventory and is based on BBI data downloaded from TWINS in May 2007. Adjustments were made in the HTWOS model for historical transfers through 4/1/2007.	T. M. Hohl	The starting tank inventories were obtained from the HTWOS model and v compared to the original input files.
IMUST inventory and retrieval (retrieved in FYs 2020-2030)	Retrieved in FYs 2020 - 2030 550 Kgal total	R. A. Kirkbride	Examined transfer file data (SVF-1646, Rev. 0) for volume and schedule c receipts. Examined the East Area waste receipts in the Balance of Missior (BOM) logic block.
A4.2. DST Operations			
A4.2.1. Sodium Hydroxide Additions			
Caustic addition for SST Retrievals	Sodium hydroxide and sodium nitrite will be added as needed so that the as-retrieved liquid phase composition satisfies the DST waste chemistry limits given in Table 3-4 of HNF-SD-WM-OCD-015, Rev 17.	R. A. Kirkbride	Used the data in the SST-RETRIEVAL-CORROSION-MITIGATION-CONTROL internal-write object to perform alternate calculations to deter whether the waste met the DST corrosion specifications, and if the waste d meet the specifications, estimated the quantity of chemicals that would nee added to bring the waste into specification.
A4.2.2. Flush Volumes			
	TFCOUP Table A-21 provides the flush volumes used in the HTWOS model.	R. A. Kirkbride	Examined the HTWOS logic blocks governing waste transfers. Examined summary mass balance for the System Plan run (see SVF-1643, Rev. 0).
A4.2.3. Minimum DST Level			
Minimum DST Levels	• Supernatants can be pumped down to within 12 inches of a settled solids layer.	R. A. Kirkbride/ G.K. Allen	• Examined the minimum volume attribute value of each DST and HT model code.

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
	• SY-101 can only be pumped down to 100 inches (275 Kgal) between now and 1/29/2012. After that date, the transfer pump will be replaced and the waste can be pumped down to 12 inches. • SY-102 can only be pumped down to 200 inches (550 Kgal) until the solids are transferred across the site to AN-104. After the solids are transferred, the waste can be pumped down to within 12 inches		• Examined the minimum volumes reported for SY-101 before 1/1/201 (Note that 1/1/2014 was a convenient cutoff date in the data set for th model run.) • Examined the minimum volumes reported for SY-101 before mid-Ap 2020. (Note that mid-April of 2020 is the approximate date when the 102 solids were sent across the site to AN-104.)
A4.2.4. Maximum DST Level			
Maximum DST Levels	The maximum operating liquid levels for the DSTs are given in OSD-T-151-00007, Rev 1, "Operating Specifications for the Double Shell Storage Tanks", March 2007. In this revision of the operating specifications, the maximum operating level for AP-Farm tanks was increased from 449 inches (1.235 Mgal) to 454 inches (1.2465 Mgal). It is assumed that each AP-Farm tank will successfully pass the in-service leak testing required to utilize this increased operating level.	R. A. Kirkbride	Compared the maximum DST levels reported in the DST file (SVF-1642, to the maximum values in the cited reference.
A4.2.5. Tank Solids Level			
Solids Settling Endpoint	• Insoluble solids retrieved from C-Farm SSTs can be settled to a solids loading comparable to that in the source SSTs within 2 days of transferring to a DST.[25] • Insoluble solids retrieved from other SSTs and currently in the DST system can be settled to 40 wt% solids within 30 days.	R. A. Kirkbride	• Examined the HTWOS model code. • Compared the HTWOS value for the "General solid/sludge mass frac parameter on the Solid Washing Assumptions workspace to the assu value.
A4.2.6. Tank Space Allocation			
DST Usage	**WTP Feed Staging tanks:** AN-101, AN-102, AN-103, AN-104, AN-105, AN-107, AP-101, AP-102, AP-103, AP-104, AP-105, AP-106, AP-107, AP-108, AW-101, AY-101, AY-102, AZ-101, and AZ-102	R. A. Kirkbride/ M. W. Leonard	Examined the transfer file from a preliminary run for DST usage. Specific: • Filtered "To Tank" = OUT-OF-TANK-2, SPARE-101 (HTOWS representation of HLW Solids receipt tank at WTP and LAW receipt ta WTP, respectively).

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
	Slurry Transfer Limitations: Use AZ, AY, and AN farms, primarily for staging HLW solids. Try to avoid staging solids through AP or AW farms after retrieving the solids currently in those farms. **Supplemental Sludge Treatment Process Feed Source and Staging Tanks:** AW-103, AW-105, and SY-102 **Supplemental LAW Treatment DST Usage: Provide feed directly from S-105 and S-109 to the DBVS and BVS operations.** Provide feed from SY-101 and SY-103 for the West Area Interim Pretreatment System and Supplemental Treatment. Then use SY-101 and SY-103 to stage feed to those systems. **Sludge Transfer for Waste Feed Staging:** C Farm solids will be retrieved to tanks AN-101, AN-106, AY-101, and AZ-101. Some of these tanks may require additional equipment for mobilizing and transferring HLW solids into other DSTs for staging to the WTP. **In-tank Sr/TRU precipitation** Tank AP-102 will be used to perform in-tank precipitation of Sr and TRU from wastes in tanks An-102 and AN-107.		• Filtered "To Tank" = OUT-OF-TANK-2; Filtered "From Tank" = AP-103, -104, -106, -107, -108, AW-101, -102, -103, 104, -105, -106. • Filtered "To Tank" = TRU-FROM-DSTS (HTWOS representation of ⁷ packaging unit receipt tanks). • Filtered "To Tank" = WEST-TF-IX-FEED-TANK (HTWOS represent IPS receipt tank); separate filters to track SY-101 feeds back to source • Filtered "From Tank" = C-101, -102, -104, -105, -107, -108, -109, -11(-112. • Filtered "From Tank logic bloc" = SR-TRU-PRECIP-DESTINATION
WTP Returns (to the DST system)	No waste streams or wastewaters are returned to DST system from the WTP.	R. A. Kirkbride	Examined the flowsheet graphics in HTWOS for connections from the WT the DSTs and examined the transfer file for WTP returns.
DST Space Allocation Categories • Evaporator Operational Space • Restricted TRU Headspace • Restricted WTP Feed Tank Space • Safety Basis	• Supports 242-A operation (AW-102, bottoms receiver, and dilute waste receivers, when used) • TRU solids (AW-103 and AW-105) • The WTP Hot Commissioning feed source tank or DSTs while being used to stage WTP feed • Waste has an associated safety issue	R. A. Kirkbride	Examined the total DST waste volume plot data (SVF-1642, Rev. 0) for th DST space allocation categories.

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
• Blend off high-sulfate supernate (FCL Issue # 1, HNF-SD-WM-OCD-015, Rev. 17, Table A-1)	• Decant and blend the AZ-102 supernate with supernates containing lower sulfate (SO_4) concentrations so that the final [SO_4]:[Na] ratio in AZ-102 and in any other tank receiving significant quantities of the high [SO_4] supernate will be less than a target level of 0.048 mole SO_4/mole Na after blending and any evaporator campaigns are completed. Constrain the blending of AZ-102 supernate to start after 9/30/2012.		• Examined the traceback matrix (SVF-1652, Rev. 0, *WTP_Traceback V-3.0-8.4r0-2009-01-16-at-00-40-11.xls*) to identify the WTP feed ba containing significant contributions of AZ-102 supernate and checke [SO_4]:[Na] ratios in the Specification 7 feed assessment (SVF-1650, *WTP_Spec_7_V and V-3.0-8.4r0-2009-01-16-at-00-40-11_M1.xls*).
• Blend off high ^{233}U solids (Revised from FCL Issue # 2, HNF-SD-WM-OCD-015, Rev. 17, Table A-1).	• Blend the solids from C-104 with the solids from C-111 and C-112 in AN-101 so that the resulting ([$U_{fissile}$]/[U_{total}]) ratio is less than a target level of 9.4.		• Examined the traceback matrix (SVF-1652, Rev. 0, *WTP_Traceback V-3.0-8.4r0-2009-01-16-at-00-40-11_M1.xls*) to identify the WTP fe batches containing significant contributions of C-104 solids and com hand-calculated values of the ([$U_{fissile}$]/[U_{total}]) ratio for selected batch the target level value.
• Prepare and protect hot commissioning feed (FCL Issue # 3, HNF-SD-WM-OCD-015, Rev. 17, Table A-1).	• The HLW and LAW hot commissioning feeds have already been consolidated in AY-102 as of January 2007.		• Examined the transfer file for transfers into or out of AY-102 before delivery to the WTP as feed.
• Segregate Envelope C (Revised from FCL Issue # 4, HNF-SD-WM-OCD-015, Rev. 17, Table A-1)	• Segregate the waste in AN-102 and AN-107 from all other wastes until it has been partially pretreated in DSTs.		• Examined the transfer file for transfers into or out of AN-102 and AN before the in-tank pretreatment of those wastes.
• Segregate TRU sludge from complexed waste (FCL Issue # 5, HNF-SD-WM-OCD-015, Rev. 17, Table A-1).	• Do not add to or store additional waste with the insoluble solids currently in AW-103 and AW-105, with the exception that the addition of remote-handled TRU from SY-102 to either tank is permitted. Control the addition of wastes to SY-102 to avoid mixing the TRU solids in SY-102 with the additional wastes.		• Examined the transfer file for transfers into or out of AW-103 and A before the washing of those solids.

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
LLW packaging (FCL Issue # 7, HNF-SD-WM-OCD-015, Rev. 17, Table A-1)	103 and AW-105, with the exception that the addition of remote-handled TRU from SY-102 to either tank is permitted. Control the addition of wastes to SY-102 to avoid mixing the TRU solids in SY-102 with additional solids. Additional solids may be settled on top of the TRU solids in SY-102 as long as they are not mixed with the SY-102 solids and the transfer of wastes through SY-102 is controlled to avoid disturbing the TRU sludge layer. Do not transfer contact-handled TRU waste into the DST system. Segregate the remote-handled TRU waste from insoluble non-TRU solids.		
• Segregate low-cesium SST waste for supplemental treatment (Revised from FCL Issue # 8, HNF-SD-WM-OCD-015, Rev. 17, Table A-1)	• Manage the low-curie waste (less than 0.05 Ci/liter ^{137}Cs when normalized to 7 M Na) retrieved from tanks S-109 and S-105 to maximize the amount of low-cesium feed that can be made available to supplemental treatment. Keep the low-cesium fraction designated for feed separate from any high-cesium waste.		• N/A; the retrieval of waste from S-105 and S-109 to feed the DBVS/ facility was turned off to simplify debugging of the West Area waste transfers. This assumption is not anticipated to be needed in the maj modeling effort and will need to be verified if and when the DBVS/E operation is simulated as part of the RPP mission.
Waste Blending	There is no deliberate blending of waste to optimize WTP feeds other than the specific blending described in the feed controls immediately above.[27]	R.A. Kirkbride	Examined the model configuration for the deliberate blending of wastes.
A4.2.9. Aging Waste Farm Condensates[28]			
	The evaporation of water from the aging waste tanks and collection in AZ-301 with subsequent transfer to AY-101 was deleted from HTWOS Version 3.0.	R. A. Kirkbride	N/A
A4.2.10. Common Use of Transfer Lines			
	There are no restrictions on the subsequent use of transfer lines based on waste types (HLW, LAW, TRU, and LLW) and chemistries.	R.A. Kirkbride	Examined the model configuration for any restrictions on the subsequent u transfer lines.
A4.2.12. Waste Transfer			

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
	slurry line can be transferred at rates between 100 and 120 gallons per minute.		
SST Retrievals	Wastes retrieved from the SSTs will be retrieved at the capacity of the retrieval system (as defined by the as-retrieved volume divided by the minimum duration) when DST space is available.	R. A. Kirkbride	Compared the modeled durations to the minimum durations (both reported SVF-1645, Rev. 0).
DST Transfer Rate	Wastes can be transferred between DSTs or to the WTP at a rate of 140 gallons per minute (excluding cross-site transfers).	R.A. Kirkbride	Examined the model parameters for the stated transfer rates.
Transfer Durations	Waste transfer durations will be calculated by dividing the total volume being transferred by the transfer rate.	R.A. Kirkbride	Examined the model code governing waste transfer durations.
Transfer System Set-up Time	There is a 5-day delay between subsequent uses of transfer routes having common components starting after C-Farm retrievals are complete to account for the closeout of one transfer route and the establishment of another route.	R.A. Kirkbride/ G. K. Allen	Examined the model parameters for the wait time between transfers.
DST Waste Residuals	100 gallons having the composition of the last waste contained in the tank.	R. A. Kirkbride	Examined the residual DST volumes reported in the DST space plot file (SVF-1642, Rev. 0).
A4.3. 242-A Evaporator			
A4.3.1. Evaporator Availability			
242-A Evaporator Shutdown & Evaporator Availability	242-A Evaporator is available through the end of calendar year 2049.	R. A. Kirkbride	Examined the transfer file data (SVF-1646, Rev. 0) for 242-A evaporator a during the mission.
A4.3.2. Evaporator Operation			
• Training Volume	• 82 Kgal of water is evaporated to train personnel if the evaporator has not been operated for 11 months. Each training run adds 50 Kgal of water to AW-102.	R. A. Kirkbride	• Examined the transfer file to see if the time between 242-A campaigr greater than eleven months and examined the data in the EVAP-TRAINING-RECORD object.
• Maximum Evaporation Rate	• The lesser of 50 gpm[29] boil-off or 140 gpm feed	R. A. Kirkbride/ J.M. Conner	• Compared HTWOS model parameters in the 242-A Evaporator logic to the stated assumptions.
• Bottoms Set Point (g/mL)	• 1.43		• Compared HTWOS model parameters in the 242-A Evaporator logic to the stated assumptions.
• Feed Staging Duration	• 3 months minimum[30]		• Compared HTWOS model parameters in the 242-A Evaporator logic to the stated assumptions.

