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River Protection Project Mission Analysis Waste Blending Study

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Abstract: Preliminary evaluation for blending Hanford site waste with the objective of minimizing the amount of high-level waste (HLW) glass volumes without major changes to the overall waste retrieval and processing sequences currently planned. The evaluation utilizes simplified spreadsheet models developed to allow screening type comparisons of blending options without the need to use the Hanford Tank Waste Operations Simulator (HTWOS) model. The blending scenarios evaluated are expected to increase tank farm operation costs due to increased waste transfers. Benefit would be derived from shorter operating time period for tank waste processing facilities, reduced onsite storage of immobilized HLW, and reduced offsite transportation and disposal costs for the immobilized HLW.

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EXECUTIVE SUMMARY

A preliminary evaluation was performed on concepts for blending Hanford Site tank waste with the objective of minimizing high-level waste (HLW) glass volumes without major changes to the overall waste retrieval and processing sequences currently planned. The evaluation is based on the ORP-11242, *River Protection Project System Plan,* Revision 4 (System Plan) Unconstrained Case Waste Tank and Immobilization Project (WTP) feed batch composition and sequence. The evaluation utilized simplified spreadsheet models developed to allow screening type comparisons of blending options without the need to use the Hanford Tank Waste Operations Simulator (HTWOS) model.

A base case designed to avoid meaningful blending of feed batches was developed for comparison with blending alternatives. Leached solids washing efficiency and HLW melter sulfate retention were adjusted from the Unconstrained Case values to more closely match recent WTP performance predictions. These adjustments for the study base case resulted in a reduction in HLW glass quantity by about 10% compared to the System Plan Unconstrained Case.

Tank farm blending was evaluated based on blending selected wastes planned for delivery within a rolling 1½- to 2-year window. No credit was taken for blending the first four batches based on the assumption that blending would be accomplished in part during refilling of tanks initially emptied by transfers to the WTP. The tank farm blending cases resulted in about 20% reduction in estimated HLW glass volume compared to the study base case.

Blending partial batches in the tank farm tanks used for HLW transfers to WTP was evaluated based on refilling the WTP feed transfer tank with the next planned WTP feed batch each time one half of the feed tank contents have been transferred. This evaluation reduced the HLW glass quantity by about 10% compared to the base case. A side benefit of this approach is that WTP feed composition would be more consistent and predictable, which is expected to result in improved operations.

The blending scenarios evaluated are expected to increase tank farm operation costs due to increased waste transfers. The increased tank farm operation costs are a small fraction of expected savings, which result primarily from:

- A shorter operating time period for tank waste processing facilities,
- Reduced onsite storage for immobilized HLW, and
- Reduced offsite transportation and disposal costs for the immobilized HLW.

However, it should be recognized that the capacity of other waste treatment systems (e.g., waste pretreatment, low-activity waste immobilization, and secondary liquid waste treatment) must be increased to take full advantage of cost savings associated with a shorter operating time period.

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Abbreviations and Acronyms

Al	aluminum
CH	contact-handled
DST	double-shell tank
FY	fiscal year
HLW	high-level waste
HTWOS	Hanford Tank Waste Operations Simulator
IHLW	immobilized high-level waste
ILAW	immobilized low-activity waste
LAW	low-activity waste
Na	sodium
RPP	River Protection Project
SBS	submerged bed scrubber
SST	single-shell tank
System Plan	*River Protection Project System Plan* (ORP-11242, Rev. 4)
TRL	Technology Readiness Level
TRU	transuranic
WRPS	Washington River Protection Solutions
WTP	Waste Treatment and Immobilization Plant

Units

g/ml	grams per milliliter
kg	kilogram
L	liter
M	molar
Mgal	million gallon
MT	metric ton
MTG	metric ton of glass
wt%	weight percent

1.0 INTRODUCTION

Material flow from tank storage through retrieval, feed staging, and treatment is modeled by the Hanford Tank Waste Operations Simulator (HTWOS) to support the River Protection Project (RPP) System Planning process. However, due to complexity of the HTWOS, simplified spreadsheet-based material balance models are used to perform preliminary alternative evaluations to reduce the number of alternatives evaluated using the HTWOS model. This study uses a simplified spreadsheet approach to evaluate waste blending and related topics to help identify potentially attractive alternatives to be further evaluated with the more detailed HTWOS model.

1.1 OBJECTIVE

The primary objective of this study is to perform preliminary evaluations of potentially attractive alternatives for blending/optimizing feed for the high-level waste (HLW) process as a method of reducing the total quantity of HLW glass produced by the tank waste mission. Reducing quantity of HLW glass produced has the potential to shorten the mission operating schedule and reduce life-cycle costs for process operation and for storage, transportation, and disposal of the immobilized HLW (IHLW).

1.2 SCOPE

The scope of work addressed by this document includes:

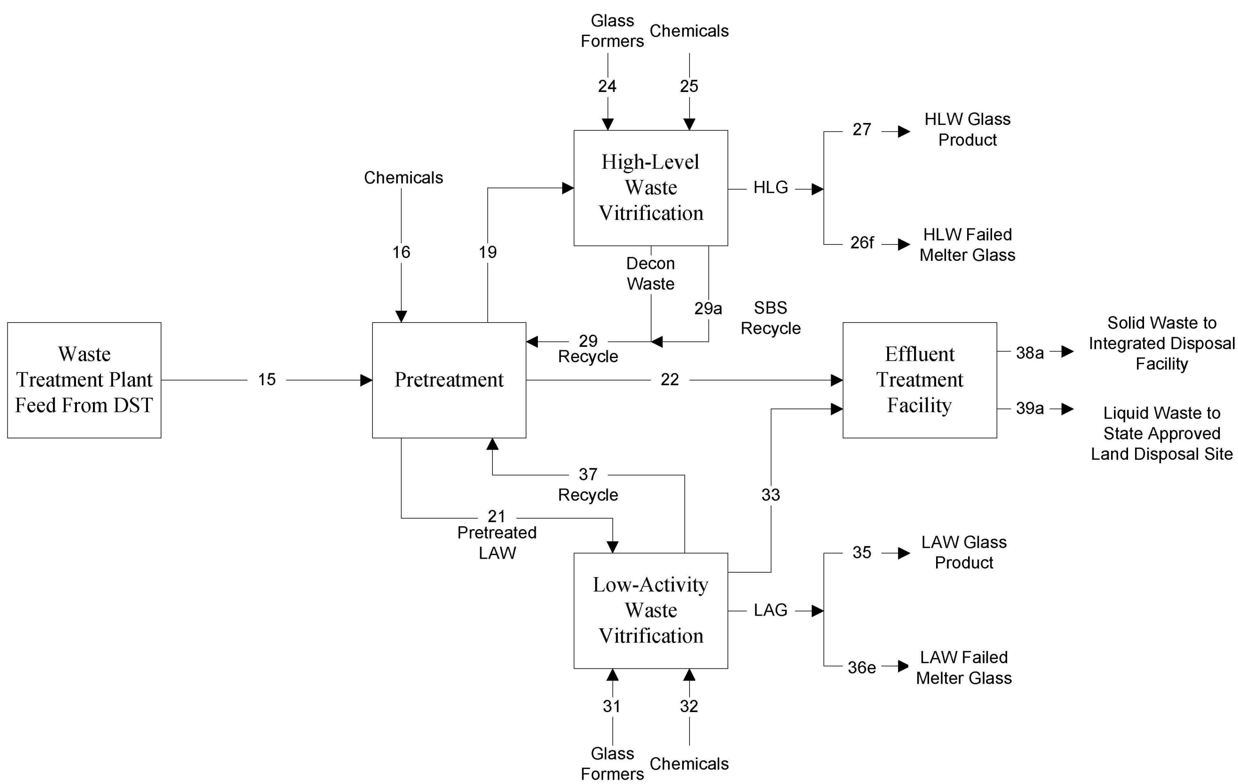
- Development of calculation tools (spreadsheet workbooks).
- Evaluation of the effect of solids washing and melter sulfate retention on glass quantity.
- Definition of a base case for blending comparisons, including: a set of 116 macro batches of waste feed to WTP based on the System Plan Unconstrained Case feed vector, and selected WTP process performance factors.
- Calculation of HLW glass quantities for the base case, several partial blending cases, and a total blend case.

Results are summarized in Section 4.0 and discussed in more detail in Section 7.0. The results described in this document (in particular, specific glass quantity estimates) should not be confused with formal predictions of the RPP material flows. Simplifications necessary to perform the spreadsheet-based calculations neglect factors that can have a significant impact on blending feasibility (e.g., logistic interferences) and must be addressed by HTWOS modeling efforts. Therefore, while glass quantity estimates were required to perform the blending study described in this report, the relative change in glass quantity as a result of blending alternatives should be considered more important than the absolute glass quantities predicted. These relative changes in glass quantity are used as a basis for recommending blending alternatives that could be considered in future HTWOS predictions to construct material balance estimates resulting in reduced quantities of HLW glass from the tank waste processing mission.

1.3 BACKGROUND

Revision 4 of ORP-11242, *River Protection Project System Plan* (hereafter System Plan), is used to provide a basis for alignment of program costs, scope, and schedules, from upper-tier contracts to individual facility operation plans. The System Plan also serves to define issues that must be resolved to ensure success of the cleanup mission. The predicted flow of materials through the tank waste retrieval, storage, and processing systems as a function of time is important to integrating the RPP facilities (see Figure 1-1). The material flows identify the required capacity and operating duration for individual facilities as the cleanup mission is completed, which influences program costs and schedule estimates.

Figure 1-1. System Plan Waste Process Flows for the Unconstrained Case.



HTWOS is a complex program that models process steps and transfers between tanks and facilities over the mission life. This results in tracking thousands of waste transfers predicted during operating time periods of 20 to 40 years as waste moves through storage, retrieval, feed staging and multiple treatment processes. HTWOS predicts the outcomes of various proposed operating scenarios. Overall, the HTWOS model incorporates 670 waste treatment vessels and operations, and unenumerated transfer and routing system segments.

Alternatives can be evaluated using the HTWOS model. However, due to complexity of the HTWOS, significant time periods can be required to incorporate code changes representing new alternatives. Therefore, simplified spreadsheet-based material balance models are used for performing preliminary alternative evaluations in order to reduce turn-around time.