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
	needed to concentrate dilute waste to meet the WTP LAW feed specification after the WTP starts.		RPP mission and inspected the Specification 7 compliance assessmei (SVF-1650, Rev. 0).
A4.3.3. Evaporator Process Chemistry			
Waste Volume Reduction	• Water is removed until the specific gravity set point is reached (as calculated by algorithms within the model). Recent issues with solids formation in the evaporator are handled as part of the historical transfer data.	R.A. Kirkbride	• Examined the model configuration related to the evaporator operatioı
	• The waste volume reduction factor can be calculated using the following equation: $$WVR = \frac{\rho_B - \rho_F}{\rho_B - 1}$$ Where: ρ_B = Evaporator set point (bottoms SpG) ρ_F = Specific gravity of evaporator feed	R. A. Kirkbride	• Calculated the WVR for one evaporator campaign using specific grav values and volume reduction values, and compared them to the WVR calculated by the HTWOS model for the same evaporator campaign.
Process Condensate Composition	• The volume of process condensate will be 1.15 times the waste volume boiled off the feed to account for seal water and the vacuum system steam jets. • The composition of process condensate from the 242-A Evaporator will be estimated using the split factors calculated using the following equation: $$SF_i = \frac{1}{\left[1 + \frac{Kp_i}{21{,}579}\left(\frac{1 - WVR}{WVR}\right)\right]}$$ Where: SF_i = split factor for component i; the split factor is the mass or activity of component i in the process condensate	R.A. Kirkbride	• Compared the parameters on the 242-A Evaporator Logic workspace HTWOS to the stated assumptions. • Compared the partition coefficient data in the HTWOS model to the Table A-29 of the TFCOUP and to the values in RPP-17239. Used d taken from the HTWOS model for one evaporator campaign to perfo alternate calculation of the split factors and of the projected composit the various evaporator streams, and compared the results of the alterr calculations to the values reported from the HTWOS model. The alt calculations and the comparison of results are documented in SVF-1(Rev. 0, *Verify_HTWOS_242-A_Splits.xls*.

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
	values are equal to the WVR because they partition equally with water.[31] 21,579 = a numerical factor accounting for the 15% volume increase and for the ratio of the volume of condensate as a vapor to the volume of condensate as a liquid.		
Gaseous Effluent	The releases from the condenser to the atmosphere will be estimated using the split factors from Table A-30 in HNF-SD-WM-SP-012, Rev. 6.[33]	R.A. Kirkbride	Compared the split factors in HTWOS to the values reported in Table A-3
A4.3.4. Liquid Effluent Treatment			
Effluent Treatment Facility	• The ETF will be modeled as a black box. Overall partitioning of feed into solid waste and treated effluent will be approximated using overall removal efficiencies for the reverse osmosis and ion exchange units (the polisher outlet). The values used are reported in HNF-4573, Appendix A.[34] Table A-31 in HNF-SD-WM-SP-012, Rev. 6 shows how the removal efficiencies found on page APP A-2 of HNF-4573 are applied to the individual radionuclides and chemical species tracked within HTWOS. • About 99.999% of the oxide solids will be removed in the ETF.[35]	R.A. Kirkbride	• Examined the HTWOS model configuration for the ETF and compar component splits in HTWOS to Table A-31. • Compared the oxide component splits in HTWOS to the assumption
LERF Capacity	The LERF will be modeled as two basins, each with a 7.8 Mgal volume, used to provide lag storage of liquid effluents from the 242-A Evaporator and the various treatment processes. One will be used to accumulate effluents while the other is used to feed the ETF.	R.A. Kirkbride	Examined the HTWOS model configuration for the LERF basins.

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
A4.4. Waste Feed Delivery			
A4.4.1 Hot Commissioning Feed Delivery Plan			
LAW Feed Delivery	Deliver the supernate in tank AY-102 as the first LAW batch for hot commissioning of the WTP.	R. A. Kirkbride	Examined the transfer file to determine the source DST for the first WTP l feed delivery.
HLW Feed Delivery	Deliver the insoluble solids in AY-102 as HLW feed for hot commissioning of the WTP, adding water as needed to mobilize the solids and dilute the feed to meet WTP contract feed specifications.	R. A. Kirkbride	Examined the transfer file to determine how much of the AY-102 solids ar delivered as HLW to support WTP hot commissioning.
A4.4.2. Feed Delivery Plans			
LAW Feed Delivery Sequence	Provide available feed from the DST system as needed to keep the LAW processes operating. Try to deliver the waste in tank AN-104 early in the sequence to free up AN-104 for use as the cross-site slurry receiver.	R. A. Kirkbride	Examined the WTP ILAW production plot for outages and examined the t file for the timing of the AN-104 waste movements.
HLW Feed Delivery	Provide available feed from the DST system as needed to keep the HLW processes in the WTP operating.	R. A. Kirkbride	Examined the WTP ILAW production plot (SVF-1644, Rev. 0) for outage:
A4.4.3. LAW Feed Specifications			
	BNI contract Specification 7 will be used to assess envelope compliance.	R. A. Kirkbride/ T. M. Hohl	N/A, This was verified as part of verifying the Specification 7 Assessment template file used by the HTWOS2XL application (SVF-1211, Rev. 4, *Specification_7_Assessment_(MASTER)_v_4.xls*).[36]
A4.4.4. LAW Entrained Solids			
Entrained Solids Quantity	• 0.5 wt% solids are entrained in decanted supernatants. • Supernatant liquids from dissolving salts will entrain the same solids concentration as exists in the tank after dissolution up to a maximum of 2 wt%.	R.A. Kirkbride	Examined the HTWOS model assumptions on the Phase 1 LAW Paramete workspace.
Entrained Solids Composition	Entrained solids have the same composition as the average composition of solids in the tank.	R.A. Kirkbride	Examined the HTWOS procedures that entrain solids in the WTP LAW ba to determine how they handle the solids.
A4.4.5. HLW Feed Specifications			

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
A4.4.6. Feed Compliance Verification			
Compliance Verification Sampling	Staged feed must remain in a DST for 210 days after filling the tank before delivering to the WTP to provide time to complete feed specification compliance sampling and analysis.	R. A. Kirkbride	Evaluated the feed compliance verification sampling dwell times for the W HLW batch groups and LAW feed batches.
A6.0. HTWOS Model or Data Analysis Assumptions			
A6.1. Estimating Waste Compositions			
	Wastes are homogenized when mixed.	R.A. Kirkbride	Examined the HTWOS code governing the mixing of waste.
A6.4. Transuranic Content Accounting			
	TRU quantities for LAW and ILAW are based on Specification 2 and 7 definitions.	N/A	N/A. This was previously verified as part of verifying the run documentec HNF-SD-WM-SP-012, Rev. 6.
A6.5. Radionuclide Decay			
	• The BBI reference decay date of 1/1/2004 is used as the reference decay date in the model. • Radionuclides are decayed to January 1 of the year of delivery for feed specification compliance assessment.	T. M. Hohl	• Examined the HTWOS model for the reference decay date. • Radionuclide decay relating to feed specification compliance assessn was verified with the Specification 7 verification.
A6.6. Waste Chemistry and Mass Balances			
	• Dissolution of solids is predicted by the application of water-wash factors downloaded from the TWINS on 3/7/2007 and by use of the Sr solubility model documented in RPP-21807.	N/A	N/A, there was no modification of this assumption for this verison of the n The coding that performs these calculations was previously verified in an (model run (see RPP-RPT-23412, Rev. 0A). The use of particular water-w factors was verified for this model run as part of verifying the wash and le factor input.

Table A-1. Assumptions Matrix. (32 Sheets)

Verification or Assumption Item	Verification Scope or Assumption Values	Person Assigned to Verify Item	Method Used Verify Item
A6.7. ILAW Package Production			
	ILAW package production rates are based on the glass production rates, glass density, and package fill assumptions.	R.A. Kirkbride	Examined the HTWOS code for the LAW melter that counts product quan
A6.8. IHLW Canister Production			
	IHLW canister production rates are based on the glass production rates, glass density, and canister fill assumptions.	R.A. Kirkbride	Examined the HTWOS code for the HLW melter that counts product quan

Terms:

BBI = Best Basis Inventory
BNI = Bechtel National, Inc.
CERCLA = Comprehensive Environmental Response, Compensation and Liability Act of 1980
CH-TRU = Contact-handled TRU
DST = Double-Shell Tank
ETF = Effluent Treatment Facility
FCL = Feed Control Limit
FY = fiscal year
HEPA = high-efficiency particulate air
HLW = high-level waste
IDF = Integrated Disposal Facility
IHLW = immobilized high-level waste
ILAW = immobilized low-activity waste
IMUST = inactive miscellaneous underground storage tanks
LAW = low-activity waste
LERF = Liquid Effluent Retention Facility
LLW = low-level waste
ORP = U.S. Department of Energy, Office of River Protection
PFP = Plutonium Finishing Plant
PT = Pretreated
PUREX = Plutonium-Uranium Extraction Plant
RCRA = Resource Conservation a
RH-TRU = remote-handled TRU I
SALDS = State-Approved Land D
SBS = Submerged Bed Scrubber
SST = Single-Shell Tank
STP = Supplemental Treatment Pl
TEDF = Treated Effluent Disposal
TFC = Tank Farm Contractor
TOC = total organic carbon
TOE = total operating efficiency
TPA = Tri-Party Agreement (Hanf
TRU = transuranic
TWINS = Tank Waste Informatio
WSCF = Waste Sampling and Cha
WESF = Waste Encapsulation and
WESP = wet electrostatic precipit
WIPP = Waste Isolation Pilot Plan
WRF = Waste Retrieval Facility
WTP = Waste Treatment and Imm
WVRF = waste volume reduction

Table A-2. Spent Ion Exchange Resin Loading.

Component	HTWOS Spent Resin Loading Value	Calculated Average Concentration in Na Form Resin[1]	Column 1 - Concentration in Na Form Resin[2]	Column 2 - Concentration in H Form Resin[2]
Metals	**µg/g dry Na Form Resin**	**µg/g dry Na Form Resin**	**µg/g dry Na Form Resin**	**µg/g dry H Form Resin**
Ag	43.1	43.1	49.0	46.5
As	9.20	9.20	7.6	13.5
Ba	6.92	6.92	12.8	1.3
Cd	2.0	2.0	1.5	3.1
Cr	2,816	2,816	2,440	3,990
^{133}Cs	1.80	1.80	1.80	0.00
Na	42,844	42,844	85,550	173
Ni	23.1	23.1	11	44.0
Pb	96.9	96.9	56.2	172
Se	4.8	4.8	4.3	6.6
U	3.28	3.28	<3.0	4.10
Radionuclides	**Ci/g dry Na Form Resin**	**µCi/g dry Na Form Resin**	**µCi/g dry Na Form Resin**	**µCi/g dry H Form Resin**
^{60}Co	1.36E-7	0.136	0.132	0.175
^{99}Tc	8.20E-8	0.082	0.095	0.085
^{106}Ru	1.50E-8	0.0150	<0.02	0.0187
^{134}Cs	1.130E-9	0.001130	0.00198	0.000351
^{137}Cs	1.17E-5	11.7	21.9	1.8
^{154}Eu	7.30E-9	0.00730	<0.0004	0.00913
^{155}Eu	4.60E-9	0.00460	<0.005	0.00575
Transuranics	**Ci/g dry Na Form Resin**	**nCi/g dry Na Form Resin**	**nCi/g dry Na Form Resin**	**nCi/g dry H Form Resin**
^{237}Np	6.35E-10	0.635	<4	0.794
^{238}Pu	3.71E-9	3.71	1.01	8.01
$^{239+240}$Pu	N/A	35.6	8.39	78.6
^{239}Pu[3]	7.64E-9	N/A	N/A	N/A
^{240}Pu[3]	2.80E-8	N/A	N/A	N/A
^{241}Am	6.290E-9	6.290	1.58	13.75
$^{243+244}$Cm	N/A	1.14	0.236	2.56
^{243}Cm[3]	4.39E-10	N/A	N/A	N/A
^{244}Cm[3]	7.01E-10	N/A	N/A	N/A

Notes:

1. The average component concentration loaded on the spent resin is calculated as the average of the concentration in the Na Form resin ("Column 1") and 80% of the concentration in the H Form resin ("Column 2"). When a less-than value is reported (<), the less-than value is ignored and the available data is used directly without averaging. A factor of 0.8 (80%) is applied to the concentration in the H Form resin to place the H Form resin results on the same basis as the Na Form resin because it was assumed that the spent resin will be converted to the Na Form for disposal.
2. The "Column 1" and "Column 2" data were taken from Table 2.5-8a of 24590-WTP-RPT-PT-02-005, Rev. 3. Loading concentration values for ^{133}Cs were not used because ^{133}Cs is not tracked within HTWOS. Loading concentration values for Total beta and Total alpha were not used because of a lack of information as to which isotopes contribute to those totals.
3. Loading concentrations for the individual isotopes ^{239}Pu, ^{240}Pu, ^{243}Cm, and ^{244}Cm were derived from the loading values for combined isotopes ($^{239+240}$Pu and $^{243+244}$Cm). It was assumed that each isotope of a particular element loaded on the column to the same molar concentration (i.e., that they are chemically similar). The isotopic loading concentration could then be calculated based on its relative contribution to the total loading concentration.

Table A-3. Glass Composition Constraints.

	Component	Minimum (wt %)	Maximum (wt %)	Allowed as glass forming chemicals?[38]
Model Domain	SiO_2	38.0	57.0	Yes
	B_2O_3	5.0	20.0	Yes
	Na_2O	5.0	20.0	Yes
	Li_2O	1.0	4.0	Yes
	Al_2O_3	None	17.0	Yes
	Fe_2O_3	2.0	15.0	Yes
	CaO	None	10.0	No
	MgO	None	8.0	No
	ZrO_2	None	15.0	No
Solubility	Cr_2O_3	None	0.5 (default) 1.0 (relaxed)	No
	P_2O_5	None	3.0	No
	SO_3	None	0.5	No
	$Rh_2O_3 + Ru_2O_3$	None	0.25	No

[38] For modeling purposes, the glass forming chemicals are assumed to be pure oxides rather than minerals with impurities.