1.4 BLENDING STUDIES

Because of substantial tank-by-tank variations in Hanford tank waste sludge compositions, separately processing waste from individual tanks is expected to result in significantly lower average glass waste loadings than could be achieved by blending wastes to provide a more uniform composition. Previous blending studies (e.g., RPP-RPT-26040, *Pairwise Blending of High-Level Waste*) have evaluated potential reductions of HLW glass quantity by sludge blending with the following primary conclusions:

- Processing tank by tank produces the largest amount of HLW.
- Blending all tanks ("Total Blend") and then processing produces the least amount of HLW.
- Pairwise blending of specific selected tanks results in substantial reductions in HLW.
- Incidental blending, where some blending occurs naturally during retrieval and inter-tank transfers prior to transfer to WTP, provides significant improvement over segregation of waste from each tank.
- Unconstrained intentional pairwise blending of problem wastes may yield close to the least amount of HLW.

Other factors inferred from prior work include:

- Blending will likely get easier later in the program as tank space is freed up.
- Known issues with intentional blending include limited tank space, tank farm retrieval logistics, and the impact of WTP feed tank waste sampling hold time and batch transfer philosophy on blending.

2.0 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions and recommendations are derived from the blending evaluations performed in this study.

Conclusion 1: Development of a base glass quantity for blending comparisons included investigation of the effect of waste solid washing efficiency and melter sulfate retention on HLW glass quantity. Based on the simplified estimates, wash efficiencies and melter sulfate retention factors approximating the latest WTP flowsheet values resulted in an estimated HLW glass quantity approximately 10% less than predicted by HTWOS for the System Plan Unconstrained Case.

Recommendation 1: While not specifically associated with blending, it is recommended that the HTWOS incorporate a more detailed model of separating soluble from insoluble waste components in the Pretreatment Facility and update the path of sulfur in melters.

Conclusion 2: Identifying specific blends of waste batches that are within a moving 1½- to 2-year time window from the System Plan Unconstrained Case waste transfer sequence is estimated to reduce total HLW glass quantities by approximately 20% relative to the base glass quantity used for comparison in this study. This is in addition to the reductions associated with wash efficiency and sulfate retention factor updates incorporated by the simplified model.

Recommendation 2: Estimates based on specific blends from the Unconstrained Case waste batch sequence indicate the potential HLW glass quantity reductions associated with a modest blending scheme that could be implemented during actual operations. This approach is dependent on the waste retrieval sequence implemented, which varies the waste batches available for blending within a time window.

It is expected that incorporation of the time window blending approach may be difficult to automate in HTWOS. Separate side calculations could be used as inputs to define specific tank blends for a particular waste transfer sequence once it is established (similar to the calculations performed in this study). Therefore, while testing within the HTWOS modeling calculations could be considered, it is recommended that implementation of an automatic routine to select tank farm blending scenarios within the HTWOS model be deferred until the retrieval sequence is projected to remain relatively constant.

Conclusion 3: The preliminary evaluation indicates that blending in the double-shell feed tanks used for transfers to WTP can yield significant HLW glass reductions. This approach could be described as intentionally increasing the effect of incidental blending. The simplified estimates indicate that HLW glass quantity is reduced by approximately 10% relative to the base glass quantity by using a transfer scheme where the tank farm tank used for waste transfers is refilled each time one half of its contents have been transferred to WTP.

Recommendation 3: Estimates in this study indicate that a waste transfer sequence that enhances incidental blending within tank farms can result in a significant reduction in HLW glass quantities. This approach is projected to be somewhat independent of the ultimate waste retrieval sequence and appears amenable to automation in HTWOS. However, the simplified analysis does not address potential logistic issues that may arise by implementing the blending scheme. It is recommended that approach of enhancing incidental blending during waste transfers through the double-shell tanks (DST) be tested using HTWOS to determine if logistics are feasible and confirm the blending benefits predicted by the simplified calculations.

While not fully evaluated, initial blending results suggest that a combination of tank farm blending, blending in the WTP feed transfer tanks, and optimization of the retrieval/staging/transfer sequence can yield total HLW glass quantities that approach the total blend case without need for major changes to the overall retrieval strategy and sequence.

3.0 APPROACH

The following summarizes conceptual methods used for this study.

- Existing HLW glass formulation calculator models were used (development of new glass models/calculators is not included in the study scope). Simplified spreadsheet models have been developed to estimate HLW melter feed compositions from feed vector or other waste composition data. Output from these models is used as input to the existing HLW glass formulation calculator models.

- System Plan feed and glass batch data were reviewed to identify potential opportunities for blending. Limiting components for specific batches were identified and potential opportunities for mitigating problem components explored. For example, certain feed batches have problem components that significantly restrict waste loading, while batches that are currently planned for processing in roughly the same time frame have reduced quantities of these problem components. These may represent productive blending opportunities that can be accomplished with modest changes to waste retrieval and WTP feed staging plans.

- System Plan results show relatively low waste loadings for a number of batches based on sodium and sulfate content. WTP process performance assumptions were examined to evaluate the potential to mitigate glass waste loading constraints by improved washing of the sludge to remove sodium, sulfate, and other soluble components. The effect of melter sulfate retention on HLW glass quantity was also examined.

- Where waste batch blending is identified as an attractive method of reducing glass quantities, the waste batches were traced to their original source tank.

The potential impact of alternative transfer rules within the DST system were investigated using the HLW glass formulation calculator combined with estimates of waste batch composition changes projected by the transfer rule changes. Where feasible, transfer rules are developed as part of the study.

The following limitations apply to this study:

- This study is based on existing WTP feed vector information on projected waste batch inventories, wash factors, and leach factors.

- The study is based on use of existing HLW glass formulation/calculation models. Glass quantity calculations presented herein use the limits as stated; that is, no allowances are added for measurement uncertainty, uncertainty in the glass models, or other operational inefficiencies.

- Technical work for the current study was developed based on the draft Revision 4 of the System Plan issued in April 2009. The Baseline Case that appears in the final issued version of the System Plan, Revision 4 was added later and, therefore, was not directly considered in the blending cases reported herein. It is expected that the conclusions and recommendations remain generally valid for the Baseline Case, although exact numerical values are likely to be slightly different for the Baseline Case.

4.0 RESULTS

This section provides a summary of results, while Section 7.0 provides an expanded description of the analysis for each alternative.

4.1 CALCULATION TOOLS AND MACRO BATCH DEFINITION

Spreadsheet workbooks listed in Table 4-1 were used for calculations supporting the blending study. Workbooks shown with SVF numbers SVF-MARxx were developed specifically to support this study and other mission analysis work and were assigned interim tracking numbers pending assignment of WRPS SVF numbers. SVF 1427 and 1623 were previously developed by Washington River Protection Solutions (WRPS) and were used to perform HLW glass formulation calculations for the blending study. Additional information on the simplified spreadsheet modeling approach is provided in RPP-RPT-42577, *River Protection Project Mission Analysis Material Balance Description.*

The calculation sequence generally starts with a "feed vector," which defines the overall sequence, scheduled transfer dates, and composition of waste feed batches planned to be transferred from tank farms to the WTP for a given scenario. The feed vector defines solid phase composition, liquid phase composition, mass, volume, and wash factors/leach factors for specific components. Results presented in this report are based on the System Plan Unconstrained Case feed vector, HTWOS output file "batches-to-wtp-fully-water-washed, case SP4 UC, run date 3/31/2009." This case defines 450 waste feed batches to be transferred.

SVF-1768 - Feed Vector to Macro Batch Calculator is used to combine feed vector batches into processing batches for current studies. For the base case, the 450 feed vector batches are combined to produce 116 macro batches as discussed in Section 6.1. The output of this spreadsheet provides input data for SVF-1767 Mission Analysis Process Stream Calculator. For each macro batch SVF-1767 calculates several WTP process streams based on a simplified steady state mass balance model, and input performance factors related to WTP process performance assumptions. Net waste feed oxides incorporated into the HLW glass are calculated and the results are arranged in an array that is directly compatible with the input data format required for the existing HLW glass calculator programs (SVF-1427 and SVF-1623). For each macro batch, the Process Stream Calculator also calculates the low-activity waste (LAW) glass mass, waste loading, and liquid process waste compositions for the LAW process.

Workbook SVF-1824 was developed to support the feed transfer tank blending evaluation. This workbook takes the macro batch output from SVF-1768 and calculated a set of blended macro batches based on a feed tank blending scenario. Output of SVF-1824 is pasted into SVF-1767 Mission Analysis Process Stream Calculator for calculation of WTP process streams.

Data on net melter feed oxides to HLW glass are provided as input to the HLW glass calculator spreadsheets (SVF-1427 and SVF-1623). These perform optimization routines intended to minimize HLW glass quantity for each macro batch. SVF-1623 is a modified version of SVF-1427. Calculations were performed for approximately 1000 macro batches using both models and the results cross checked. In all cases the resulting glass quantities were either equal or smaller using SVF-1623, while all glass constraints were met. The conclusion from this comparison is that SVF-1623 is more effective in optimizing the HLW glass formulation. SVF-1427 also frequently fails to converge and must be run multiple times to get convergence, while SVF-1623 rarely fails to converge. Therefore, all HLW glass results included in this report were generated using SVF-1623.

Results for each group of macro batches from the glass calculator spreadsheet are compiled in SVF-1817 Mission Analysis Glass Batch Results Summary. This spreadsheet also performs analyses of the glass data and formats key results into a one-page summary. The one-page summaries for glass runs used for this report are provided in Appendix A. Appendix B provides a summary of feed vector batches and primary source tanks that are included in each macro batch for the various blending cases.

Table 4-1. Spreadsheets Used for Blending Study.

SVF Number	Workbook Title	Summary Description
SVF-1756 Previously SVF-MAR02	SVF-1756 Performance Factor Calculation - Planning Case	This workbook calculates selected process performance factors based on the System Plan planning case summary mass balance in SVF-1663 Rev. 1.
SVF-1768 Previously SVF-MAR03	YYMMDD-0 SVF-1768 - Macro Batch Calculator - UC -	This workbook combines feed vector batches for the Unconstrained Case into macro batches. The number of macro batches and the feed vector batches included in each macro batch varies with the specific study or case under consideration.
SVF-1767 Previously SVF-MAR04	YYMMDD-N-SVF-1767 Mission Analysis Process Stream Calculator	Workbook calculates selected WTP process streams for each macro batch. WTP performance factors and SBS recycle configuration may be varied to evaluate effect on output process stream characteristics. Process streams calculated include HLW melter feed net of offgas losses, LAW glass, SBS recycle stream, and liquid process effluent streams.
SVF-1817 Previously SVF-MAR05	YYMMDD-N-SVF-1817 Mission Analysis Glass Batch Results Summary	This workbook compiles results of HLW glass calculator runs and performs data analysis calculations using glass calculator results.
SVF-1824 previously SVF-MAR15	YYMMDD-N-SVF-1824 Mission Analysis Feed Tank Blending Blended-Batch Calculator	This workbook calculates blended macro batches assuming a feed tank blending scenario.
SVF-1427 Rev 0	SP3_HLW_Glass_Limit_Sensitivity.xls	Calculates optimized HLW glass composition for each macro batch based on melter feed waste oxide composition and defined glass composition limits.
SVF-1623 Rev 0	HLW_Glass_Formulation_Verify_v_0.xlsm	Calculates optimized HLW glass composition for each macro batch based on melter feed waste oxide composition and defined glass composition limits.