Table A-4. SST Retrieval Technology Assignments. (3 Sheets)

Tank	Retrieval Technology	Projected As-Retrieved Volume, gallons	Minimum Retrieval Duration, days	Tank	Retrieval Technology	Projected As-Retrieved Volume, gallons	Minimum Retrieval Duration, days
A-101	MS	886,796	274	S-110	MS	1,107,346	362
A-102	MS	109,890	106	S-111	MS	802,803	354
A-103	MRS	2,980,908	1,449	S-112	RC	N/A	N/A
A-104	MRS	1,295,462	630	SX-101	MS	1,206,961	467
A-105	MRS	1,425,896	693	SX-102	MS	925,794	425
A-106	MS	155,476	317	SX-103	MS	1,470,505	515
AX-101	MS	1,124,599	517	SX-104	MRS	3,285,907	1,198
AX-102	MRS	1,387,923	675	SX-105	MS	978,370	444
AX-103	MS	237,955	336	SX-106	MS	967,002	272
AX-104	MRS	265,192	129	SX-107	MRS	1,686,465	615
B-101	MRS	1,752,508	426	SX-108	MRS	1,595,206	582
B-102	MS	65,935	50	SX-109	MRS	2,355,301	859
B-103	MRS	1,512,352	368	SX-110	MRS	1,513,553	552
B-104	MS	5,038,025	356	SX-111	MRS	1,782,528	650
B-105	MRS	2,577,446	626	SX-112	MRS	1,598,808	583
B-106	MS	1,980,762	266	SX-113	MRS	846,370	309
B-107	MRS	322,818	346	SX-114	MRS	1,965,047	716
B-108	MS	447,824	255	SX-115	MRS	106,688	39
B-109	MS	813,835	267	T-101	MRS	1,710,481	416
B-110	MRS	490,832	412	T-102	MS	310,032	233
B-111	MRS	482,906	409	T-103	MRS	1,242,628	302
B-112	MRS	1,417,490	345	T-104	MRS	2,698,725	469
B-201	VRS	261,430	45	T-105	MRS	196,016	296
B-202	VRS	257,827	45	T-106	MRS	978,456	238
B-203	VRS	356,291	62	T-107	MRS	346,065	355
B-204	VRS	352,689	61	T-108	MRS	687,867	167
BX-101	MRS	1,475,128	430	T-109	MRS	1,541,171	375
BX-102	MRS	1,616,820	472	T-110	MRS	2,940,082	510
BX-103	MS	1,011,911	262	T-111	MRS	3,289,509	571
BX-104	MS	1,588,916	272	T-112	MRS	133,143	271
BX-105	MS	688,961	260	T-201	VRS	266,233	46
BX-106	MS	163,628	245	T-202	VRS	220,603	38
BX-107	MS	5,653,784	379	T-203	VRS	291,449	51

Table A-4. SST Retrieval Technology Assignments. (3 Sheets)

Tank	Retrieval Technology	Projected As-Retrieved Volume, gallons	Minimum Retrieval Duration, days	Tank	Retrieval Technology	Projected As-Retrieved Volume, gallons	Minimum Retrieval Duration, days
BX-108	MRS	1,401,880	409	T-204	VRS	291,449	51
BX-109	MS	3,143,383	312	TX-101	MS	1,205,681	254
BX-110	MRS	2,234,022	652	TX-102	MS	548,839	117
BX-111	MRS	2,115,145	617	TX-103	MS	368,071	91
BX-112	MS	2,656,805	300	TX-104	MS	559,781	246
BY-101	MS	1,289,415	355	TX-105	MRS	3,877,893	1,414
BY-102	MS	894,033	139	TX-106	MS	936,401	943
BY-103	MRS	3,137,010	762	TX-107	MRS	1,374,714	334
BY-104	MS	1,232,292	367	TX-108	MS	317,978	267
BY-105	MRS	3,445,611	837	TX-109	MS	5,920,756	352
BY-106	MRS	3,207,856	780	TX-110	MRS	3,383,170	822
BY-107	MRS	2,493,391	606	TX-111	MS	899,487	353
BY-108	MRS	2,268,845	551	TX-112	MS	1,663,941	267
BY-109	MS	697,315	325	TX-113	MRS	4,160,076	1,011
BY-110	MS	999,874	353	TX-114	MRS	3,674,960	893
BY-111	MS	1,322,006	183	TX-115	MRS	3,772,224	917
BY-112	MS	1,230,854	141	TX-116	MRS	3,977,557	967
C-101	MRS	1,658,847	806	TX-117	MRS	3,440,808	836
C-102	MS	385,950	487	TX-118	MS	670,804	310
C-103	RC	N/A	N/A	TY-101	MRS	1,795,737	524
C-104	MS	328,889	446	TY-102	MS	196,388	76
C-105	MRS	1,859,378	904	TY-103	MRS	1,961,444	572
C-106	RC	N/A	N/A	TY-104	MRS	1,460,718	426
C-107	MS	317,001	438	TY-105	MRS	2,308,470	673
C-108	MS	123,363	346	TY-106	MRS	714,284	208
C-109	MS	133,401	357	U-101	MRS	1,044,499	381
C-110	MS	248,052	388	U-102	MS	770,988	417
C-111	MRS	1,519,557	1,477	U-103	MS	1,078,950	442
C-112	MS	173,820	335	U-104	MRS	1,505,147	549
C-201	RC	N/A	N/A	U-105	MS	930,437	431
C-202	RC	N/A	N/A	U-106	MS	400,133	150
C-203	RC	N/A	N/A	U-107	MS	799,302	399
C-204	RC	N/A	N/A	U-108	MS	1,126,908	475
S-101	MS	596,492	348	U-109	MS	990,179	434

Table A-4. SST Retrieval Technology Assignments. (3 Sheets)

Tank	Retrieval Technology	Projected As-Retrieved Volume, gallons	Minimum Retrieval Duration, days	Tank	Retrieval Technology	Projected As-Retrieved Volume, gallons	Minimum Retrieval Duration, days
S-102	MS	436,506	453	U-110	MRS	2,057,507	750
S-103	MS	631,153	307	U-111	MS	548,839	360
S-104	MRS	2,567,839	624	U-112	MRS	1,465,522	534
S-105	SD/MS	1,447,600	368	U-201	VRS	146,155	53
S-106	MS	1,373,833	385	U-202	VRS	144,954	53
S-107	MS	481,461	350	U-203	VRS	143,753	52
S-108	MS	1,703,004	419	U-204	VRS	137,074	50
S-109	SD/MS	1,746,000	413	-	-	-	-

Key

MS	Modified Sluicing
MSwR	Modified Sluicing with Recycle
MRS	Mobile Retrieval System
RC	Retrieval Complete
SD	Selective Dissolution
VRS	Vacuum Retrieval System

	Tanks designated for Supplemental TRU Treatment
	Additional efforts are anticipated to be needed to remove a hard heel from the tank
	Waste retrieval operations are complete

Note:

It is expected that all the retrievals performed using MS will include the recycle of the sluicing liquids. The use of recycle was considered when estimating the as-retrieved volumes for wastes retrieved using MS. The recycle stream will be modeled explicitly only for the retrieval of wastes from the C-Farm tanks within this model run.

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Appendix B

SUPPORTING VERIFICATION AND VALIDATION DOCUMENTATION FOR HTWOS VERSION 3.0

Table B-1. HTWOS Reaction Check

	All HTWOS Reactions
1	UV-ORGANIC-1 reaction is balanced and the extent of reaction is correct.
2	UV-ORGANIC-2 reaction is balanced and the extent of reaction is correct.
3	UV-ORGANIC-3 reaction is balanced and the extent of reaction is correct.
4	UV-ORGANIC-4 reaction is balanced and the extent of reaction is correct.
5	UV-ORGANIC-5 reaction is balanced and the extent of reaction is correct.
6	UV-ORGANIC-6 reaction is balanced and the extent of reaction is correct.
7	UV-ORGANIC-7 reaction is balanced and the extent of reaction is correct.
8	UV-ORGANIC-8 reaction is balanced and the extent of reaction is correct.
9	UV-ORGANIC-9 reaction is balanced and the extent of reaction is correct.
10	UV-ORGANIC-10 reaction is balanced and the extent of reaction is correct.
11	UV-ORGANIC-11 reaction is balanced and the extent of reaction is correct.
12	UV-ORGANIC-12 reaction is balanced and the extent of reaction is correct.
13	UV-ORGANIC-13 reaction is balanced and the extent of reaction is correct.
14	UV-ORGANIC-14 reaction is balanced and the extent of reaction is correct.
15	UV-ORGANIC-15 reaction is balanced and the extent of reaction is correct.
16	UV-ORGANIC-16 reaction is balanced and the extent of reaction is correct.
17	UV-ORGANIC-17 reaction is balanced and the extent of reaction is correct.
18	UV-ORGANIC-18 reaction is balanced and the extent of reaction is correct.
19	UV-ORGANIC-19 reaction is balanced and the extent of reaction is correct.
20	UV-ORGANIC-20 reaction is balanced and the extent of reaction is correct.
21	UV-ORGANIC-21 reaction is balanced and the extent of reaction is correct.
22	NEUT-REACTION reaction is balanced and the extent of reaction is correct.
23	PEROXIDE-DECOMPOSE-REACTION reaction is balanced and the extent of reaction is correct.
24	DISSOLVE-CO2-REACTION reaction is balanced and the extent of reaction is correct.
25	V15013-NEUT-REACTION reaction is balanced and the extent of reaction is correct.
26	OHBOUND-REACTION reaction is balanced and the extent of reaction is correct.
27	H-OH-NEUT-REACTION reaction is balanced and the extent of reaction is correct.
28	V12011-SR1-REACTION reaction is balanced and the extent of reaction is correct.
29	V12011-SR2-REACTION reaction is balanced and the extent of reaction is correct.
30	V12011-OH1-REACTION reaction is balanced and the extent of reaction is correct.
31	V12011-OH2-REACTION reaction is balanced and the extent of reaction is correct.
32	V12011-OH3-REACTION reaction is balanced and the extent of reaction is correct.
33	V12011-OH4-REACTION reaction is balanced and the extent of reaction is correct.
34	V12011-OH5-REACTION reaction is balanced and the extent of reaction is correct.
35	V12011-OH6-REACTION reaction is balanced and the extent of reaction is correct.
36	V12011-OH7-REACTION reaction is balanced and the extent of reaction is correct.
37	V12011-OH8-REACTION reaction is balanced and the extent of reaction is correct.
38	V12011-OH9-REACTION reaction is balanced and the extent of reaction is correct.
39	V12011-OH10-REACTION reaction is balanced and the extent of reaction is correct.
40	V12011-MN-1 reaction is balanced and the extent of reaction is correct.
41	V12011-MN-2 reaction is balanced and the extent of reaction is correct.

Table B-1. HTWOS Reaction Check

All HTWOS Reactions	
42	V12011-MN-3 reaction is balanced and the extent of reaction is correct.
43	V12011-MN-4 reaction is balanced and the extent of reaction is correct.
44	V12011-MN-5 reaction is balanced and the extent of reaction is correct.
45	V12011-MN-6 reaction is balanced and the extent of reaction is correct.
46	V12011-MN-7 reaction is balanced and the extent of reaction is correct.
47	V12011-MN-8 reaction is balanced and the extent of reaction is correct.
48	OXIDATIVE-LEACH-CR reaction is balanced and the extent of reaction is correct.
49	V12011-MN-9 reaction is balanced and the extent of reaction is correct.
50	CONDENSE-WATER-REACTION reaction is balanced and the extent of reaction is correct.
51	H-OH-NEUTRALIZATION-WITH-CATION-REACTION reaction is balanced and the extent of reaction is correct.
52	NO-SCRUBBER-REACTION reaction is balanced and the extent of reaction is correct.
53	NO2-SCRUBBER-REACTION reaction is balanced and the extent of reaction is correct.
54	HCL-SCRUBBER-REACTION reaction is balanced and the extent of reaction is correct.
55	HF-SCRUBBER-REACTION reaction is balanced and the extent of reaction is correct.
56	P2O5-SCRUBBER-REACTION reaction is balanced and the extent of reaction is correct.
57	SO2-SCRUBBER-REACTION reaction is balanced and the extent of reaction is correct.
58	CO2-SCRUBBER-REACTION reaction is balanced and the extent of reaction is correct.
59	NO-SCR-REACTION reaction is balanced and the extent of reaction is correct.
60	NO2-SCR-REACTION reaction is balanced and the extent of reaction is correct.
61	NH3-REACTION reaction is balanced and the extent of reaction is correct.
62	NO-NH3-REACTION reaction is balanced and the extent of reaction is correct.
63	NO2-NH3-REACTION reaction is balanced and the extent of reaction is correct.
64	NO-NH3-REACTION2 reaction is balanced and the extent of reaction is correct.
65	EVAP-NA-REACTION reaction is balanced and the extent of reaction is correct.
66	SUBLIME-NA-REACTION reaction is balanced and the extent of reaction is correct.
67	EVAP-CS-REACTION reaction is balanced and the extent of reaction is correct.
68	EVAP-K-REACTION reaction is balanced and the extent of reaction is correct.
69	EVAP-TC-REACTION reaction is balanced and the extent of reaction is correct.
70	SUBLIME-CS-REACTION reaction is balanced and the extent of reaction is correct.
71	SUBLIME-K-REACTION reaction is balanced and the extent of reaction is correct.
72	SUBLIME-TC-REACTION reaction is balanced and the extent of reaction is correct.
73	MAKE-OH-SCRUBBER-REACTION reaction is balanced and the extent of reaction is correct.
74	LAW-NO-WESP-REACTION reaction is balanced and the extent of reaction is correct.
75	EXTRACT-NH3-REACTION reaction is balanced and the extent of reaction is correct.
76	OD-1 reaction is balanced and the extent of reaction is correct.
77	OD-2 reaction is balanced and the extent of reaction is correct.
78	OD-3 reaction is balanced and the extent of reaction is correct.
79	OD-4 reaction is balanced and the extent of reaction is correct.
80	OD-5 reaction is balanced and the extent of reaction is correct.
81	OD-6 reaction is balanced and the extent of reaction is correct.
82	OD-7 reaction is balanced and the extent of reaction is correct.
83	OD-8 reaction is balanced and the extent of reaction is correct.
84	OD-9 reaction is balanced and the extent of reaction is correct.
85	OD-10 reaction is balanced and the extent of reaction is correct.