HLW = high-level waste.
LAW = low-activity waste.
SBS = submerged bed scrubber.
WTP = Waste Treatment and Immobilization Plant.

4.2 DEVELOPMENT OF A BASE CASE FOR BLENDING COMPARISONS

Prior to development of blending comparisons, key WTP processing parameters were examined to assess their impact on HLW glass quantities. HLW glass quantities were found to be fairly sensitive to pretreatment solids washing efficiency and HLW melter sulfate retention assumptions. These were examined in more detail and compared with HTWOS results and current WTP flowsheet bases. Based on the result of this evaluation a base case for comparisons is established with the following key characteristics:

- 116 macro batches of waste transferred to WTP, based on consolidation from 450 feed vector batches for the System Plan Unconstrained Case. Most of the difference between the 116 macro batches and the feed vector is a result of the 160,000-gallon limit on volume of HLW batches transferred. This limitation results in about six feed vector batches required to transfer a single tank/batch of HLW. The groups of feed vector batches with the same composition are combined for the 116 macro batch base case substantially reduce the number of batches compared to the feed vector. The set of 116 macro batches was designed to avoid meaningful waste blending. Appendix B identifies specific feed vector batches and primary waste source tanks for each of the 116 macro batches.

- Overall purge efficiency for soluble components averages about 99% for the base case.
- 67% sulfate retention for the HLW melter.

A second case was defined that attempts to take credit only for incidental blending of HLW and LAW waste that occurs in WTP due to parallel processing of the high solids HLW and low solids LAW batches. This case resulted in 56 macro batches. Appendix B identifies specific feed vector batches and primary waste source tanks for each of the 56 macro batches. Development of the base case is summarized in the following sections, and is discussed in more detail in Section 7.1.

4.2.1 Evaluation of Solids Washing Efficiency

Initial steps in the WTP process include caustic leaching to dissolve selected components and ultrafiltration that splits the waste into two streams: (1) a solids free feed stream for ion exchange and (2) a concentrated solids slurry stream. The solids slurry is washed by repeated dilution with water and reconcentration by purging liquid via the ultra filters. For some batches oxidative leaching to remove chromium is also performed and the slurry is washed again and reconcentrated by purging liquid though the ultra filters. The concentrated washed slurry and concentrated neutralized eluate from ion exchange are combined and transferred from pretreatment to HLW vitrification.

SVF-1767 Mission Analysis Process Stream Calculator models removal of soluble sulfur, aluminum, phosphorus, and chromium as two steps: (1) initial purge of liquid to concentrate the slurry to 20 wt% solids concentration, and (2) water washing and reconcentration of the leached solids. Overall purge efficiency for soluble components (combine initial solids concentration and washing) typically averages about 99% with 95% solids washing efficiency. Because of the sodium added during leaching, sodium washing is modeled simply as a parameter ($P_{Na(aq),19b,15LSol}$) that is proportional to soluble sodium concentration in the final washed leached solids slurry. The base case value of $P_{Na(aq),19b,15LSol}$ is 0.023, which is equivalent to a dissolved sodium concentration of 0.25 mole/L in the final washed solids slurry with 20 wt% leached solids (see also Section 7.1.1).

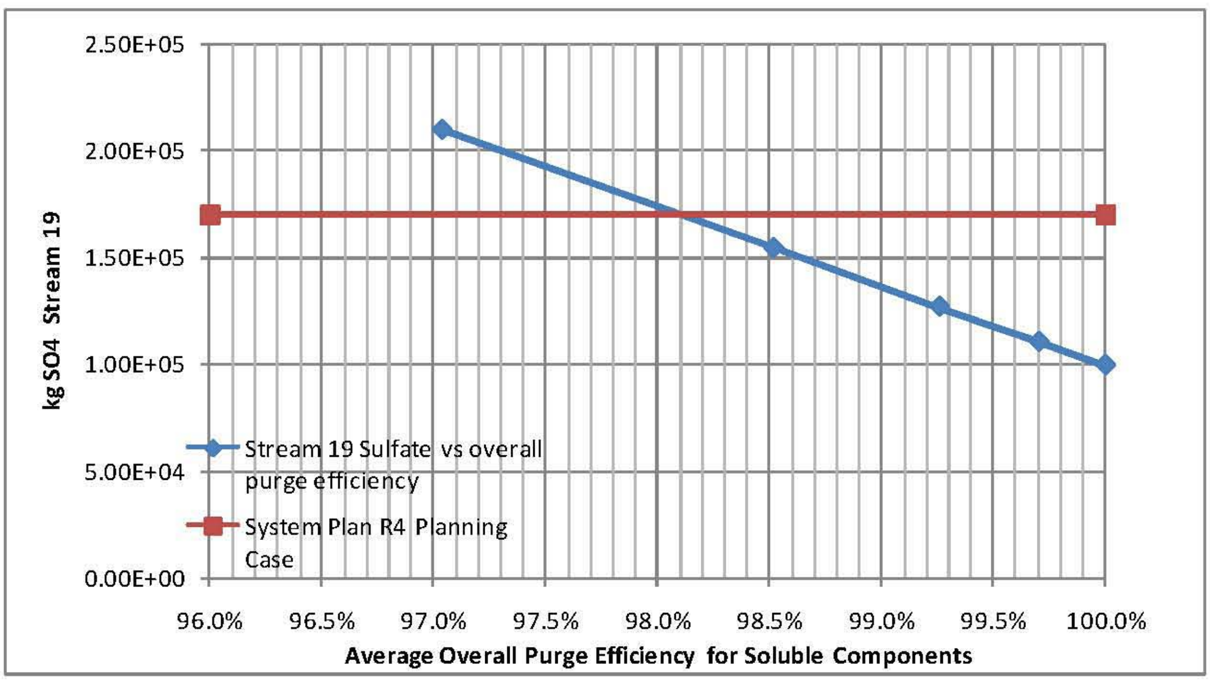
4.2.1.1 Comparison of Calculated High-Level Waste Feed with Hanford Tank Waste Operations Simulator Results. Calculated HLW feed components (Stream 19, Figure 1-1) and comparable HTWOS values for the System Plan Planning Case (SVF-1663 Rev. 1) are listed in Table 4-2. Figure 4-1 shows the results for sulfate graphically. Graphs for other components are included in Section 7.1.1.2. Conclusion from this comparison is that the overall purge efficiency for soluble components is about 98% for the System Plan Initial Planning Case.

Table 4-2. Results of Solids Washing Calculations.

	SVF-MAR04 Calculations for HLW Feed (Stream 19)					SVF1663
Wash Efficiency	100.00%	98.00%	95.00%	90.00%	80.00%	Not given
Total Purge Efficiency	100.0%	99.7%	99.3%	98.5%	97.0%	Not given
Sulfur as SO_4, kg	9.92E+04	1.10E+05	1.27E+05	1.54E+05	2.09E+05	1.70E+05
Total Al, kg	1.90E+06	1.92E+06	1.95E+06	1.99E+06	2.09E+06	1.98E+06
Al(aq), kg	0.00E+00	1.92E+04	4.81E+04	9.61E+04	1.92E+05	1.50E+05
Phosphorus as PO_4, kg	3.80E+05	3.93E+05	4.13E+05	4.46E+05	5.12E+05	4.72E+05
Na, kg	1.64E+06	1.83E+06	2.11E+06	2.56E+06	3.44E+06	3.24E+06
$P_{Na(aq),19b,15LSol}$	0	0.0092	0.023	0.045	0.088	Not given
Na (final) Mole/L	0	0.05	0.25	0.50	1.0	Not given

Al = aluminum.
HLW = high-level waste.
Na = sodium.

Figure 4-1. Sulfate in Stream 19 Versus Overall Washing Efficiency.



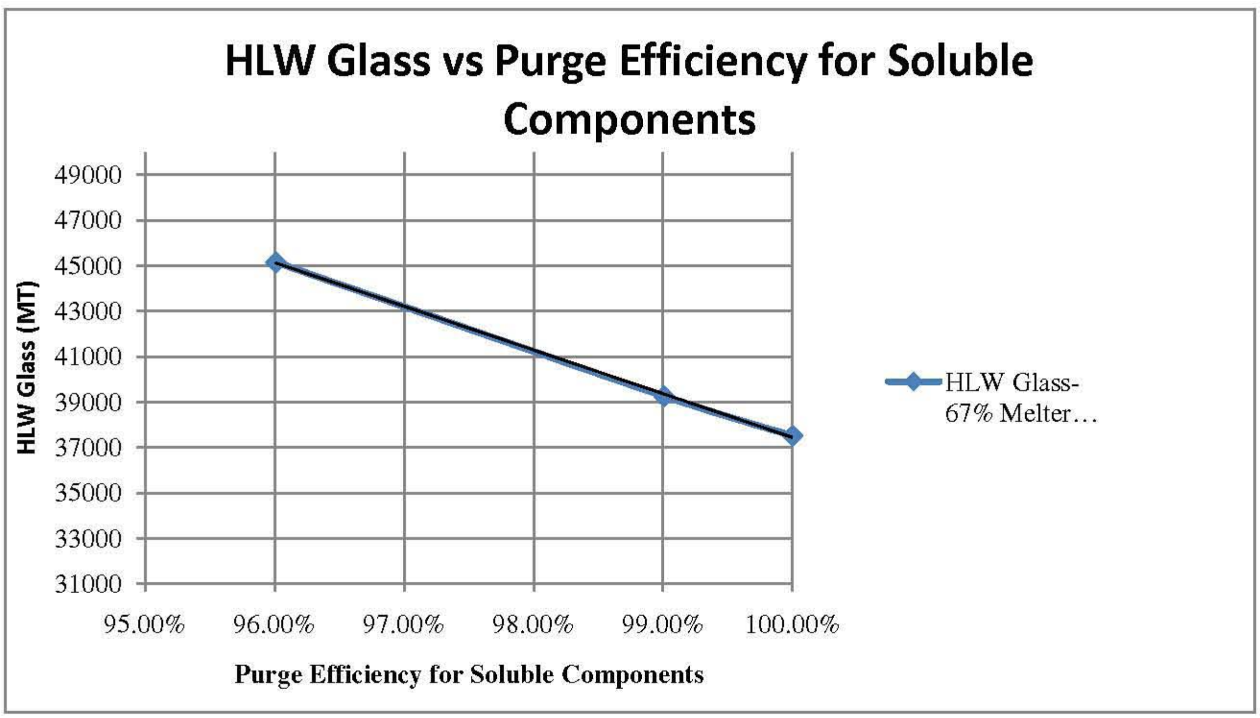
4.2.1.2 Effect of Wash Efficiency on High-Level Waste Glass Quantity. Glass quantity was calculated for each of the 116 base case macro batches as a function of purge efficiency for soluble components. Results for total glass quantity are shown in Table 4-3 and Figure 4-2. Increasing overall purge efficiency from 96 to 99% reduces estimated HLW glass by about 13% while increasing from 99 to 100% reduces HLW glass by an additional 4.5%. Results for each of the 116 macro batches show that some batches are strongly influenced by purge efficiency; while for other there is little or no effect on glass quantity as washing efficiency is increased (see Section 7.1.1.2). This suggests that optimization of plant operations could involve batch by batch adjustment of purge efficiency.