Table B-1. HTWOS Reaction Check

All HTWOS Reactions	
86	OD-11 reaction is balanced and the extent of reaction is correct.
87	OD-12 reaction is balanced and the extent of reaction is correct.
88	OD-13 reaction is balanced and the extent of reaction is correct.
89	OD-14 reaction is balanced and the extent of reaction is correct.
90	OD-15 reaction is balanced and the extent of reaction is correct.
91	OD-16 reaction is balanced and the extent of reaction is correct.
92	OD-17 reaction is balanced and the extent of reaction is correct.
93	OD-18 reaction is balanced and the extent of reaction is correct.
94	OD-19 reaction is balanced and the extent of reaction is correct.
95	OD-20 reaction is balanced and the extent of reaction is correct.
96	OD-21 reaction is balanced and the extent of reaction is correct.
97	OD-22 reaction is balanced and the extent of reaction is correct.
98	AG-OXIDE reaction is balanced and the extent of reaction is correct.
99	AL-OXIDE reaction is balanced and the extent of reaction is correct.
100	AM-OXIDE reaction is balanced and the extent of reaction is correct.
101	AS-OXIDE reaction is balanced and the extent of reaction is correct.
102	B-OXIDE reaction is balanced and the extent of reaction is correct.
103	BA-OXIDE reaction is balanced and the extent of reaction is correct.
104	BE-OXIDE reaction is balanced and the extent of reaction is correct.
105	BI-OXIDE reaction is balanced and the extent of reaction is correct.
106	CA-OXIDE reaction is balanced and the extent of reaction is correct.
107	CD-OXIDE reaction is balanced and the extent of reaction is correct.
108	CE-OXIDE reaction is balanced and the extent of reaction is correct.
109	CL-OXIDE reaction is balanced and the extent of reaction is correct.
110	CM-OXIDE reaction is balanced and the extent of reaction is correct.
111	CO-OXIDE reaction is balanced and the extent of reaction is correct.
112	CR-OXIDE reaction is balanced and the extent of reaction is correct.
113	AL-OXIDE2 reaction is balanced and the extent of reaction is correct.
114	CR-OXIDE2 reaction is balanced and the extent of reaction is correct.
115	CS-OXIDE reaction is balanced and the extent of reaction is correct.
116	CU-OXIDE reaction is balanced and the extent of reaction is correct.
117	FE-OXIDE reaction is balanced and the extent of reaction is correct.
118	K-OXIDE reaction is balanced and the extent of reaction is correct.
119	LA-OXIDE reaction is balanced and the extent of reaction is correct.
120	LI-OXIDE reaction is balanced and the extent of reaction is correct.
121	MG-OXIDE reaction is balanced and the extent of reaction is correct.
122	MN-OXIDE reaction is balanced and the extent of reaction is correct.
123	MO-OXIDE reaction is balanced and the extent of reaction is correct.
124	NA-OXIDE reaction is balanced and the extent of reaction is correct.
125	ND-OXIDE reaction is balanced and the extent of reaction is correct.
126	NI-OXIDE reaction is balanced and the extent of reaction is correct.
127	NB-OXIDE reaction is balanced and the extent of reaction is correct.
128	NP-OXIDE reaction is balanced and the extent of reaction is correct.
129	P-OXIDE reaction is balanced and the extent of reaction is correct.
130	PB-OXIDE reaction is balanced and the extent of reaction is correct.

Table B-1. HTWOS Reaction Check

All HTWOS Reactions	
131	PU-OXIDE reaction is balanced and the extent of reaction is correct.
132	RB-OXIDE reaction is balanced and the extent of reaction is correct.
133	RH-OXIDE reaction is balanced and the extent of reaction is correct.
134	RU-OXIDE reaction is balanced and the extent of reaction is correct.
135	SB-OXIDE reaction is balanced and the extent of reaction is correct.
136	SE-OXIDE reaction is balanced and the extent of reaction is correct.
137	SI-OXIDE reaction is balanced and the extent of reaction is correct.
138	SM-OXIDE reaction is balanced and the extent of reaction is correct.
139	SN-OXIDE reaction is balanced and the extent of reaction is correct.
140	SR-OXIDE reaction is balanced and the extent of reaction is correct.
141	TC-OXIDE reaction is balanced and the extent of reaction is correct.
142	S-OXIDE reaction is balanced and the extent of reaction is correct.
143	TE-OXIDE reaction is balanced and the extent of reaction is correct.
144	TH-OXIDE reaction is balanced and the extent of reaction is correct.
145	TI-OXIDE reaction is balanced and the extent of reaction is correct.
146	TL-OXIDE reaction is balanced and the extent of reaction is correct.
147	U-OXIDE reaction is balanced and the extent of reaction is correct.
148	V-OXIDE reaction is balanced and the extent of reaction is correct.
149	W-OXIDE reaction is balanced and the extent of reaction is correct.
150	ZN-OXIDE reaction is balanced and the extent of reaction is correct.
151	ZR-OXIDE reaction is balanced and the extent of reaction is correct.
152	MN-OXIDE2 reaction is balanced and the extent of reaction is correct.
153	F-OXIDE reaction is balanced and the extent of reaction is correct.
154	NO2-DECOMPOSITION reaction is balanced and the extent of reaction is correct.
155	NO3-DECOMPOSITION reaction is balanced and the extent of reaction is correct.
156	CO3-DECOMPOSITION reaction is balanced and the extent of reaction is correct.
157	OH-DECOMPOSITION reaction is balanced and the extent of reaction is correct.
158	NH3-DECOMPOSITION reaction is balanced and the extent of reaction is correct.
159	SUGAR-DECOMPOSITION reaction is balanced and the extent of reaction is correct.
160	BOIL-WATER-REACTION reaction is balanced and the extent of reaction is correct.
161	SO4-DECOMPOSITION reaction is balanced and the extent of reaction is correct.
162	PR-OXIDE reaction is balanced and the extent of reaction is correct.
163	Y-OXIDE reaction is balanced and the extent of reaction is correct.
164	HG-OXIDE reaction is balanced and the extent of reaction is correct.
165	PD-OXIDE reaction is balanced and the extent of reaction is correct.
166	TA-OXIDE reaction is balanced and the extent of reaction is correct.
167	EU-OXIDE reaction is balanced and the extent of reaction is correct.
168	AC-OXIDE reaction is balanced and the extent of reaction is correct.
169	C14-DECOMPOSITION reaction is balanced and the extent of reaction is correct.
170	EVAP-IODINE-REACTION reaction is balanced and the extent of reaction is correct.
171	IODINE-SUBLIME-REACTION reaction is balanced and the extent of reaction is correct.
172	SUGAR-NO3-DECOMPOSITION reaction is balanced and the extent of reaction is correct.
173	SUGAR-NO2-DECOMPOSITION reaction is balanced and the extent of reaction is correct.
174	CN-DECOMPOSITION reaction is balanced and the extent of reaction is correct.
175	MN-OXIDE3 reaction is balanced and the extent of reaction is correct.

Table B-1. HTWOS Reaction Check

All HTWOS Reactions	
176	CL-OXIDE2 reaction is balanced and the extent of reaction is correct.
177	F-OXIDE2 reaction is balanced and the extent of reaction is correct.
178	HTWOS-OXIDATIVE-LEACH-CR-REACTION REACTION DIFFERENCE = -31.999 kgs!!
179	FC-1 reaction is balanced and the extent of reaction is correct.
180	FC-2 reaction is balanced and the extent of reaction is correct.
181	FC-4 reaction is balanced and the extent of reaction is correct.
182	FC-5 reaction is balanced and the extent of reaction is correct.
183	FC-3 reaction is balanced and the extent of reaction is correct.
184	FC-6 reaction is balanced and the extent of reaction is correct.
185	BV-CO-SCR-REACTION reaction is balanced and the extent of reaction is correct.
186	BV-NO-SCR-REACTION reaction is balanced and the extent of reaction is correct.
187	BV-NO2-SCR-REACTION reaction is balanced and the extent of reaction is correct.
188	BV-OD1 reaction is balanced and the extent of reaction is correct.
189	BV-OD2 reaction is balanced and the extent of reaction is correct.
190	BV-NO3-DECOMP1 reaction is balanced and the extent of reaction is correct.
191	BV-NO3-DECOMP2 reaction is balanced and the extent of reaction is correct.
192	BV-NO3-DECOMP3 reaction is balanced and the extent of reaction is correct.
193	BV-NO2-DECOMP1 reaction is balanced and the extent of reaction is correct.
194	BV-NO2-DECOMP2 reaction is balanced and the extent of reaction is correct.
195	BV-NO2-DECOMP3 reaction is balanced and the extent of reaction is correct.
196	BV-HYDROSONIC-CO2-REACTION reaction is balanced and the extent of reaction is correct.
197	BV-HYDROSONIC-HCL-REACTION reaction is balanced and the extent of reaction is correct.
198	BV-HYDROSONIC-HF-REACTION reaction is balanced and the extent of reaction is correct.
199	BV-HYDROSONIC-NO-REACTION reaction is balanced and the extent of reaction is correct.
200	BV-HYDROSONIC-NO2-REACTION reaction is balanced and the extent of reaction is correct.
201	BV-HYDROSONIC-SO2-REACTION reaction is balanced and the extent of reaction is correct.
202	BV-HYDROSONIC-P2O5-REACTION reaction is balanced and the extent of reaction is correct.
203	BV-HYDROSONIC-PO4-REACTION reaction is balanced and the extent of reaction is correct.
204	BV-CO3-DECOMPOSITION-1 reaction is balanced and the extent of reaction is correct.
205	BV-CO3-DECOMPOSITION-2 reaction is balanced and the extent of reaction is correct.
206	BV-HYDROSONIC-PO4-G-REACTION reaction is balanced and the extent of reaction is correct.
207	RXN-ALUMINATE reaction is balanced and the extent of reaction is correct.
208	RXN-CR-AL-DISS reaction is balanced and the extent of reaction is correct.
209	RXN-CR-AL-PRECIP reaction is balanced and the extent of reaction is correct.
210	RXN-CR-AL-LI-PRECIP-5 reaction is balanced and the extent of reaction is correct.
211	RXN-CR-AL-LI-PRECIP-4 reaction is balanced and the extent of reaction is correct.
212	RXN-CR-AL-LI-PRECIP-3 reaction is balanced and the extent of reaction is correct.
213	RXN-CR-AL-LI-PRECIP-2 reaction is balanced and the extent of reaction is correct.
214	RXN-CR-AL-LI-PRECIP-1 reaction is balanced and the extent of reaction is correct.
215	RXN-CR-AL-LI-PRECIP reaction is balanced and the extent of reaction is correct.

Table B-1. HTWOS Reaction Check

All HTWOS Reactions	
216	RXN-ALUMINATE-2 reaction is balanced and the extent of reaction is correct.
217	RXN-CR-NAOH reaction is balanced and the extent of reaction is correct.
218	RXN-CR-CATHODE-2 reaction is balanced and the extent of reaction is correct.
219	RXN-CR-NAOH2 reaction is balanced and the extent of reaction is correct.
220	RXN-CR-CATHODE reaction is balanced and the extent of reaction is correct.
221	RXN-CR-AL-1 reaction is balanced and the extent of reaction is correct.
222	101B-R1 reaction is balanced and the extent of reaction is correct.
223	101B-R2 reaction is balanced and the extent of reaction is correct.
224	101B-R3 reaction is balanced and the extent of reaction is correct.
225	101B-R4 reaction is balanced and the extent of reaction is correct.
226	101B-R5 reaction is balanced and the extent of reaction is correct.
227	101B-R6 reaction is balanced and the extent of reaction is correct.
228	101B-R7 reaction is balanced and the extent of reaction is correct.
229	101B-R8 reaction is balanced and the extent of reaction is correct.
230	101B-R9 reaction is balanced and the extent of reaction is correct.
231	101B-R11 reaction is balanced and the extent of reaction is correct.
232	101B-R12 reaction is balanced and the extent of reaction is correct.
233	101B-R13 reaction is balanced and the extent of reaction is correct.
234	101B-R14 reaction is balanced and the extent of reaction is correct.
235	101C-R1 reaction is balanced and the extent of reaction is correct.
236	101C-R2 reaction is balanced and the extent of reaction is correct.
237	101C-R3 reaction is balanced and the extent of reaction is correct.
238	101C-R4 reaction is balanced and the extent of reaction is correct.
239	101C-R5 reaction is balanced and the extent of reaction is correct.
240	101C-R6 reaction is balanced and the extent of reaction is correct.
241	101C-R7 reaction is balanced and the extent of reaction is correct.
242	101C-R8 reaction is balanced and the extent of reaction is correct.
243	101C-R9 reaction is balanced and the extent of reaction is correct.
244	101C-R10 reaction is balanced and the extent of reaction is correct.
245	101C-R11 reaction is balanced and the extent of reaction is correct.
246	101C-R12 reaction is balanced and the extent of reaction is correct.
247	101C-R13 reaction is balanced and the extent of reaction is correct.
248	101B-R13-232 reaction is balanced and the extent of reaction is correct.
249	101B-R13-233 reaction is balanced and the extent of reaction is correct.
250	101B-R13-234 reaction is balanced and the extent of reaction is correct.
251	101B-R13-235 reaction is balanced and the extent of reaction is correct.
252	101B-R13-236 reaction is balanced and the extent of reaction is correct.
253	101B-R13-238 reaction is balanced and the extent of reaction is correct.
254	There was 1 reaction that didn't balance out of 253 checked. Look on the message-board for details.

Table B-2. Wet Solids Calculation Verification

Wet Solids Calculation Verification
Beginning conditions when solids volume based upon ORIGINAL DRY SOLIDS VOLUME for pumping AW-102 to AW-106 -> AW-102 free liquid volume = 1.068e6, unsettled solid volume = 12332.785, total dry solid volume = 12332.785, total wet solid volume = 0.0 and total volume = 1.08e6. AW-106 is empty. After pumping all of AW-102 into AW-106 when solids volume based upon ORIGINAL DRY SOLIDS VOLUME -> AW-102 is empty. AW-106 free liquid volume = 1.016e6, total dry solid volume = 12332.785, total slurry volume = 63721.989, the settled solids mass fraction = 0.4, and total volume = 1.08e6.
Beginning conditions when solids volume based upon NEW WET SOLIDS VOLUME for pumping AW-102 to AW-106 -> AW-102 free liquid volume = 1.068e6, unsettled solid volume = 12332.785, total dry solid volume = 12332.785, total wet solid volume = 30644.9 and total volume = 1.08e6. AW-106 is empty. After pumping all of AW-102 into AW-106 when solids volume based upon NEW WET SOLIDS VOLUME -> AW-102 is empty. AW-106 free liquid volume = 1.049e6, total dry solid volume = 12332.785, total slurry volume = 30644.9, the settled solids mass fraction = 0.652, and total volume = 1.08e6.

Table B-3.Traceback Initialization for AN-101.

AN-101	initial	Solid Layers
Description	Layer	Sum
Liquid(Non Water) (kg)	0	2270313.569
Solids (kg)	0	0
Water Dissolution Factors	0	NA
Caustic Dissolution Factors	0	NA
Caustic Leach Factors	0	NA
Liquid(Non Water) (kg)	3	0
Solids (kg)	3	0
Water Dissolution Factors	3	NA
Caustic Dissolution Factors	3	NA
Caustic Leach Factors	3	NA
Liquid(Non Water) (kg)	2	0
Solids (kg)	2	0
Water Dissolution Factors	2	NA
Caustic Dissolution Factors	2	NA
Caustic Leach Factors	2	NA
Liquid(Non Water) (kg)	1	109583.8849
Solids (kg)	1	5318.870823
Water Dissolution Factors	1	NA
Caustic Dissolution Factors	1	NA
Caustic Leach Factors	1	NA
AN-101		
Description	Layer	Sum
Liquid Traceback (kg)	0	2270313.569
Solids Traceback (kg)	0	0
Liquid Traceback (kg)	3	0
SolidsTraceback (kg)	3	0
Liquid Traceback (kg)	2	0
SolidsTraceback (kg)	2	0
Liquid Traceback (kg)	1	109583.8849
SolidsTraceback (kg)	1	5318.870823
(Liquid Traceback (Calc) - Liquid Traceback) / Liquid Traceback	0	-4.10218E-16
(Solids Traceback (Calc) - Solids Traceback) / Solids Traceback	0	0
(Liquid Traceback (Calc) - Liquid Traceback) / Liquid Traceback	3	0
(Solids Traceback (Calc) - Solids Traceback) / Solids Traceback	3	0
(Liquid Traceback (Calc) - Liquid Traceback) / Liquid Traceback	2	0
(Solids Traceback (Calc) - Solids Traceback) / Solids Traceback	2	0
(Liquid Traceback (Calc) - Liquid Traceback) / Liquid Traceback	1	-1.46072E-15
(Solids Traceback (Calc) - Solids Traceback) / Solids Traceback	1	0

Table B-4.Test 1 Results – Traceback Mass Distribution for C-105.

	C-105 Traceback(kgs)			
	1/1/2008 (Initial)		1/1/2018 (Final)	
Tanks	Solids	Liquids	Solids	Liquids
AP-102	0	0	217.103206	17101.7778
AW-102	0	0	202.774894	15324.3868
AW-106	0	0	0	16681.5965
AY-101	0	0	627277.885	2920.2972
AZ-102	0	0	57.3620255	4732.36255
C-105	631514.904	56789.3265	3759.77852	28.9057032
Total	631514.904	56789.3265	631514.904	56789.3265
(Final - Initial)/(Initial)			-1.3181E-13	1.9987E-13

Table B-5. Traceback Mass Error for Tanks. (2 Sheets)

Traceback Mass (1/1/2018) / (Traceback Mass (1/1/2008)								
Tank	Liquids	Solids	Tank	Liquids	Solids	Tank	Liquids	Solids
AN-101	1.13E-15	8.21E-16	BX-106	0	0	SX-113	0	0
AN-102	0	0	BX-107	0	0	SX-114	0	0
AN-103	0	0	BX-108	0	0	SX-115	0	0
AN-104	0	0	BX-109	0	0	T-101	0	0
AN-105	0	0	BX-110	0	0	T-102	0	0
AN-106	6.62E-15	0	BX-111	0	0	T-103	0	0
AN-107	0	0	BX-112	0	0	T-104	0	0
AP-101	1.29E-15	0	BY-101	0	0	T-105	0	0
AP-102	1.78E-15	0	BY-102	0	0	T-106	0	0
AP-103	1.35E-15	-2.03E-15	BY-103	0	0	T-107	0	0
AP-104	-2.2E-15	0	BY-104	0	0	T-108	0	0
AP-105	1.48E-15	-6.64E-15	BY-105	0	0	T-109	0	0
AP-106	0	0	BY-106	0	0	T-110	0	1.05E-13
AP-107	-7.67E-17	0	BY-107	0	0	T-111	1.82E-15	-6.9E-13
AP-108	0	0	BY-108	0	0	T-112	0	0
AW-101	0	0	BY-109	0	0	T-201	0.8	-4.85E-14
AW-102	-1.37E-15	0	BY-110	0	0	T-202	1.42E-15	1.18E-13
AW-103	0	0	BY-111	0	0	T-203	-3.8E-14	-1.5E-14
AW-104	0	0	BY-112	0	0	T-204	9.52E-15	3.26E-14
AW-105	0	0	C-101	-5.59E-14	1.18E-13	TX-101	0	0
AW-106	5.46E-15	3.53E-17	C-102	-3.19E-14	1.22E-15	TX-102	0	0
AY-101	-1.54E-15	0	C-103	0	0	TX-103	0	0
AY-102	0	0	C-104	4.96E-14	-2.88E-14	TX-104	0	0
AZ-101	-2.74E-14	3.9E-15	C-105	2E-13	-1.32E-13	TX-105	0	0
AZ-102	-1.77E-15	0	C-106	0	0	TX-106	0	0
SY-101	2.66E-15	1.91E-15	C-107	-9.81E-15	-1.82E-15	TX-107	0	0
SY-102	-4.77E-15	0	C-108	-2.21E-14	0	TX-108	0	0
SY-103	2.08E-15	6.07E-16	C-109	-5.94E-14	-3.59E-15	TX-109	0	0
A-101	0	0	C-110	1.13E-14	1.92E-14	TX-110	0	0
A-102	0	0	C-111	-1.59E-13	1.08E-13	TX-111	0	0
A-103	0	0	C-112	2.26E-14	-8.49E-16	TX-112	0	0
A-104	0	0	C-201	0	0	TX-113	0	0
A-105	0	0	C-202	0	0	TX-114	0	0
A-106	0	0	C-203	0	0	TX-115	0	0
AX-101	0	0	C-204	0	0	TX-116	0	0

Table B-5. Traceback Mass Error for Tanks. (2 Sheets)

Traceback Mass (1/1/2018) / (Traceback Mass (1/1/2008)								
Tank	Liquids	Solids	Tank	Liquids	Solids	Tank	Liquids	Solids
AX-102	0	0	S-101	0	0	TX-117	0	0
AX-103	0	0	S-102	0	1.57E-16	TX-118	0	0
AX-104	0	0	S-103	0	0	TY-101	0	0
B-101	0	0	S-104	0	0	TY-102	0	0
B-102	0	0	S-105	0	0	TY-103	0	0
B-103	0	0	S-106	0	6.51E-14	TY-104	0	0
B-104	0	0	S-107	0	0	TY-105	0	0
B-105	0	0	S-108	0	0	TY-106	0	0
B-106	0	0	S-109	0	0	U-101	0	0
B-107	0	0	S-110	0	0	U-102	0	0
B-108	0	0	S-111	0	0	U-103	0	0
B-109	0	0	S-112	1.05E-14	5.3E-16	U-104	0	0
B-110	0	0	SX-101	0	0	U-105	0	0
B-111	0	0	SX-102	0	0	U-106	0	0
B-112	0	0	SX-103	0	0	U-107	0	0
B-201	1.99E-14	-2.6E-14	SX-104	0	0	U-108	0	0
B-202	5.61E-15	4.97E-14	SX-105	0	0	U-109	0	0
B-203	0.8	5.22E-14	SX-106	0	-3.29E-14	U-110	0	0
B-204	0.8	1.4E-14	SX-107	0	0	U-111	0	0
BX-101	0	0	SX-108	0	0	U-112	0	0
BX-102	0	0	SX-109	0	0	U-201	0	0
BX-103	0	0	SX-110	0	0	U-202	0	0
BX-104	0	0	SX-111	0	0	U-203	0	0
BX-105	0	0	SX-112	0	0	U-204	0	0

Table B-6. Make New Solid Layer for AZ-101.

Initial											
AZ-101	Initial	Solid Layers	1								
Description	Layer	Sum	Al+3	Bi+3	C2O4-2	Cr(TOTAL	F-	Fe+3	Na+	Si+4	SO4-2
Liquid(Non Water) (kg)	0	65335.9856	683.658	20.816	366.713	231.797	634.093	1.15254	22528.1	93.4608	3274.19
Solids (kg)	0	311032.119	76509.6	162.506	401.728	36.0201	0.06307	2008.05	9644.99	15144	0.33335
Water Dissolution Factors	0	NA	4.1E-08	8.2E-08	3.6E-05	2.1E-05	0.64709	5.8E-09	1.6E-05	4E-06	0.50442
Caustic Leach Factors	0	NA	0.939	0.003	0	0.19002	0	0.00705	0.46002	0.36	0.97059
Final											
AZ-101	Make New Solid Layer for AZ-101	Solid Layers									
Description	Layer	Sum	Al+3	Bi+3	C2O4-2	Cr(TOTAL	F-	Fe+3	Na+	Si+4	SO4-2
Liquid(Non Water) (kg)	0	63002.9893	659.246	20.0727	353.618	223.52	611.451	1.11138	21723.7	90.1236	3157.28
Solids (kg)	0	0	0	0	0	0	0	0	0	0	0
Water Dissolution Factors	0	NA	0	0	0	0	0	0	0	0	0
Caustic Leach Factors	0	NA	0.939	0.003	0	0.19002	0	0.00705	0.46002	0.36	0.97059
Liquid(Non Water) (kg)	2	2332.99635	24.4119	0.74329	13.0945	8.27692	22.642	0.04115	804.426	3.33727	116.914
Solids (kg)	2	311032.119	76509.6	162.506	401.728	36.0201	0.06307	2008.05	9644.99	15144	0.33335
Water Dissolution Factors	2	NA	4.1E-08	8.2E-08	3.6E-05	2.1E-05	0.64709	5.8E-09	1.6E-05	4E-06	0.50442
Caustic Leach Factors	2	NA	0.939	0.003	0	0.19002	0	0.00705	0.46002	0.36	0.97059

Table B-6. Make New Solid Layer for AZ-101.

Initial											
AZ-101	Initial	Solid Layers	1								
Description	Layer	Sum	Al+3	Bi+3	C2O4-2	Cr(TOTAL	F-	Fe+3	Na+	Si+4	SO4-2
Liquid(Non Water) (kg)	0	65335.9856	683.658	20.816	366.713	231.797	634.093	1.15254	22528.1	93.4608	3274.19
Solids (kg)	0	311032.119	76509.6	162.506	401.728	36.0201	0.06307	2008.05	9644.99	15144	0.33335
Water Dissolution Factors	0	NA	4.1E-08	8.2E-08	3.6E-05	2.1E-05	0.64709	5.8E-09	1.6E-05	4E-06	0.50442
Caustic Leach Factors	0	NA	0.939	0.003	0	0.19002	0	0.00705	0.46002	0.36	0.97059
Final											
AZ-101	Make New Solid Layer for AZ-101	Solid Layers									
Description	Layer	Sum	Al+3	Bi+3	C2O4-2	Cr(TOTAL	F-	Fe+3	Na+	Si+4	SO4-2
Liquid(Non Water) (kg)	0	63002.9893	659.246	20.0727	353.618	223.52	611.451	1.11138	21723.7	90.1236	3157.28
Solids (kg)	0	0	0	0	0	0	0	0	0	0	0
Water Dissolution Factors	0	NA	0	0	0	0	0	0	0	0	0
Caustic Leach Factors	0	NA	0.939	0.003	0	0.19002	0	0.00705	0.46002	0.36	0.97059
Liquid(Non Water) (kg)	2	2332.99635	24.4119	0.74329	13.0945	8.27692	22.642	0.04115	804.426	3.33727	116.914
Solids (kg)	2	311032.119	76509.6	162.506	401.728	36.0201	0.06307	2008.05	9644.99	15144	0.33335
Water Dissolution Factors	2	NA	4.1E-08	8.2E-08	3.6E-05	2.1E-05	0.64709	5.8E-09	1.6E-05	4E-06	0.50442
Caustic Leach Factors	2	NA	0.939	0.003	0	0.19002	0	0.00705	0.46002	0.36	0.97059

Table B-6. Make New Solid Layer for AZ-101.