Table 4-3. Effect of Solids Washing on Total High-Level Waste Glass Quantity.

	116 Macro Batch-(No Blending)			
Average Overall Purge Efficiency for Solubles	100%	**99%**	98%	96%
Glass quantity (MT)*	37,500	**39,200**	41,100	45,100

*Based on melter sulfate retention of 67%.
MT = metric tons.

Figure 4-2. Effect of Soluble Component Purge Efficiency on High-Level Waste Glass Quantity.



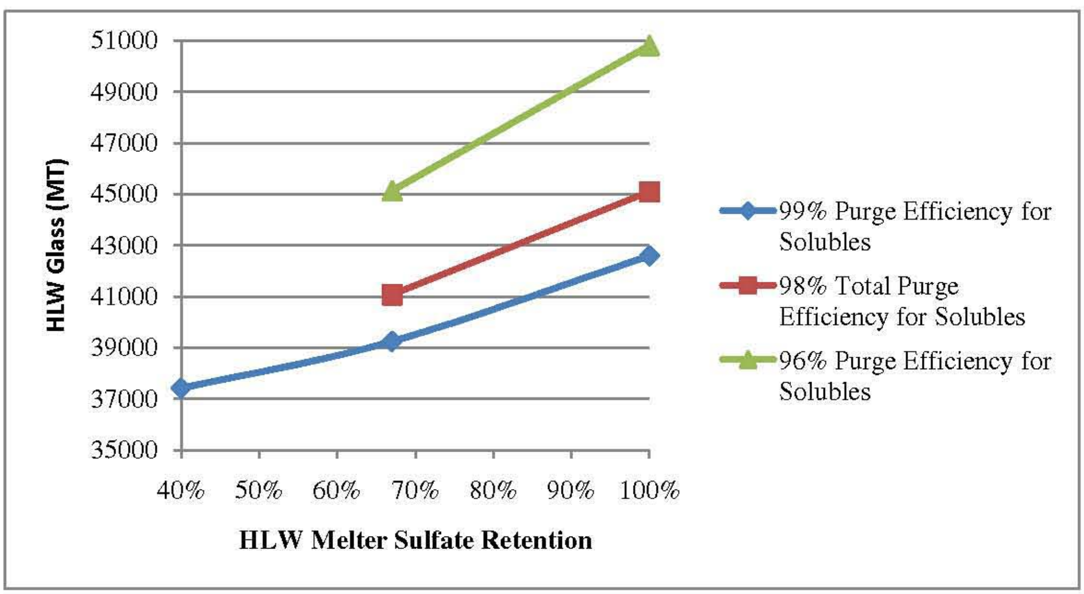
4.2.2 Melter Sulfate Retention

During heating and melting of melter feed, a portion of the sulfate is driven off as semi-volatile and gaseous sulfur compounds and reports to the melter offgas. Most of the sulfur compounds are removed from the offgas and report to the submerged bed scrubber condensate stream. Because sulfate content of HLW glass may limit waste loading, fractional sulfate retention in the glass is an important parameter for estimating required HLW glass quantity. Table 4-4 and Figure 4-3 summarize the results of calculated HLW glass quantity versus melter sulfate retention for the 116 macro batch base case. The case with 98% average overall purge efficiency for soluble components and 100% HLW melter sulfate retention corresponds approximately to the System Plan Unconstrained Case HTWOS calculation. The most recent WTP flowsheet (24590-WTP-RPT-PT-02-005, *Flowsheet bases, Assumptions and Requirements*) indicates an expected average melter sulfate retention of 67%, which is used for the base case calculations herein.

Table 4-4. Effect of Melter Sulfate Retention on High-Level Waste Glass Quantity.

	116 Macro Batch No Blending						
Average Overall Purge Efficiency	96%	96%	98%	98%	99%	**99%**	99%
Melter Sulfate Retention	100%	67%	100%	67%	100%	**67%**	40%
Glass Quantity (Metric Tons)	50,800	45,100	45,100	41,100	42,600	**39,200**	37,400

Figure 4-3. Effect of Melter Sulfate Retention and Purge Efficiency on High-Level Waste Glass.



4.3 INITIAL BLENDING RESULTS

Two conceptual blending approaches were evaluated: (1) blending in the tank farms during preparation of waste batches for transfer to WTP; and (2) blending in the tank used to transfer waste to WTP. Results are summarized in Sections 4.3.1 and 4.3.2, respectively. Sections 7.2 and 7.3 provide additional details.

4.3.1 Tank Farm Batch Blending

Results of tank farm blending evaluations are summarized in Table 4-5 and Figure 4-4. Blending evaluations were performed for four cases in addition to the 116 macro batch case:

- **Single Macro Batch-Total Blend:** All 450 feed vector batches were combined into a single total blend. With base case process performance factors, the estimated HLW glass quantity is reduce to about 29,000 MT, a 26% reduction compared to the 116 macro batch base case.

- **56 Macro Batch with WTP Incidental Blending:** The case combines HLW and LAW batches planned for roughly the same time frame to approximately simulate incidental blending that results from parallel processing of HLW and LAW batches in WTP. This change results in about 7% reduction in estimated HLW glass compared to the 116 macro batch no blending case.

- **23 Macro Match Blend:** Limiting components for the 116 macro batch case were reviewed and potentially attractive tank farm blending groups were selected based on planned batch delivery dates listed in the Unconstrained Case feed vector. For each blending group, the time between the earliest and latest planned delivery date was limited to approximately two years. No blending was performed on the first four batches or first two years of operations based on the assumption that blending will be accomplished, in part, during refilling of tanks that are initially emptied. This blending case resulted in an approximate 20% HLW glass reduction compared to the 116 macro batch base case and about 7% more glass than the single macro batch total blend.

- **21 Macro Batch Blend:** Similar to the 23 macro batch case except the waste delivery window for blend groups was reduced to about 18 months. Estimated HLW glass quantity is essentially the same as the 23 macro batch case.

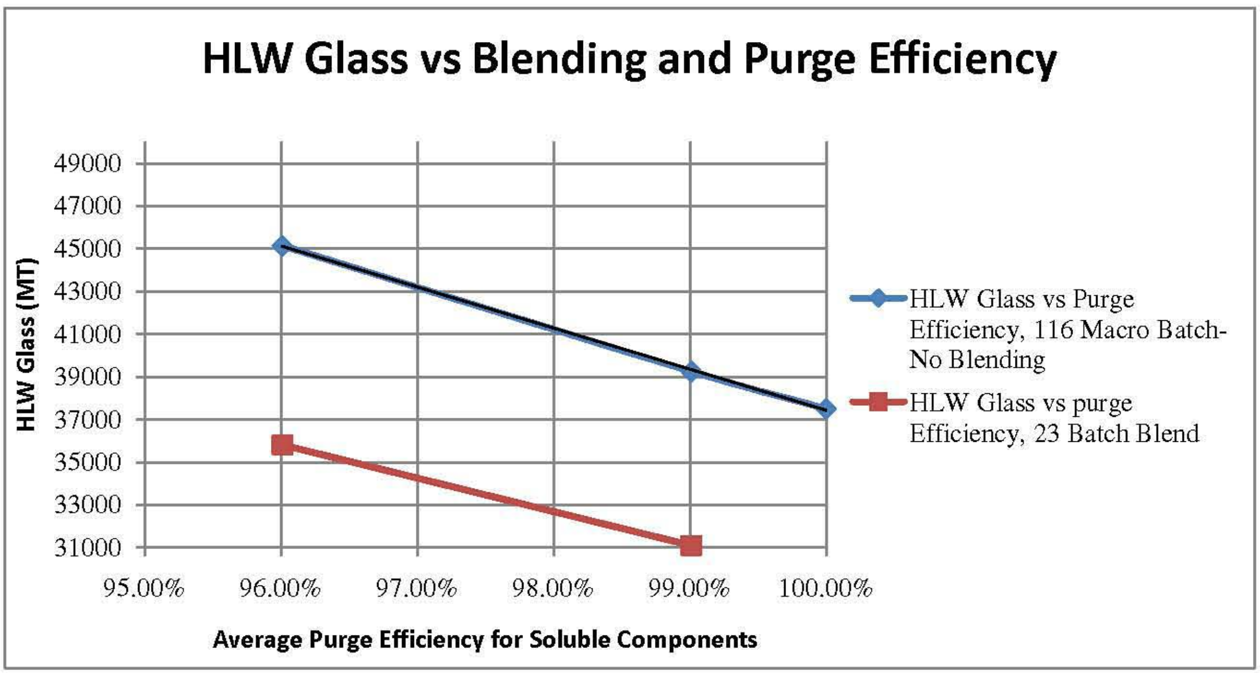
The 23 and 21 macro batch cases results are for an initial first-cut analysis. Some additional improvement may be possible by carefully examining the results for each of the blended batches, testing potential alternative combinations, and making adjustments to better optimize blending results. Also note that because of the way the waste batches are grouped, most of the benefit of WTP incidental blending discussed for the 56 macro batch case is also captured by the 23 and 21 macro batch cases.

Table 4-5. Summary of Initial Tank Farm Blending Results.

	116 Macro Batch-No Blending			**56 Macro Batch-WTP Incidental Blending**	**23 Macro Batch Blend**		**21 Macro Batch Blend**	**Single Macro Batch (Total Blend)**
Average Overall Purge Efficiency	100%	**99%**	96%	99%	99%	96%	99%	99.3%
HLW Glass (MT)*	37,500	**39,200**	45,100	36,400	31,100	35,800	30,900	29,000

*Based on 67% melter sulfate retention.
HLW = high-level waste.
MT = metric tons.

Figure 4-4. Effect of Blending and Purge Efficiency on High-Level Waste Glass Quantity.



4.3.2 Blending of Partial Batches in Waste Feed Transfer Tanks

To assess the impact of blending in the WTP feed transfer tanks a simplified blending model was developed based on assuming that tank farm tanks used for transfers to WTP ("feed tanks") are only half emptied before being refilled. Therefore, the incoming waste batch is always blended with half of the prior batch.

The 56 macro batch set was used as the set of source tanks. The batches were blended using a simple feed tank blending scenario to yield 112 blended macro batches (see Section 7.3). The feed vector processing sequence was used without attempting to further improve or optimize the processing sequence. Results are shown in Table 4-6 and compared with the 56 macro batch base case, the 116 macro batch base case, the 23 macro batch tank farm blending case discussed in Section 4.3.1, and a total blend of all tank waste. The WTP feed transfer tank blending case shows approximately 11% glass reduction compared to the 56 batch case, or 17% reduction compared to the no blend 116 macro batch case. The feed tank blend case is about 4% higher than the 23 macro batch tank farm blending case and almost 12% higher than the total blend. Feed tank blending performance could be further improved by using slightly more complex concepts such as using two source tanks in parallel or in series, by optimization of the waste feed sequence, and/or by combining feed tank blending with tank farm blending.

Table 4-6. Feed Tank Blending Results.

Macro Batch Case	56 Macro Batch	112 Macro Batch Blend	**116 Macro Batch**	23 Macro Batch Blend	Single Macro Batch
Blending scenario	WTP Incidental Blending (Combine HLW and LAW)	WTP Feed Transfer Tank, ½ Batch Blending	**No Blending**	Tank Farm Blending	Total Blend of All Wastes
HLW Melter Sulfate Retention	67%	67%	**67%**	67%	67%
Average Purge Efficiency for Soluble Components	99%	99%	**99%**	99%	99%
HLW Glass Quantity (MT)	36,400	32,400	**39,200**	31,100	29,000
LAW Glass Quantity (MT)	543,000	532,000	**561,000**	529,000	517,000

HLW = high-level waste.
LAW = low-activity waste.
MT = metric tons.
WTP = Waste Treatment and Immobilization Plant.

4.3.3 Low-Activity Waste Glass Impacts from Blending

Primary focus of the current study is HLW glass. However, process modeling calculations also provided information on the effect of blending on LAW glass. These results are provided for information in Table 4-6. The results show that a small but meaningful reduction in LAW glass is expected from blending.

5.0 FUNCTIONS REQUIREMENTS AND OBJECTIVES

Figure 5-1 is a simplified process flow diagram for the RPP system based on the System Plan Initial Planning and Unconstrained Cases. The Baseline Case is similar, except that an Aluminum Removal Facility is added to process waste upstream of the WTP. The RPP system is comprised of four major subsystems (storage, treatment, offsite disposal, and onsite disposal). The following provides a brief description of the facilities (planned or operational) within each subsystem for the Initial Planning and Unconstrained cases, which is summarized from the System Plan.

5.1 FUNCTIONS

For purposes of the current study, primary functions of the RPP system include waste storage, treatment, offsite disposal, and onsite disposal. The following provides a brief description of the functions and related facilities (planned or operational) that perform each function, summarized from the System Plan.

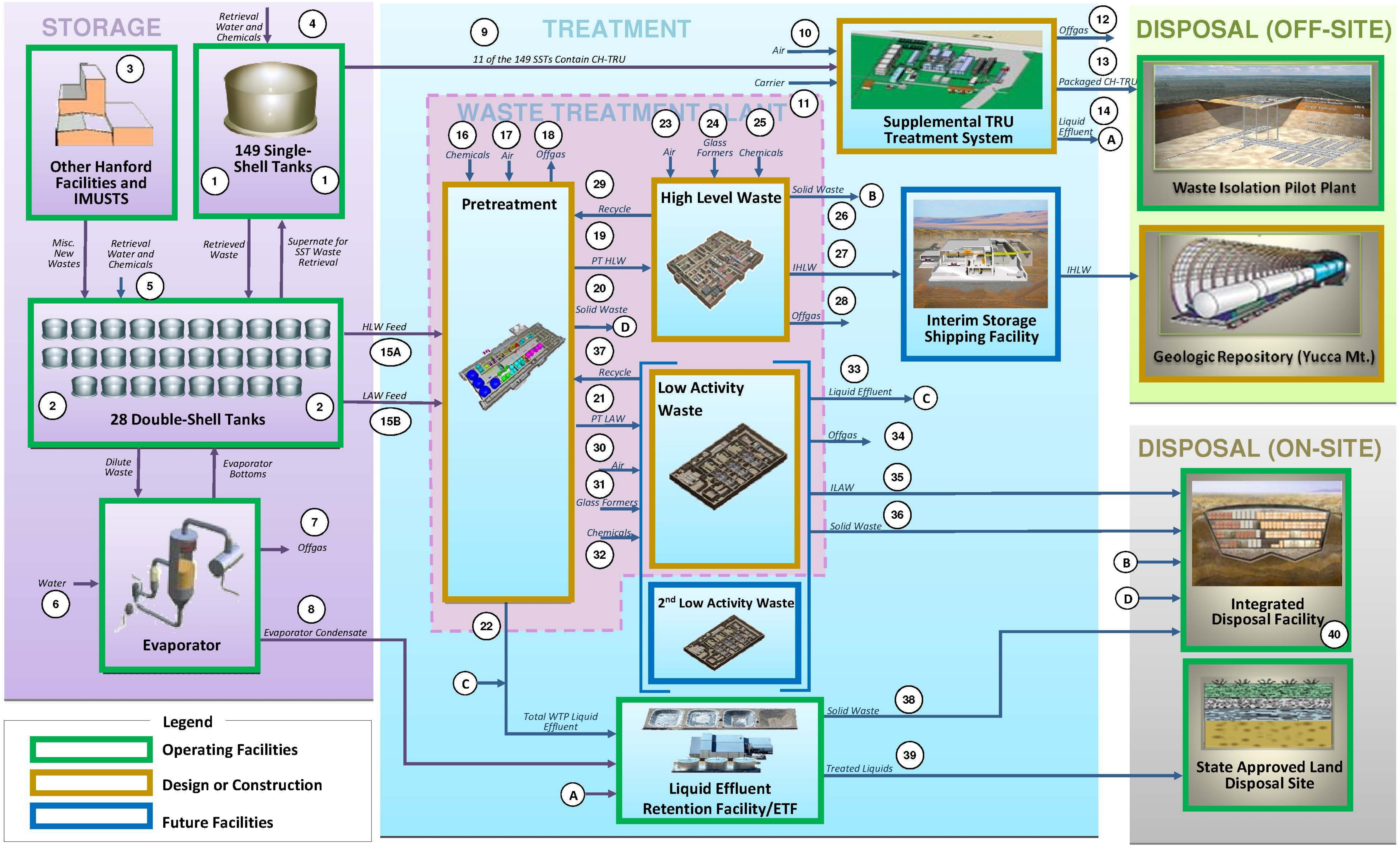
5.1.1 Storage

Storage encompasses numerous facilities used for tank waste management until the waste is delivered to treatment. These facilities include 149 single-shell tanks (SST), 28 DSTs, 71 inactive miscellaneous underground storage tanks, and 242-A Evaporator. In general, waste is retrieved from SSTs and accumulated in DSTs. DST supernates are periodically processed through the 242-A Evaporator to reduce the waste volume held in DST inventory.

The entire DST storage capacity cannot be allotted to waste storage from SST retrievals. The combined DST storage capacity is 32.3 Mgal, of which approximately 27 Mgal is consumed by existing DST inventory. Furthermore, some DST capacity must be reserved to address operating constraints.

Inherent within the storage function is the incidental and intentional blending that occurs as waste is moved from tank to tank as it is staged for delivery to WTP for treatment.

Figure 5-1. River Protection Project System Unconstrained Case Simplified Process Flow Diagram.



Source: ORP-11242, 2009, *River Protection Project System Plan,* Rev. 4, Office of River Protection, U.S. Department of Energy, Richland, Washington.

5.1.2 Treatment

Treatment encompasses the WTP, Second LAW Facility, Supplemental Transuranic (TRU) Treatment System, Hanford Shipping Facility, and Liquid Effluent Retention Facility/Effluent Treatment Facility. For the Baseline Case, treatment also includes the Aluminum Removal Facility. Only the Liquid Effluent Retention Facility and Effluent Treatment Facility are existing facilities. The others are either in the planning or construction phase of implementation.

The Pretreatment Facility will receive DST waste and process it into HLW and LAW fractions. This facility also receives a recycle stream from each vitrification facility. The Pretreatment Facility process includes concentration, caustic and oxidative leaching, ultrafiltration, and cesium ion exchange. The resulting HLW and LAW are subsequently transferred to their respective vitrification facility. Liquid effluents from the Pretreatment Facility are transferred to the Liquid Effluent Retention Facility/Effluent Treatment Facility for processing.

The HLW Vitrification Facility will immobilize HLW in glass, which is poured into stainless steel canisters. On average each IHLW canister will hold 3.04 MTG. The IHLW canisters will be transferred to the Hanford Shipping Facility for interim storage until their transport to the National Geologic Repository for disposal.

The LAW Vitrification Facility will immobilize LAW in glass, which is poured into stainless steel packages. On average each immobilized LAW (ILAW) package will hold 5.92 MTG. The ILAW packages will be transferred to the onsite Integrated Disposal Facility for disposal. Hot commissioning of HLW and LAW vitrification facilities is scheduled to start in May 2018. The Second LAW Facility is envisioned to use a process flowsheet similar to the WTP LAW Vitrification. However, required throughput capacity will vary depending on assumptions embodied in its processing mission. Some supplemental pretreatment capacity may also be needed to support the Second LAW Facility.

Eleven SSTs are projected to contain contact-handled TRU (CH-TRU) waste. This waste is planned to be processed with a supplemental treatment system and packaged in 55-gallon drums for offsite disposal at the Waste Isolation Pilot Plant.

5.1.3 Disposal

The disposal function includes interim storage of immobilized waste and transportation to the disposal site. Hanford's IHLW canisters will be disposed of at an offsite geologic repository. However, the repository has not been sited and its availability is uncertain. The Hanford Shipping Facility will interim store IHLW canisters and prepare the canisters for offsite transport once shipments to the repository commence. The facility will initially provide storage capacity for 2,000 IHLW canisters, and will be expandable as needed.

The Liquid Effluent Retention Facility/Effluent Treatment Facility was designed to interim store and treat 242-A Evaporator process condensate and other dilute aqueous waste streams from various sources (including the WTP). The aqueous waste is decontaminated to yield a liquid fraction suitable for disposal at the state-approved land disposal site and a solid fraction acceptable for disposal at the Integrated Disposal Facility.