Initial											
AZ-101	Initial	Solid Layers	1								
Description	Layer	Sum	Al+3	Bi+3	C2O4-2	Cr(TOTAL	F-	Fe+3	Na+	Si+4	SO4-2
Liquid(Non Water) (kg)	0	65335.9856	683.658	20.816	366.713	231.797	634.093	1.15254	22528.1	93.4608	3274.19
Solids (kg)	0	311032.119	76509.6	162.506	401.728	36.0201	0.06307	2008.05	9644.99	15144	0.33335
Water Dissolution Factors	0	NA	4.1E-08	8.2E-08	3.6E-05	2.1E-05	0.64709	5.8E-09	1.6E-05	4E-06	0.50442
Caustic Leach Factors	0	NA	0.939	0.003	0	0.19002	0	0.00705	0.46002	0.36	0.97059
Final											
AZ-101	Make New Solid Layer for AZ-101	Solid Layers									
Description	Layer	Sum	Al+3	Bi+3	C2O4-2	Cr(TOTAL	F-	Fe+3	Na+	Si+4	SO4-2
Liquid(Non Water) (kg)	0	63002.9893	659.246	20.0727	353.618	223.52	611.451	1.11138	21723.7	90.1236	3157.28
Solids (kg)	0	0	0	0	0	0	0	0	0	0	0
Water Dissolution Factors	0	NA	0	0	0	0	0	0	0	0	0
Caustic Leach Factors	0	NA	0.939	0.003	0	0.19002	0	0.00705	0.46002	0.36	0.97059
Liquid(Non Water) (kg)	2	2332.99635	24.4119	0.74329	13.0945	8.27692	22.642	0.04115	804.426	3.33727	116.914
Solids (kg)	2	311032.119	76509.6	162.506	401.728	36.0201	0.06307	2008.05	9644.99	15144	0.33335
Water Dissolution Factors	2	NA	4.1E-08	8.2E-08	3.6E-05	2.1E-05	0.64709	5.8E-09	1.6E-05	4E-06	0.50442
Caustic Leach Factors	2	NA	0.939	0.003	0	0.19002	0	0.00705	0.46002	0.36	0.97059

Table B-7.Make New Solid Layer for AZ-101.

Initial				
AZ-101	Initial	Solid Layers	1	
Description	Layer	Sum	AZ-101	C-105
Liquid Traceback	0	65336.77	37214.46	28122.3
Solids Traceback	0	311031.3	12.35618	311019
Final				
AZ-101	Make New Solid Layer for AZ-101	Solid Layers	2	
Description	Layer	Sum	AZ-101	C-105
Liquid Traceback (kg)	0	63003.74	35885.62	27118.12
Solids Traceback (kg)	0	0	0	0
Liquid Traceback	2	2333.024	1328.842	1004.182
Solids Traceback	2	311031.3	12.35618	311019
Calculated Final				
AZ-101	Make New Solid Layer for AZ-101	Solid Layers	2	
Description	Layer	Sum	AZ-101	C-105
Liquid Traceback	0	63003.74	35885.62	27118.12
Solids Traceback	0	0	0	0
Liquid Traceback *	2	2333.024	1328.842	1004.182
Solids Traceback	2	311031.3	12.35618	311019
((Calculated - Actual)/(Calculated + Actual)/2)				
AZ-101	Make New Solid Layer for AZ-101	Solid Layers	2	
Description	Layer	Sum	AZ-101	C-105
Liquid Traceback	0	3.46E-16	-2E-16	-2.7E-15
Solids Traceback	0	0	0	0
Liquid Traceback *	2	0	0	0
Solids Traceback	2	0	0	0

Table B-8.Mix Part (20%) Top Solid Layer for AZ-101.

Initial											
AZ-101	Initial	Solid Layers	2								
Description	Layer	Sum	Al+3	Bi+3	C2O4-2	Cr(TOTAL)	F-	Fe+3	Na+	Si+4	SO4-2
Liquid(Non Water) (kg)	0	63002.99	659.2465	20.07272	353.6183	223.5196	611.4507	1.111381	21723.68	90.12356	3157.28
Solids (kg)	0	0	0	0	0	0	0	0	0	0	0
Water Dissolution Factors	0	NA	0	0	0	0	0	0	0	0	0
Caustic Leach Factors	0	NA	0.939001	0.003	0	0.190017	0	0.007046	0.460021	0.359998	0.970588
Liquid(Non Water) (kg)	2	2332.996	24.41185	0.743292	13.09446	8.276917	22.64198	0.041154	804.4262	3.337269	116.9139
Solids (kg)	2	311032.1	76509.58	162.5065	401.7277	36.02015	0.063073	2008.048	9644.994	15144.04	0.333351
Water Dissolution Factors	2	NA	4.06E-08	8.24E-08	3.57E-05	2.1E-05	0.647092	5.75E-09	1.56E-05	4.02E-06	0.504419
Caustic Leach Factors	2	NA	0.939001	0.003	0	0.190017	0	0.007046	0.460021	0.359998	0.970588
Final											
AZ-101	Mix Part(20 %) of Top Layer for AZ-101	Solid Layers	2								
Description	Layer	Sum	Al+3	Bi+3	C2O4-2	Cr(TOTAL)	F-	Fe+3	Na+	Si+4	SO4-2
Liquid(Non Water) (kg)	0	63469.59	664.1289	20.22138	356.2372	225.175	615.9791	1.119612	21884.56	90.79101	3180.663
Solids (kg)	0	62206.42	15301.92	32.5013	80.34555	7.204029	0.012615	401.6097	1928.999	3028.808	0.06667
Water Dissolution Factors	0	NA	4.06E-08	8.24E-08	3.57E-05	2.1E-05	0.647092	5.75E-09	1.56E-05	4.02E-06	0.504419
Caustic Leach Factors	0	NA	0.939001	0.003	0	0.190017	0	0.007046	0.460021	0.359998	0.970588
Liquid(Non Water) (kg)	2	1866.397	19.52948	0.594633	10.47557	6.621533	18.11358	0.032923	643.5409	2.669815	93.53109
Solids (kg)	2	248825.7	61207.66	130.0052	321.3822	28.81612	0.050458	1606.439	7715.995	12115.23	0.266681
Water Dissolution Factors	2	NA	4.06E-08	8.24E-08	3.57E-05	2.1E-05	0.647092	5.75E-09	1.56E-05	4.02E-06	0.504419
Caustic Leach Factors	2	NA	0.939001	0.003	0	0.190017	0	0.007046	0.460021	0.359998	0.970588

Table B-8.Mix Part (20%) Top Solid Layer for AZ-101. (Cont.)

Initial											
AZ-101	Initial	Solid Layers	1								
Description	Layer	Sum	Al+3	Bi+3	C2O4-2	Cr(TOTAL	F-	Fe+3	Na+	Si+4	SO4-2
Liquid(Non Water) (kg)	0	65335.9856	683.658	20.816	366.713	231.797	634.093	1.15254	22528.1	93.4608	3274.19
Solids (kg)	0	311032.119	76509.6	162.506	401.728	36.0201	0.06307	2008.05	9644.99	15144	0.33335
Water Dissolution Factors	0	NA	4.1E-08	8.2E-08	3.6E-05	2.1E-05	0.64709	5.8E-09	1.6E-05	4E-06	0.50442
Caustic Leach Factors	0	NA	0.939	0.003	0	0.19002	0	0.00705	0.46002	0.36	0.97059
Final											
AZ-101	Make New Solid Layer for AZ-101	Solid Layers									
Description	Layer	Sum	Al+3	Bi+3	C2O4-2	Cr(TOTAL	F-	Fe+3	Na+	Si+4	SO4-2
Liquid(Non Water) (kg)	0	63002.9893	659.246	20.0727	353.618	223.52	611.451	1.11138	21723.7	90.1236	3157.28
Solids (kg)	0	0	0	0	0	0	0	0	0	0	0
Water Dissolution Factors	0	NA	0	0	0	0	0	0	0	0	0
Caustic Leach Factors	0	NA	0.939	0.003	0	0.19002	0	0.00705	0.46002	0.36	0.97059
Liquid(Non Water) (kg)	2	2332.99635	24.4119	0.74329	13.0945	8.27692	22.642	0.04115	804.426	3.33727	116.914
Solids (kg)	2	311032.119	76509.6	162.506	401.728	36.0201	0.06307	2008.05	9644.99	15144	0.33335
Water Dissolution Factors	2	NA	4.1E-08	8.2E-08	3.6E-05	2.1E-05	0.64709	5.8E-09	1.6E-05	4E-06	0.50442
Caustic Leach Factors	2	NA	0.939	0.003	0	0.19002	0	0.00705	0.46002	0.36	0.97059

Table B-8. Mix Part (20%) Top Solid Layer for AZ-101. (Cont.)

Calculated											
AZ-101	20%										
Description	Layer	Sum	Al+3	Bi+3	C2O4-2	Cr(TOTAL)	F-	Fe+3	Na+	Si+4	SO4-2
Liquid(Non Water)	0	63469.59	659.2465	20.07272	353.6183	223.5196	611.4507	1.111381	21723.68	90.12356	3157.28
Solids	0	62206.42	15301.92	32.5013	80.34555	7.204029	0.012615	401.6097	1928.999	3028.808	0.06667
Water Dissolution Factors	0	NA	4.06E-08	8.24E-08	3.57E-05	2.1E-05	0.647092	5.75E-09	1.56E-05	4.02E-06	0.504419
Caustic Leach Factors	0	NA	0.939001	0.003	0	0.190017	0	0.007046	0.460021	0.359998	0.970588
Liquid(Non Water) *	2	1866.397	19.52948	0.594633	10.47557	6.621533	18.11358	0.032923	643.5409	2.669815	93.53109
Solids	2	248825.7	61207.66	130.0052	321.3822	28.81612	0.050458	1606.439	7715.995	12115.23	0.266681
Water Dissolution Factors	2	NA	4.06E-08	8.24E-08	3.57E-05	2.1E-05	0.647092	5.75E-09	1.56E-05	4.02E-06	0.504419
Caustic Leach Factors	2	NA	0.939001	0.003	0	0.190017	0	0.007046	0.460021	0.359998	0.970588
((Calculated - Actual)/(Calculated + Actual)/2)											
AZ-101											
Description	Layer	Sum	Al+3	Bi+3	C2O4-2	Cr(TOTAL)	F-	Fe+3	Na+	Si+4	SO4-2
Liquid(Non Water)	0	8.02E-16	-0.007379	-0.007379	-0.007379	-0.007379	-0.007379	-0.007379	-0.007379	-0.007379	-0.007379
Solids	0	-1.64E-15	5.23E-15	0	-1.24E-15	-1.36E-15	1.38E-16	1.42E-16	2.24E-15	-3.3E-15	0
Water Dissolution Factors	0	NA	-1.63E-16	0	0	0	0	0	0	0	0
Caustic Leach Factors	0	NA	-1.18E-16	0	0	0	0	0	0	0	1.14E-16
Liquid(Non Water)	2	1.22E-16	2.18E-15	-3.73E-16	1.7E-16	5.37E-16	-2.35E-15	2.53E-15	1.24E-15	1.66E-16	-4.25E-15
Solids	2	-8.19E-16	3.57E-16	0	1.24E-15	1.36E-15	1.38E-16	3.82E-15	-3.54E-16	-4.95E-15	2.29E-15
Water Dissolution Factors	2	NA	0	0	0	0	0	0	0	0	0
Caustic Leach Factors	2	NA	0	0	0	0	0	0	0	0	0

Table B-9. Results – Mix Part (20%) Top Solid Layer for AZ-101.

Initial				
AZ-101	Make New Solid Layer for AZ-101	Solid Layers	2	
Description	Layer	Sum	AZ-101	C-105
Liquid Traceback	0	63003.74	35885.62	27118.12
Solids Traceback	0	0	0	0
Liquid Traceback	2	2333.024	1328.842	1004.182
Solids Traceback	2	311031.3	12.35618	311019
Final				
AZ-101	Mix Part(20%) of Top Layer for AZ-101	Solid Layers	2	
Description	Layer	Sum	AZ-101	C-105
Liquid Traceback (kg)	0	63470.35	36151.39	27318.96
Solids Traceback (kg)	0	62206.27	2.471236	62203.8
Liquid Traceback	2	1866.419	1063.074	803.3458
Solids Traceback	2	248825.1	9.884943	248815.2
Calculated				
AZ-101	Mix Part(20%) of Top Layer for AZ-101	Solid Layers	2	
Description	Layer	Sum	AZ-101	C-105
Liquid Traceback	0	63470.35	36151.39	27318.96
Solids Traceback	0	62206.27	2.471236	62203.8
Liquid Traceback	2	1866.419	1063.074	803.3458
Solids Traceback	2	248825.1	9.884943	248815.2
((Calculated - Actual)/(Calculated + Actual)/2)				
AZ-101	Mix Part(20%) of Top Layer for AZ-101	Solid Layers	2	
Description	Layer	Sum	AZ-101	C-105
Liquid Traceback	0	-6.9E-16	0	2E-15
Solids Traceback	0	0	-4E-15	-1.6E-15
Liquid Traceback *	2	-3.2E-15	7.7E-15	-4.8E-15
Solids Traceback	2	0	-6.1E-15	7.02E-16

Table B-10. Mix Top Solid Layer for AZ-101.