The Integrated Disposal Facility will accept ILAW packages and failed melters from the WTP, mixed low-level waste and low-level waste from various Hanford Site generators, and potentially mixed low-level waste and low-level waste from offsite generators.

5.2 REQUIREMENTS AND OBJECTIVES

There are a large number of requirements related to tank waste processing and disposal. However, requirements and objectives specifically related to the current study are primarily focused on the following:

- Minimize overall life cycle cost, including: cost of constructing new facilities; operations; decontamination and decommissioning; and storage, transportation, and disposal of immobilized waste product.

- Minimize schedule risk. Specifically minimize risk of not meeting agreed dates for completion of the waste immobilization mission.

- Minimize safety and environmental impacts and risks.

- For this study it is assumed that no new major capital projects can be started before 2014.

- 24590-WTP-ICD-MG-01-019, *ICD-19-Interface Control Document for Waste Feed*, requires the Tank Farm Contractor to "provide the WTP Contractor with samples of each batch at least 180 days before the projected transfer of such waste to the WTP." For some options or sensitivity cases the current study may assume that waste from two or more tanks that have been sampled can be blended after sampling without triggering a requirement for repeat sampling and 180-day hold on the blended waste. For example, if tanks A and B had both been sampled and waste from tank B were added to tank A, a new sample and hold event may not be triggered. Composition of the blended tank would be estimated based on the waste samples from the source tanks. Resampling requirements can significantly affect tank farm logistics for blending options and should be clarified if these options are pursued further.

- It is assumed that borosilicate glass sealed in stainless steel canisters is the required IHLW product, and that established glass property constraints must be met. Results presented in this report assume the same glass property constraints used by the HTWOS model for the System Plan.

- Tank farm operational and safety requirements must be followed. This includes requirements for minimum reserve tank volume and constraints on properties of waste transferred. For the current study it is assumed that there are no constraints on mixing of tank waste. This must be verified before specific scenarios can be implemented.

Because of the expected high cost of HLW plant operation and for storage, transportation and disposal of IHLW, minimizing the quantity of IHLW is considered to be a major driver towards minimizing overall cost. Similarly, reducing quantity of IHLW is expected to reduce schedule risk. Some options could require additional tank farm operation costs due to increased number of transfers that may partially offset cost savings from reduced IHLW. This trade-off should be considered prior to making a final decision on implementation. Options that involve major new facilities are not currently included in this study. If such options surface, the costs and other impacts of constructing and operating the new facilities will need to be considered.

Options currently identified are expected to have only a small marginal effect on safety and environmental risks. Reduced IHLW quantity will reduce risks related to handling, shipping and disposal operations and may reduce the number and size of onsite storage facilities needed. These may be offset by increased tank farm operations risks if additional tank farm waste transfers are needed.

6.0 ALTERNATIVE DESCRIPTIONS

6.1 BASE CASE FOR BLENDING COMPARISONS

For the purpose of the current study the starting point for comparisons is the System Plan Unconstrained Case. This includes primarily the feed vector, glass quantity estimates, schedules, and processing facility performance characteristics.

The glass quantity calculations performed for this study use simplified spreadsheet models with somewhat different calculation methods and assumptions as compared to the HTWOS model used for the System Plan Unconstrained Case. Comparing blending results from the spreadsheet models directly with the System Plan results creates the possibility of artificial differences resulting from different calculation methods. Therefore, an unblended base case was developed for blending comparisons. The base case waste feed batches are based on consolidating the 450 Unconstrained Case feed vector batches into 116 macro batches. Adjacent feed vector batches with identical composition are consolidated into macro batches and feed vector batches with very small (essentially negligible) waste content are also consolidated into macro batches. The 116 batch case does not incorporate meaningful blending as compared to the 450 feed vector batches. The major difference between the base case and Unconstrained Case feed batches results from the 160,000 gallon per batch limitation on HLW transfers to WTP. This limitation results in about six feed vector batch transfers in order to transfer the contents of a nominal 1 Mgal tank farm tank containing HLW. The LAW transfers do not have this limitation. The entire contents of an LAW tank can be transferred to WTP in a single transfer.

There are also some differences between process performance assumptions and mass balance calculation methods used to model the WTP processes. Primary differences between the blending base case and the System Plan Unconstrained Case are: (1) In the base case spreadsheet calculations, the solids washing efficiency after leaching is set at 95% resulting in an average overall purge efficiency for soluble components of about 99%. For comparison, calculation methods used by HTWOS result in about 98% purge efficiency for soluble components. (2) In the base case calculations, credit is taken for reduced sulfate retention (67%) in the HLW melter. (3) In the base case calculations sodium from neutralized cesium ion exchange eluate is included in the HLW stream.

Key aspects of the Unconstrained Case related to the current study are shown in Table 6-1. In comparison, the total IHLW glass calculated for the base case is 39,200 MT with no blending.

Table 6-1. System Plan Unconstrained Case Description.

Start of Hot operations	5/31/2018
Completion of HLW Immobilization	8/14/2047
Estimated Total IHLW product (MT)	44,326[a] 45,703[b]
Estimated Total ILAW Product (MT)	611,000[b]
Feed vector batch transfer to WTP	450

[a] HTWOS Case: WTP_HLW_Glass_SP4 UC 1-3.0-8.4r0-2009-03-31-at-15-16-26.xls, SVF-1031 Rev. 3.
[b] Table E-1 of ORP-11242, 2009, *River Protection Project System Plan,* Rev. 4, Office of River Protection, U.S. Department of Energy, Richland, Washington.

HLW high-level waste.
IHLW = immobilized high-level waste.
ILAW = immobilized low-activity waste.
MT = metric tons.
WTP = Waste Treatment and Immobilization Plant.

6.2 WASTE TREATMENT AND IMMOBILIZATION PLANT INCIDENTAL BLENDING

The 116 macro batch grouping includes low solids/LAW batches and high solids/HLW batches. Calculations for 116 macro batch case estimate the glass for each macro batch separately. However, during normal WTP operations HLW and LAW batches will be processed in parallel. Solids removed from the LAW and neutralized ion exchange eluate will be blended with HLW solids being processed at the same time. Therefore, a revised grouping was developed that is intended to roughly simulate the incidental blending in WTP that results from parallel processing of HLW and LAW.

- A total of 56 HLW batches were identified from the original 116 base case.
- Low solids/LAW batches were identified that are scheduled to be delivered in approximately the same time frame as each HLW batch.
- Low solids/LAW batches were selected and combined with the 56 HLW batches resulting in a new set of 56 macro batches. Appendix B Table B-3 identifies the specific batches from the feed vector and 116 macro batch case that were combined to produce each batch for the 56 macro batch case.

6.3 BLENDING OF WASTE BATCHES IN TANK FARMS

In this alternative, waste batches staged for transfer to WTP will first be blended in tank farms. There are several ways this might be accomplished operationally. The following provides an example:

- After the first HLW feed tank is emptied, the partial contents of multiple tanks that have been prepared for transfer are transferred into the emptied tank to accomplish a target blend. The freed up space in the source tanks can then be refilled in a planned manner to accomplish additional blending. If desired, it may be feasible to consolidate waste in the source tanks leaving one tank nearly empty allowing fresh waste to be transferred in (See Section 7.2.2 for more detailed examples).

- If all source tanks have been sampled and completed the 180-day hold period, it significantly simplifies tank farm logistics if credit can be taken for source tank sampling, allowing transfer of the receipt/blend tank to WTP without requiring another sample and hold cycle. If this is allowed, the contents of the receipt/blend tank will be calculated based on the fraction of each source tank transferred into it. This blending approach can be considered even if resampling and an additional 180-day hold is required; however, the overall timing and logistics could be more difficult and additional costs may be incurred for sampling and analysis.

The blending cases evaluated are based on blending of wastes currently planned to be delivered in roughly the same time frame (e.g., within 1½ to 2 years based on schedule dates listed for the feed vector batches). This avoids the need for large changes to the overall tank waste retrieval and transfer plans and schedules. There may be some opportunities to further improve blending results by processing waste from selected tanks outside this time window. These could be evaluated further on a case-by-case basis.

6.4 BLENDING OF PARTIAL BATCHES IN WASTE FEED TANKS

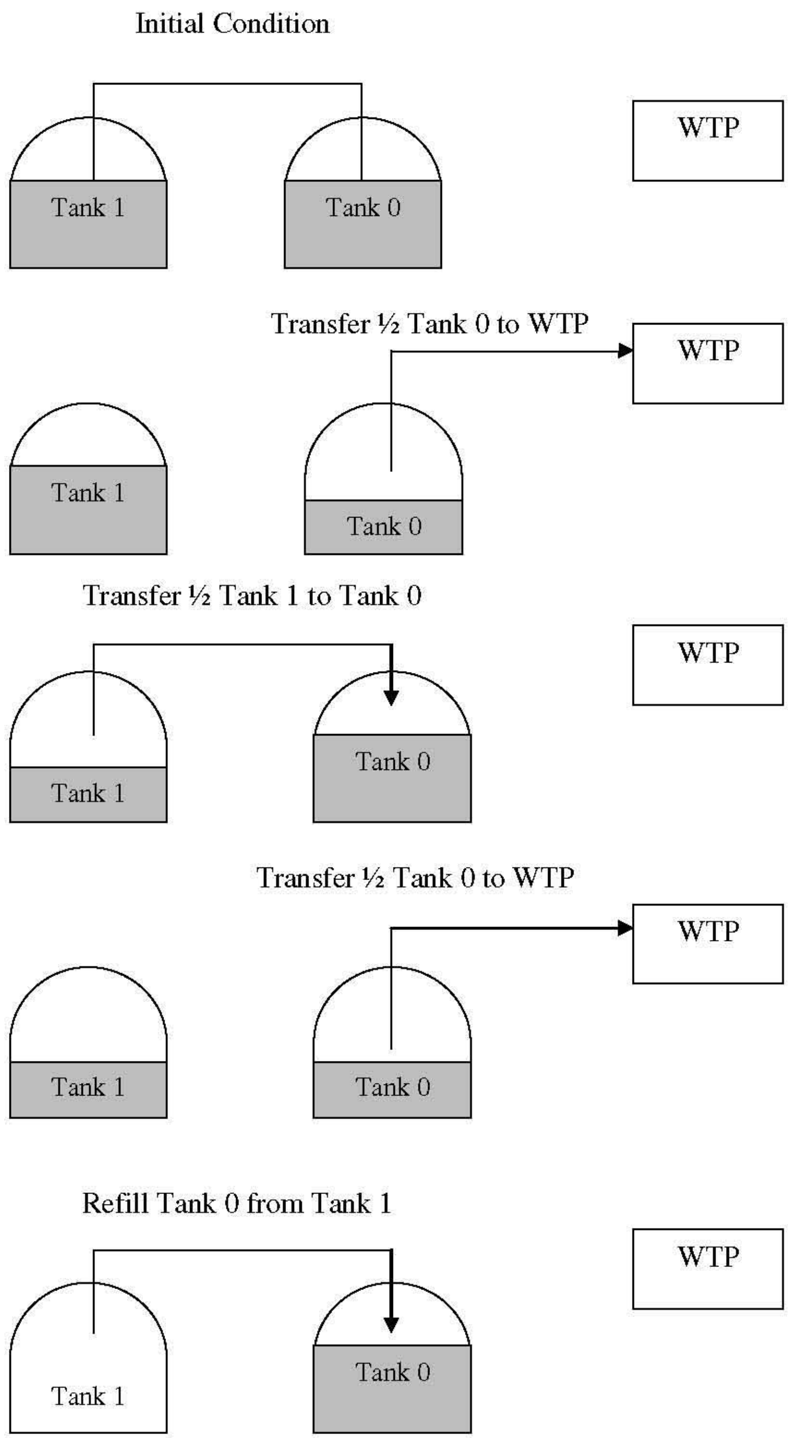
In this alternative, the tank farm tanks used for transfers to WTP ("feed tanks") are only partially emptied before being refilled so that the incoming waste batch is always blended with part of the prior batch. The following provides a simplified example of how this might work and is shown in a schematic format on Figure 6-1:

- One half the waste volume of the feed tank is first transferred to WTP. Then one half the volume of a second source tank is transferred to the feed tank and blended with the residual waste in the feed tank. One half the volume in the feed tank is then transferred to WTP. The balance of the waste in the source tank is then transferred to the feed tank and blended with its contents. The source tank is now empty and ready to receive waste.

> One half the waste in the feed tank is then transferred to WTP and it is then refilled with one half the contents of a second source tank.

For blending in the WTP feed transfer tank(s) it would be desirable that if, when the initial feed tank and each of the source tanks has been sampled and completed, the 180-day hold period then the receipt/blend tank would not require another sample and hold cycle. Contents of this tank would be calculated based on the fraction of each source tank transferred into it. This should improve WTP knowledge of the expected properties of incoming batches, since after the first batch 50% of each batch would consist of waste from the immediately preceding batch. If re-sampling and hold is required, blending further back in the feed staging process may be more desirable.

Figure 6-1. Feed Transfer Tank Blending Scheme.



There are other more complex ways to apply this concept to further improve blending. Examples:

- Use a three-tank set in series, feed tank, queue tank, and source tank. Transfer one-half the feed tank to WTP, then refill it from the queue tank then refill the queue tank from the source tank.

- Use a three-tank set in parallel, feed tank and two source tanks. Transfer one-half the feed tank volume then refill it from the first source tank. Transfer one-half the feed tank volume then refill it from the second source tank. Transfer one-half the feed tank then refill it from the first source tank, which is now empty and ready to receive more waste.

- Transfer less than one-half the feed tank each time and then refill from a source tank.

- Use a similar approach further back in the feed staging sequence.

7.0 ALTERNATIVE COMPARISONS

7.1 UNBLENDED AND INCIDENTAL BLENDING CASES

Sections 7.1.1 through 7.1.4 discuss results for two cases that do not take credit for intentional blending prior to delivery to WTP:

- The 116 macro batch case that assumes each batch is processed separately through WTP.

- A 56 macro batch case that assumes HLW and LAW batches are processed in parallel in WTP, resulting in glass quantity reduction due to incidental blending of the LAW and HLW wastes in the WTP.

Prior to development of blending comparisons, key WTP processing parameters were examined to assess their impact on HLW glass quantities. HLW glass quantities were found to be fairly sensitive to pretreatment solids washing efficiency and HLW melter sulfate retention assumptions. These are examined in more detail in the following sections and compared with HTWOS results and current WTP flowsheet bases. Based on the result of this evaluation, a base case for blending comparisons is defined as follows.

- 116 macro batches of waste transferred to WTP. As discussed in Section 6.1, this set of macro batches was designed to avoid meaningful waste blending. Appendix B identifies specific feed vector batches and primary waste source tanks for each of the 116 macro batches.

- 95% leached solids wash efficiency. Overall purge efficiency for soluble components varies by batch and typically averages about 99% with a 95% leached solids wash efficiency. Evaluation of solids washing and purge efficiency is discussed in Section 7.1.1.

- 67% sulfate retention for the HLW melter. Effect of melter sulfate retention is discussed in Section 7.1.2.

7.1.1 Evaluation of Solids Washing Efficiency

Initial steps in the WTP process include caustic leaching to dissolve selected components and ultrafiltration to split the waste into a solids free feed stream for ion exchange and a concentrated solids slurry stream. The solids slurry is then washed by repeated dilution with water and reconcentration by purging liquid through the ultra filters. For some batches oxidative leaching to remove chromium is then performed and the slurry is washed again and reconcentrated by purging liquid though the ultra filters. The washed reconcentrated slurry and concentrated neutralized eluate from ion exchange are transferred from pretreatment to HLW vitrification. SVF-1767 Mission Analysis Process Stream Calculator models removal of soluble sulfur, aluminum, phosphorus, and chromium as two steps: (1) initial purge of liquid through the ultra filters to achieve a 20 wt% leached solids concentration, and (2) water washing of the leached solids and reconcentration by purging liquid through the ultra filters. The efficiency for purging liquid phase components in the initial solids concentration step is calculated by the spreadsheet, wash efficiency in the second step is set as an input parameter. Overall purge efficiency for soluble components (combine initial solids concentration and washing) varies by batch and typically averages about 99% with 95% wash efficiency. Because a variable amount of sodium may be added during leaching, sodium washing is modeled as a parameter ($P_{Na(aq),19b,15LSol}$) that is proportional to the soluble sodium concentration in the final washed and reconcentrated leached solids slurry. The nominal or base case value of $P_{Na(aq),19b,15LSol}$ is 0.023, which is equivalent to a dissolved sodium concentration of 0.25 mole/L in the washed solids slurry aqueous phase with 20 wt% leached solids. This equivalence is calculated as follows:

> $P_{Na(aq),19b,15LSol}$ is defined as the ratio of dissolved sodium mass to leached solids mass.
>
> Aqueous phase density for 0.25 molar sodium is estimated at 1.01 g/ml.
>
> Basis 1 kg of slurry
>
> Leached Solids Mass = 0.200 kg (20%)
>
> Liquid Mass = 0.8 kg (80%)
>
> Liquid Volume = 0.8/1.01 = 0.792 L
>
> Sodium in Liquid = $P_{Na(aq),19b,15LSol}$ * leached solids mass = 0.023*.2= 0.0046 kg
>
> Sodium Concentration = 0.0046*1000g/(23(g/mole)*0.792L) = 0.25 mole/L

If the leached solids slurry is 5 mole/L sodium at 20 wt% leached solids prior to washing, the 0.25 mole/L final concentration assumed for the base case represents approximately 95% washing efficiency. Note that calculation of sodium in the washed solids slurry does not include sodium in the neutralized cesium ion exchange eluate, which is calculated separately and blended with the concentrated washed solids slurry.

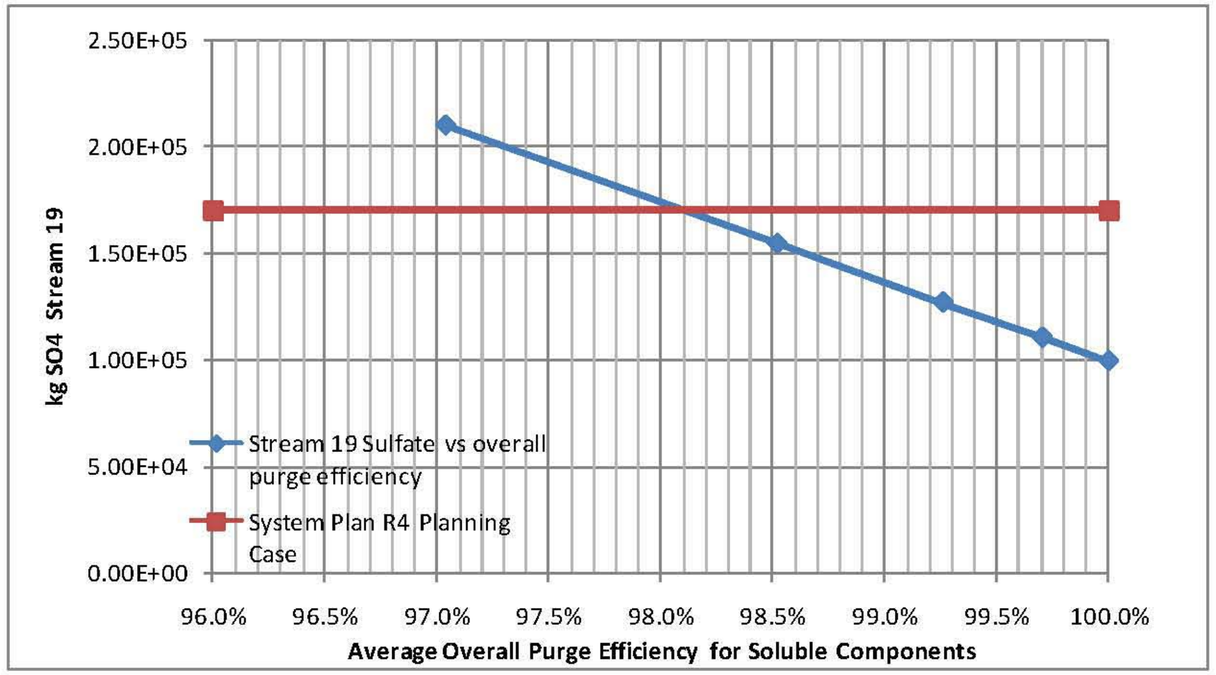
7.1.1.1 Comparison of Calculated High-Level Waste Feed with Hanford Tank Waste Operations Simulator Results. Calculated HLW feed components (Stream 19, Figure 1-1) and comparable values from the System Plan Planning Case (SVF-1663 Rev. 1) are listed in Table 7-1. Figure 7-1a through Figure 7-1d show the results for individual components graphically. Conclusion from this comparison is that the System Plan Planning Case effective overall purge efficiency is about 98%. This is equivalent to a second stage washing efficiency of about 90% or less.

Table 7-1. Results of Solids Washing Calculations.