Initial											
AZ-101	Initial	Solid Layers	2								
Description	Layer	Sum	Al+3	Bi+3	C2O4-2	Cr(TOTAL)	F-	Fe+3	Na+	Si+4	SO4-2
Liquid(Non Water) (kg)	0	63469.59	664.1289	20.22138	356.2372	225.175	615.9791	1.119612	21884.56	90.79101	3180.663
Solids (kg)	0	62206.42	15301.92	32.5013	80.34555	7.204029	0.012615	401.6097	1928.999	3028.808	0.06667
Water Dissolution Factors	0	NA	4.06E-08	8.24E-08	3.57E-05	2.1E-05	0.647092	5.75E-09	1.56E-05	4.02E-06	0.504419
Caustic Leach Factors	0	NA	0.939001	0.003	0	0.190017	0	0.007046	0.460021	0.359998	0.970588
Liquid(Non Water) (kg)	2	1866.397	19.52948	0.594633	10.47557	6.621533	18.11358	0.032923	643.5409	2.669815	93.53109
Solids (kg)	2	248825.7	61207.66	130.0052	321.3822	28.81612	0.050458	1606.439	7715.995	12115.23	0.266681
Water Dissolution Factors	2	NA	4.06E-08	8.24E-08	3.57E-05	2.1E-05	0.647092	5.75E-09	1.56E-05	4.02E-06	0.504419
Caustic Leach Factors	2	NA	0.939001	0.003	0	0.190017	0	0.007046	0.460021	0.359998	0.970588
Final											
AZ-101	Mix Top Layer for AZ-101	Solid Layers	1								
Description	Layer	Sum	Al+3	Bi+3	C2O4-2	Cr(TOTAL)	F-	Fe+3	Na+	Si+4	SO4-2
Liquid(Non Water) (kg)	0	65335.99	683.6583	20.81602	366.7128	231.7966	634.0927	1.152536	22528.1	93.46083	3274.194
Solids (kg)	0	311032.1	76509.58	162.5065	401.7277	36.02015	0.063073	2008.048	9644.994	15144.04	0.333351
Water Dissolution Factors	0	NA	4.06E-08	8.24E-08	3.57E-05	2.1E-05	0.647092	5.75E-09	1.56E-05	4.02E-06	0.504419
Caustic Leach Factors	0	NA	0.939001	0.003	0	0.190017	0	0.007046	0.460021	0.359998	0.970588
Liquid(Non Water) (kg)	2	0	0	0	0	0	0	0	0	0	0
Solids (kg)	2	0	0	0	0	0	0	0	0	0	0
Water Dissolution Factors	2	NA	0	0	0	0	0	0	0	0	0
Caustic Leach Factors	2	NA	0	0	0	0	0	0	0	0	0

Table B-10. Results – Mix Part (20%) Top Solid Layer for AZ-101. (Cont.)

Calculated											
AZ-101	100%										
Description	Layer	Sum	Al+3	Bi+3	C2O4-2	Cr(TOTAL)	F-	Fe+3	Na+	Si+4	SO4-2
Liquid(Non Water)	0	65335.99	664.1289	20.22138	356.2372	225.175	615.9791	1.119612	21884.56	90.79101	3180.663
Solids	0	311032.1	76509.58	162.5065	401.7277	36.02015	0.063073	2008.048	9644.994	15144.04	0.333351
Water Dissolution Factors	0	NA	4.06E-08	8.24E-08	3.57E-05	2.1E-05	0.647092	5.75E-09	1.56E-05	4.02E-06	0.504419
Caustic Leach Factors	0	NA	0	0	0	0	0	0	0	0	0
Liquid(Non Water) *	2	0	0	0	0	0	0	0	0	0	0
Solids	2	0	0	0	0	0	0	0	0	0	0
Water Dissolution Factors	2	NA	0	0	0	0	0	0	0	0	0
Caustic Leach Factors	2	NA	0	0	0	0	0	0	0	0	0
((Calculated - Actual)/(Calculated + Actual)/2)											
AZ-101											
Description	Layer	Sum	Al+3	Bi+3	C2O4-2	Cr(TOTAL)	F-	Fe+3	Na+	Si+4	SO4-2
Liquid(Non Water)	0	0	-0.02898	-0.02898	-0.02898	-0.02898	-0.02898	-0.02898	-0.02898	-0.02898	-0.02898
Solids	0	9.36E-16	-1.33E-15	0	-7.07E-16	-7.89E-16	0	-3.06E-15	0	4.68E-15	-1.83E-15
Water Dissolution Factors	0	NA	0	0	0	0	-1.72E-16	0	0	0	0
Caustic Leach Factors	0	NA	-2	-2	0	-2	0	-2	-2	-2	-2
Liquid(Non Water)	2	0	0	0	0	0	0	0	0	0	0
Solids	2	0	0	0	0	0	0	0	0	0	0
Water Dissolution Factors	2	NA	0	0	0	0	0	0	0	0	0
Caustic Leach Factors	2	NA	0	0	0	0	0	0	0	0	0

Table B-11. Results - Mix Top Solid Layer for AZ-101.

Initial				
AZ-101	Mix Part(20%) of Top Layer for AZ-101	Solid Layers	2	
Description	Layer	Sum	AZ-101	C-105
Liquid Traceback	0	63470.35	36151.39	27318.96
Solids Traceback	0	62206.27	2.471236	62203.8
Liquid Traceback	2	1866.419	1063.074	803.3458
Solids Traceback	2	248825.1	9.884943	248815.2
Final				
AZ-101	Mix Top Layer for AZ-101	Solid Layers	1	
Description	Layer	Sum	AZ-101	C-105
Liquid Traceback (kg)	0	65336.77	37214.46	28122.3
Solids Traceback (kg)	0	311031.3	12.35618	311019
Liquid Traceback	2	0	0	0
Solids Traceback	2	0	0	0
Calculated				
AZ-101	Mix Top Layer for AZ-101	Solid Layers	2	
Description	Layer	Sum	AZ-101	C-105
Liquid Traceback	0	65336.77	37214.46	28122.3
Solids Traceback	0	311031.3	12.35618	311019
Liquid Traceback	2	0	0	0
Solids Traceback	2	0	0	0
((Calculated - Actual)/(Calculated + Actual)/2)				
AZ-101	Mix Top Layer for AZ-101	Solid Layers	2	
Description	Layer	Sum	AZ-101	C-105
Liquid Traceback	0	4.45E-16	0	7.76E-16
Solids Traceback	0	0	5.61E-15	-1.9E-16
Liquid Traceback *	2	0	0	0
Solids Traceback	2	0	0	0

Table B-12. Results – Mix All Solid Layer for AZ-101.

Initial											
AZ-101	Initial	Solid Layers	2	Immobile Solid Layers	0						
Description	Layer	Sum	Al+3	Bi+3	C2O4-2	Cr(TOTAL)	F-	Fe+3	Na+	Si+4	SO4-2
Liquid(Non Water) (kg)	0	63002.99	659.2465	20.07272	353.6183	223.5196	611.4507	1.111381	21723.68	90.12356	3157.28
Solids (kg)	0	0	0	0	0	0	0	0	0	0	0
Water Dissolution Factors	0	NA	0	0	0	0	0	0	0	0	0
Caustic Leach Factors	0	NA	0.939001	0.003	0	0.190017	0	0.007046	0.460021	0.359998	0.970588
Liquid(Non Water) (kg)	3	0	0	0	0	0	0	0	0	0	0
Solids (kg)	3	0	0	0	0	0	0	0	0	0	0
Water Dissolution Factors	3	NA	0	0	0	0	0	0	0	0	0
Caustic Leach Factors	3	NA	0	0	0	0	0	0	0	0	0
Liquid(Non Water) (kg)	2	2332.996	24.41185	0.743292	13.09446	8.276917	22.64198	0.041154	804.4262	3.337269	116.9139
Solids (kg)	2	311032.1	76509.58	162.5065	401.7277	36.02015	0.063073	2008.048	9644.994	15144.04	0.333351
Water Dissolution Factors	2	NA	4.06E-08	8.24E-08	3.57E-05	2.1E-05	0.647092	5.75E-09	1.56E-05	4.02E-06	0.504419
Caustic Leach Factors	2	NA	0.939001	0.003	0	0.190017	0	0.007046	0.460021	0.359998	0.970588
Liquid(Non Water) (kg)	1	40074.08	856.5818	0	142.685	97.02579	283.9546	0.212258	15707.13	9.660021	2287.675
Solids (kg)	1	198615.1	38413.77	0.746109	787.4078	149.3202	945.9288	19218.46	7079.505	1083.615	4999.382
Water Dissolution Factors	1	NA	0.001214	0.269034	0.273462	0.076121	0.647092	9.01E-06	0.319583	0.842979	0.504419
Caustic Leach Factors	1	NA	0.961	0.170475	0	0.25	0	0.078491	0.894173	0	0.970588

AZ-101				
Description	Layer	Sum	AZ-101	C-105
Liquid Traceback (kg)	0	63003.74	35885.62	27118.12
Solids Traceback (kg)	0	0	0	0
Liquid Traceback (kg)	3	0	0	0
Solids Traceback (kg)	3	0	0	0
Liquid Traceback (kg)	2	2333.024	1328.842	1004.182
Solids Traceback (kg)	2	311031.3	12.35618	311019
Liquid Traceback (kg)	1	53379.38	53379.38	0
Solids Traceback (kg)	1	185309.8	185309.8	0

Table B-12. Results – Mix All Solid Layer for AZ-101. (Cont.)

Final											
AZ-101	Mix Solid Layers for AZ-101	Solid Layers	0								
Description	Layer	Sum	Al+3	Bi+3	C2O4-2	Cr(TOTAL)	F-	Fe+3	Na+	Si+4	SO4-2
Liquid(Non Water) (kg)	0	105410.1	1540.24	20.81602	509.3978	328.8223	918.0473	1.364794	3368.237	6.549933	0.146809
Solids (kg)	0	509647.2	114923.4	163.2526	1189.136	185.3403	945.9918	21226.51	1396.306	10.94955	32.53318
Water Dissolution Factors	0	NA	0.000406	0.00123	0.18109	0.061331	0.647092	8.16E-06	0.329269	0	0
Caustic Leach Factors	0	NA	0.946354	0.003765	0	0.238342	0	0.071732	0	0	0
Liquid(Non Water) (kg)	3	0	0	0	0	0	0	0	0	0	0
Solids (kg)	3	0	0	0	0	0	0	0	0	0	0
Water Dissolution Factors	3	NA	0	0	0	0	0	0	0	0	0
Caustic Leach Factors	3	NA	0	0	0	0	0	0	0	0	0
Liquid(Non Water) (kg)	2	0	0	0	0	0	0	0	0	0	0
Solids (kg)	2	0	0	0	0	0	0	0	0	0	0
Water Dissolution Factors	2	NA	0	0	0	0	0	0	0	0	0
Caustic Leach Factors	2	NA	0	0	0	0	0	0	0	0	0
Liquid(Non Water) (kg)	1	0	0	0	0	0	0	0	0	0	0
Solids (kg)	1	0	0	0	0	0	0	0	0	0	0
Water Dissolution Factors	1	NA	0	0	0	0	0	0	0	0	0
Caustic Leach Factors	1	NA	0	0	0	0	0	0	0	0	0
AZ-101											
Description	Layer	Sum	AZ-101	C-105							
Liquid Traceback (kg)	0	118716.2	90593.85	28122.3							
Solids Traceback (kg)	0	496341.2	185322.2	311019							
Liquid Traceback (kg)	3	0	0	0							
Solids Traceback (kg)	3	0	0	0							
Liquid Traceback (kg)	2	0	0	0							
Solids Traceback (kg)	2	0	0	0							
Liquid Traceback (kg)	1	0	0	0							
Solids Traceback (kg)	1	0	0	0							

Table B-12. Results – Mix All Solid Layer for AZ-101.

Calculated											
AZ-101	Mix Solid Layers for AZ-101	Solid Layers	0								
Description	Layer	Sum	Al+3	Bi+3	C2O4-2	Cr(TOTAL)	F-	Fe+3	Na+	Si+4	SO4-2
Liquid(Non Water) (kg)	0	105410.1	1540.24	20.81602	509.3978	328.8223	918.0473	1,364794	38235.23	103.1208	5561.868
Solids (kg)	0	509647.2	114923.4	163.2526	1189.136	185.3403	945.9918	21226.51	16724.5	16227.66	4999.716
Water Dissolution Factors	0	0	0.000406	0.00123	0.18109	0.061331	0.647092	8.16E-06	0.135289	0.056294	0.504419
Caustic Leach Factors	0	0	0.946354	0.003765	0	0.238342	0	0.071732	0.643798	0.335959	0.970588
AZ-101											
Description	Layer	Sum	AZ-101	C-105							
Liquid Traceback (kg)	0	118716.2	90593.85	28122.3							
Solids Traceback (kg)	0	496341.2	185322.2	311019							
((Calculated - Actual)/(Calculated + Actual)/2)											
AZ-101	0	0	0	0							
Description	Layer	Sum	Al+3	Bi+3	C2O4-2	Cr(TOTAL)	F-	Fe+3	Na+	Si+4	SO4-2
Liquid(Non Water)	0	4.28E-15	4.43E-15	1.19E-15	-3.01E-15	2.07E-15	3.72E-16	2.12E-15	-7.61E-16	3.17E-15	-1.31E-15
Solids	0	0	6.96E-15	2.79E-15	5.93E-15	-1.07E-15	2.4E-16	-1.37E-15	6.53E-16	-3.14E-15	5.46E-16
Water Dissolution Factors	0	N/A	-3.34E-15	-2.65E-15	3.68E-15	-9.05E-16	0	-2.08E-16	5.33E-15	4.44E-15	0
Caustic Leach Factors	0	N/A	4.69E-16	1.27E-15	0	-4.66E-16	0	3.87E-16	8.62E-16	1.65E-15	-1.14E-16

Table B-13. Results –Transfer from C-105 to AZ-101 Initial.

Initial												
Tank	Property	Phase	Sum	Al+3	Bi+3	C2O4-2	Cr(TOTAL)	F-	Fe+3	Na+	Si+4	SO4-2
C-105	Mass	Liquid	56790.4	0	42.036	510.5716	311.7115	822.831	1.985333	20177.64	173.166	2924.8
C-105	Mass	Solid	631514	155345	329.964	815.5884	73.11751	0	4074.675	19582.89	30749.33	0
C-105	Mass	Total	688304	155346.9	372.006	1326.16	385.209	822.831	4076.674	39761.44	30923.22	2924.8
Tank	Property	Phase	Sum	C-104	C-105	C-106						
C-105	TB	Liquid	56790.4	0	56790.37	0						
C-105	TB	Solid	631514	0	631513.9	0						
C-105	TB	Total	688304	0	688304.2	0						
Tank	Property	Phase	Sum	Al+3	Bi+3	C2O4-2	Cr(TOTAL)	F-	Fe+3	Na+	Si+4	SO4-2
AZ-101	Mass	Liquid	77287.7	1540.24	0	256.5653	174.4644	510.5856	0.381667	28243.37	17.36991	4113.522
AZ-101	Mass	Solid	198628	38416.33	0.746159	787.4603	149.3301	945.9918	19219.74	7079.977	1083.687	4999.716
AZ-101	Mass	Total	275916	39958.5	1.625178	1044.573	324.4468	1457.872	19220.28	35325.77	1102.743	9116.188
Tank	Property	Phase	Sum	AY-102	AZ-101	AZ-102						
AZ-101	TB	Liquid	90593.8	0	90593.85	0						
AZ-101	TB	Solid	185322	0	185322.2	0						
AZ-101	TB	Total	275916	0	275916	0						
Tank	Property	Phase	Sum	Al+3	Bi+3	C2O4-2	Cr(TOTAL)	F-	Fe+3	Na+	Si+4	SO4-2
C-105 + AZ-101	Mass	Liquid	134078	1540.24	42.036	767.1369	486.1759	1333.417	2.367	48421.01	190.5359	7038.322
C-105 + AZ-101	Mass	Solid	830142	193761.3	330.7102	1603.049	222.4476	945.9918	23294.42	26662.86	31833.02	4999.716
C-105 + AZ-101	Mass	Total	964220	195305.4	373.6312	2370.733	709.6558	2280.703	23296.96	75087.22	32025.96	12040.99
Tank	Property	Phase	Sum	AZ-101	C-105							
C-105 + AZ-101	TB	Liquid	147384	90593.85	56790.37							
C-105 + AZ-101	TB	Solid	816836	185322.2	631513.9							
C-105 + AZ-101	TB	Total	964220	275916	688304.2							

Table B-14. Results –Transfer from C-105 to AZ-101 Final.

Transfer from C-105 to AZ-101 until AZ-101 is Full - Make Solid Layer - Mix Top Solid Layer												
Tank	Property	Phase	Sum	Al+3	Bi+3	C2O4-2	Cr(TOTAL)	F-	Fe+3	Na+	Si+4	SO4-2
C-105	Mass	Liquid	28668.2	0	21.21998	257.7391	157.3535	415.3692	1.002206	10185.77	87.41507	1476.454
C-105	Mass	Solid	320495	78837.98	167.4576	413.9132	37.10732	0	2067.908	9938.364	15605.36	0
C-105	Mass	Total	349163	78839.86	188.6835	671.6523	194.8408	415.3692	2068.924	20125.06	15693.5	1476.454
Tank	Property	Phase	Sum	C-104	C-105	C-106						
C-105	TB	Liquid	28668.1	0	28668.06	0						
C-105	TB	Solid	320495	0	320494.9	0						
C-105	TB	Total	349163	0	349162.9	0						
Tank	Property	Phase	Sum	Al+3	Bi+3	C2O4-2	Cr(TOTAL)	F-	Fe+3	Na+	Si+4	SO4-2
AZ-101	Mass	Liquid	105410	1540.24	20.81602	509.3978	328.8223	918.0473	1.364794	38235.23	103.1208	5561.868
AZ-101	Mass	Solid	509647	114923.4	163.2526	1189.136	185.3403	945.9918	21226.51	16724.5	16227.66	4999.716
AZ-101	Mass	Total	615057	116465.5	184.5111	1698.807	514.6788	1865.333	21227.96	54961.41	16331.98	10564.53
Tank	Property	Phase	Sum	AY-102	AZ-101	AZ-102						
AZ-101	TB	Liquid	118716	0	90593.85	0						
AZ-101	TB	Solid	496341	0	185322.2	0						
AZ-101	TB	Total	615057	0	275916	0						
Tank	Property	Phase	Sum	Al+3	Bi+3	C2O4-2	Cr(TOTAL)	F-	Fe+3	Na+	Si+4	SO4-2
C-105 + AZ-101	Mass	Liquid	134078	1540.24	42.036	767.1369	486.1759	1333.417	2.367	48421.01	190.5359	7038.322
C-105 + AZ-101	Mass	Solid	830142	193761.3	330.7102	1603.049	222.4476	945.9918	23294.42	26662.86	31833.02	4999.716
C-105 + AZ-101	Mass	Total	964220	195305.4	373.1947	2370.459	709.5197	2280.703	23296.89	75086.46	32025.48	12040.99
Tank	Property	Phase	Sum	AZ-101	C-105							
C-105 + AZ-101	TB	Liquid	147384	90593.85	56790.37							
C-105 + AZ-101	TB	Solid	816836	185322.2	631513.9							
C-105 + AZ-101	TB	Total	964220	275916	688304.2							

Table B-15. Results –Transfer from C-105 to AZ-101

Transfer from C-105 to AZ-101 until AZ-101 is Full - Make Solid Layer - Mix Top Solid Layer			
Conservation of Mass			
Tank	Property	Phase	Change
C-105	Delta Mass	Liquid	-28122.19463
C-105	Delta Mass	Solid	-311019.0888
C-105	Delta Mass	Total	-339141.2834
AZ-101	Delta Mass	Liquid	28122.40964
AZ-101	Delta Mass	Solid	311018.8738
AZ-101	Delta Mass	Total	339141.2834
C-105 + AZ-101	Delta Mass	Liquid	0.215009612
C-105 + AZ-101	Delta Mass	Solid	-0.215009611
C-105 + AZ-101	Delta Mass	Total	0
Conservation of Mass Error			
ABS(C-105 Delta / AZ-101 Delta)		Liquid	0.999992355
ABS(C-105 Delta / AZ-101 Delta)		Solid	1.000000691
ABS(C-105 Delta / AZ-101 Delta)		Total	1
Conservation of Traceback Mass			
Tank	Property	Phase	Change
C-105	Delta TB Mass	Liquid	-28122.30426
C-105	Delta TB Mass	Solid	-311018.9802
C-105	Delta TB Mass	Total	-339141.2845
AZ-101	Delta TB Mass	Liquid	28122.30426
AZ-101	Delta TB Mass	Solid	311018.9802
AZ-101	Delta TB Mass	Total	339141.2845
C-105 + AZ-101	Delta TB Mass	Liquid	0
C-105 + AZ-101	Delta TB Mass	Solid	-1.39698E-09
C-105 + AZ-101	Delta TB Mass	Total	-1.39698E-09
Conservation of Traceback Mass Error			
ABS(C-105 Delta / AZ-101 Delta)		Liquid	1
ABS(C-105 Delta / AZ-101 Delta)		Solid	1
ABS(C-105 Delta / AZ-101 Delta)		Total	1

Table B-16. Results –Transfer from C-105 to AZ-101 Traceback Calculations.

Pre Transfer Trace Back Data (Actual)			
Tank	Phase	C-105	AZ-101
C-105	Liquid	56761.4605	0
C-105	Solid	627754.0915	0
C-105	Total	684515.552	0
Tank	Phase	C-105	AZ-101
AZ-101	Liquid	0	37214.46483
AZ-101	Solid	0	12.35617822
AZ-101	Total	0	37226.82101
Post Transfer Trace Back Data (Actual)			
Tank	Phase	C-105	AZ-101
C-105	Liquid	28639.15625	0
C-105	Solid	316735.1113	0
C-105	Total	345374.2676	0
Tank	Phase	C-105	AZ-101
AZ-101	Liquid	28122.30426	37214.46483
AZ-101	Solid	311018.9802	12.35617822
AZ-101	Total	339141.2845	37226.82101
Post Transfer Trace Back Data (Calculated)			
Tank	Phase	C-105	AZ-101
C-105	Liquid	28639.26587	0
C-105	Solid	316735.0028	0
C-105	Total	345374.2687	0
Tank	Phase	C-105	AZ-101
AZ-101	Liquid	28122.19463	37214.46483
AZ-101	Solid	311019.0888	12.35617822
AZ-101	Total	339141.2834	37226.82101
Post Transfer Trace Back Data ((Calculated - Actual)/Calculated)			
Tank	Phase	C-105	AZ-101
C-105	Liquid	3.82783E-06	N/A
C-105	Solid	-3.4277E-07	N/A
C-105	Total	3.06656E-09	N/A
Tank	Phase	C-105	AZ-101
AZ-101	Liquid	-3.89821E-06	0
AZ-101	Solid	3.49069E-07	0
AZ-101	Total	-3.12291E-09	0

Table B-17. Results –Transfer from C-105 to AZ-101 Properties Calculations.

Pre Transfer Factors Data (Actual)										
Tank	Factor	Al+3	Bi+3	C2O4-2	Cr(TOTAL)	F-	Fe+3	Na+	Si+4	SO4-2
C-105	Water Dissolution Factors	0	0	0	0	0	0	0	0	0
C-105	Caustic Leach Factors	0.939	0.003	0	0.19	0	0.007	0.46	0.36	0
AZ-101	Water Dissolution Factors	0.00121405	0.2690339	0.273462	0.07612125	0.64709236	9.0142E-06	0.31958274	0.84297878	0.50441891
AZ-101	Caustic Leach Factors	0.961	0.17047539	0	0.25	0	0.07849074	0.89417271	0	0.97058824
Post Transfer Factors Data (Actual)										
Tank	Factor	Al+3	Bi+3	C2O4-2	Cr(TOTAL)	F-	Fe+3	Na+	Si+4	SO4-2
C-105	Water Dissolution Factors	0	0	0	0	0	0	0	0	0
C-105	Caustic Leach Factors	0.939	0.003	0	0.19	0	0.007	0.46	0.36	0
AZ-101	Water Dissolution Factors	4.0644E-08	8.2362E-08	3.574E-05	2.1041E-05	0.64709236	5.7525E-09	1.5641E-05	4.0219E-06	0.50441891
AZ-101	Caustic Leach Factors	0.93900074	0.00300005	0	0.19001658	0	0.00704562	0.46002125	0.35999828	0.97058824
Post Transfer Factors Data (Calculated)										
Tank	Factor	Al+3	Bi+3	C2O4-2	Cr(TOTAL)	F-	Fe+3	Na+	Si+4	SO4-2
C-105	Water Dissolution Factors	0	0	0	0	0	0	0	0	0
C-105	Caustic Leach Factors	0.939	0.003	0	0.19	0	0.007	0.46	0.36	0
AZ-101	Water Dissolution Factors	4.0644E-08	8.2362E-08	3.574E-05	2.1041E-05	0.64709236	5.7525E-09	1.5641E-05	4.0219E-06	0.50441891
AZ-101	Caustic Leach Factors	0.93900074	0.00300005	0	0.19001658	0	0.00704562	0.46002125	0.35999828	0.97058824
Post Transfer Factors Data ((Calculated - Actual)/Calculated)										
Tank	Factor	Al+3	Bi+3	C2O4-2	Cr(TOTAL)	F-	Fe+3	Na+	Si+4	SO4-2
C-105	Water Dissolution Factors	0	0	0	0	0	0	0	0	0
C-105	Caustic Leach Factors	0	0	0	0	0	0	0	0	0
AZ-101	Water Dissolution Factors	8.1408E-15	-1.607E-15	4.3608E-15	5.1528E-15	0	-3.02E-15	-2.166E-15	-2.106E-16	0
AZ-101	Caustic Leach Factors	1.6553E-15	8.6735E-16	0	2.9214E-15	0	-1.231E-16	-1.327E-15	-2.313E-15	0

Table B-18. Representative Model Objects (Split Calculation Procedure). (2 Sheets)

Pump Procedure Checked	Equipment Class	Equipment Name
DEFAULT-LIQUID-SCRUBBER-PUMP	LIQUID-SCRUBBER	DEGASIFICATION
		HLW-HEME
		HLW-WESP
		HTWOS-HLW-HEME
		HTWOS-HLW-WESP
		HTWOS-LAW-CAUSTIC-SCRUBBER
		HTWOS-LAW-WESP
		LAW-CAUSTIC-SCRUBBER
		LAW-WESP
		LIQUID-SCRUBBER-DESIGN-SPEC-DUMMY
		PEROXIDE-DECOMPOSER
		UV-OX
HTWOS-GLASS-MELTER-PUMP-BV-METHOD	GLASS-MELTER	HTWOS-HLW-MELTER-1
		HTWOS-LAW-MELTER-1
NEW-HTWOS-SBS-PUMP-STUDY-17	SBS-SCRUBBER	HTWOS-HLW-SBS
		HTWOS-LAW-SBS
DEFAULT-ACCUMULATION-SCRUBBER-PUMP-NEW	ACCUMULATION-SCRUBBER	PDM-FILTER
		INFL-FILTER
		AUX-FINE-FILTER
		INFL-FILTER-2
		INFL-FILTER-3
		AUX-FILTER
		FALSE-IX
		HEPA-FILTER1
		LAW-VOC-SCRUBBER
		LAW-NOX-SCRUBBER
		HEPA-FILTER-2
		HLW-HEPA-1
		HLW-HEPA-2

Table B-18. Representative Model Objects (Split Calculation Procedure). (2 Sheets)

Pump Procedure Checked	Equipment Class	Equipment Name
		HLW-NOX-SCRUBBER
		HLW-VOC-SCRUBBER
		SILVER-MORDENITE-COLUMN
		HLW-AG-MORDENITE-COL
		HLW-NOX-SCRUB
		HLW-VOC-SCRUB
		HLW-HEPA2
		HLW-HEPA1
		LAW-NOX-SCRUB
		LAW-VOC-SCRUB
		LAW-HEPA2
		LAW-HEPA1
		WEST-BV-CARBON-FILTER
		WD-BV-CARBON-FILTER
		EAST-BV-CARBON-FILTER
NEW-HTWOS-EVAPORATOR-CONDENSER-PUMP	EVAPORATOR-CONDENSER-TANK	EAST-BV-DRYER-CONDENSER
		SUPP-TRU-DRYER-CONDENSER
		WD-BV-DRYER-CONDENSER
		WEST-BV-DRYER-CONDENSER
EXPANDED-SPLITS-SUP-TRU-DRYER-PUMP	SPLIT-EVAPORATOR	SUP-TRU-DRYER

Note: The six representative objects that were tested are highlighted in yellow. Section 3.2.5 provides a discussion of the test.