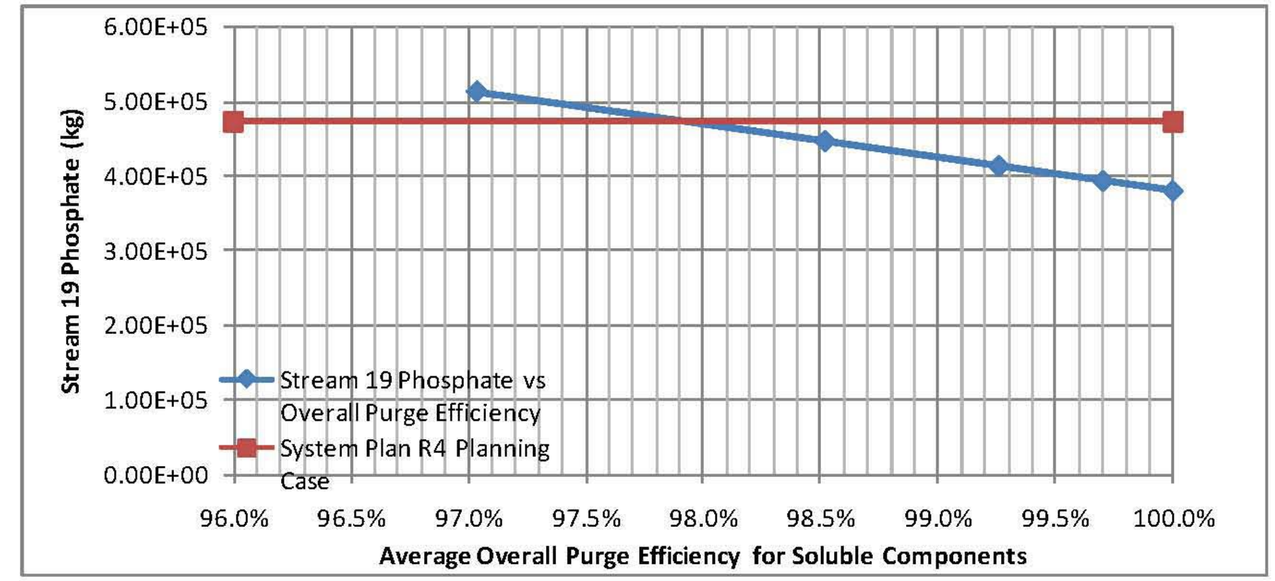
	SVF-MAR04 Calculations for HLW Feed (Stream 19)*					**SVF1663**
Wash Efficiency	100.00%	98.00%	**95.00%**	90.00%	80.00%	Not given
Total Purge Efficiency	100.0%	99.7%	**99.3%**	98.5%	97.0%	Not given
Sulfur as SO_4, kg	9.92E+04	1.10E+05	**1.27E+05**	1.54E+05	2.09E+05	1.70E+05
Total Al, kg	1.90E+06	1.92E+06	**1.95E+06**	1.99E+06	2.09E+06	1.98E+06
Al(aq), kg	0.00E+00	1.92E+04	**4.81E+04**	9.61E+04	1.92E+05	1.50E+05
Phosphorus as PO_4, kg	3.80E+05	3.93E+05	**4.13E+05**	4.46E+05	5.12E+05	4.72E+05
Na, kg	1.64E+06	1.83E+06	**2.11E+06**	2.56E+06	3.44E+06	3.24E+06
$P_{Na(aq),19b,15LSol}$	0	0.0092	**0.023**	0.045	0.088	Not given
Na (final) Mole/L	0	0.05	**0.25**	0.50	1.0	Not given

*090818-5-SVF-MAR04 Macro Batch to Process Stream Calculator Rev. D.xlsm
Al = aluminum.
HLW = high-level waste.
Na = sodium.

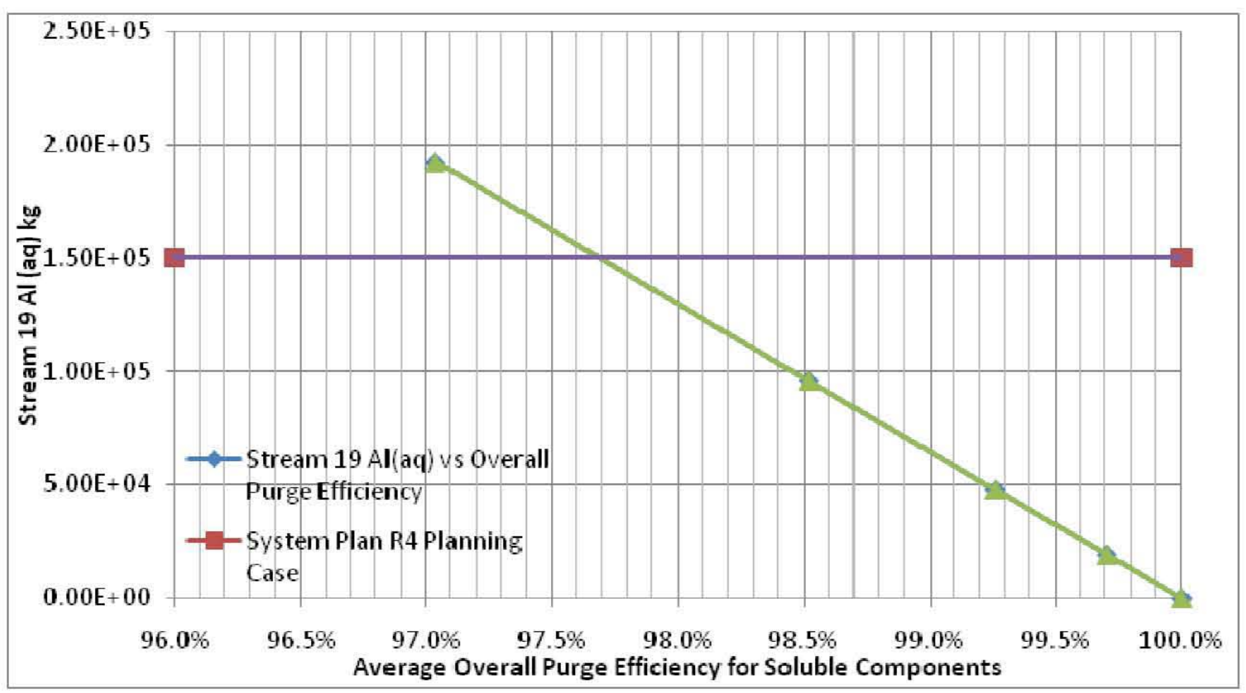
Figure 7-1. Variation of High-Level Waste Vitrification Feed Component Mass Estimates with Purge Efficiency.



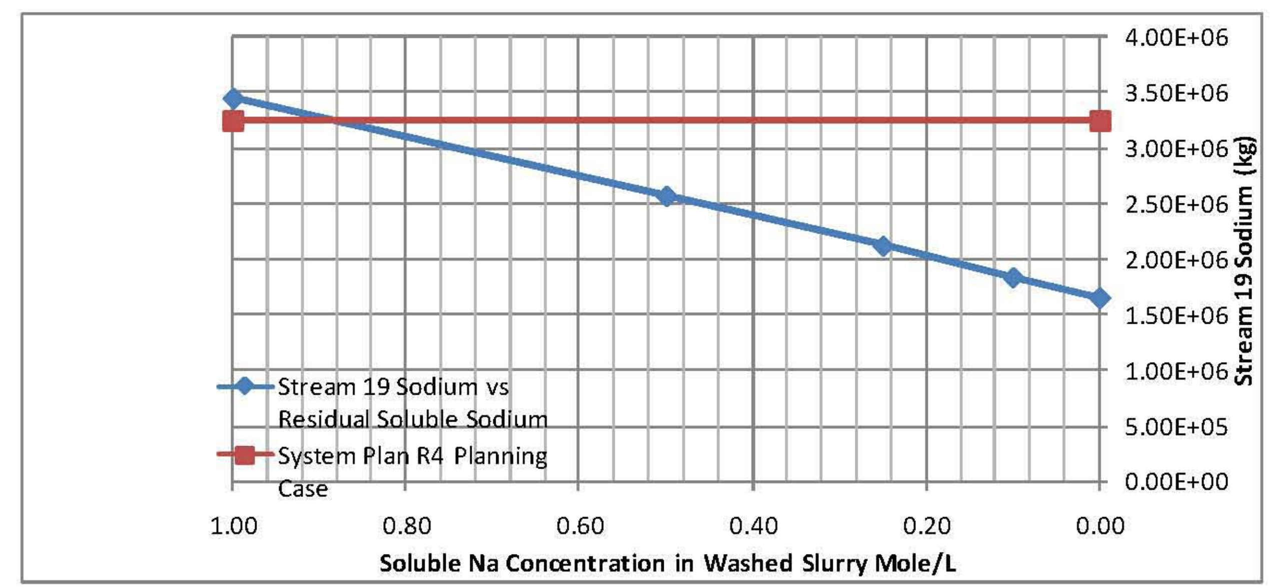
(a) Sulfate in Stream 19 Versus Overall Purge Efficiency



(b) Phosphate in Stream 19 Versus Overall Purge Efficiency



(c) Liquid Phase Aluminum in Stream 19 Versus Overall Purge Efficiency



(d) Sodium in Stream 19 Versus Soluble Sodium in Washed Leached Solids Slurry.

7.1.1.2 Effect of wash efficiency on high-level waste glass quantity. Glass quantity was calculated for each of the 116 base case macro batches as a function of wash efficiency and total purge efficiency for soluble components. Results for total glass quantity are shown in Table 7-2 and

7.1.1.3 Figure **7-2**. The results show that increasing from 96 to 99% overall purge efficiency reduces HLW glass by about 13% while increasing from 99 to 100% reduces HLW glass by an additional 4.5%. Based on results presented in Section 7.1.1.1, it appears that the HTWOS model may be somewhat under-washing the solids.

Table 7-3 provides results for each of the 116 macro batches. These results show that some batches are strongly influenced by purge efficiency for soluble components, while for other there is little or no effect on glass quantity as purge efficiency in increased. This suggests that optimization of plant operations may involve batch by batch adjustment of purge efficiency.

Table 7-2. Effect of Solids Washing on Total High-Level Waste Glass Quantity.

	116 Macro Batch-(No Blending)			
Wash Efficiency for Leached Solids Slurry	100%	**95%**	90%	80%
Average Overall Purge Efficiency for Solubles	100%	**99%**	98%	96%
Glass quantity (MT)*	37,500	**39,200**	41,100	45,100

*Based on melter sulfate retention of 67%.
MT metric tons.

Figure 7-2. Effect of Soluble Component Purge Efficiency on High-Level Waste Glass Quantity.

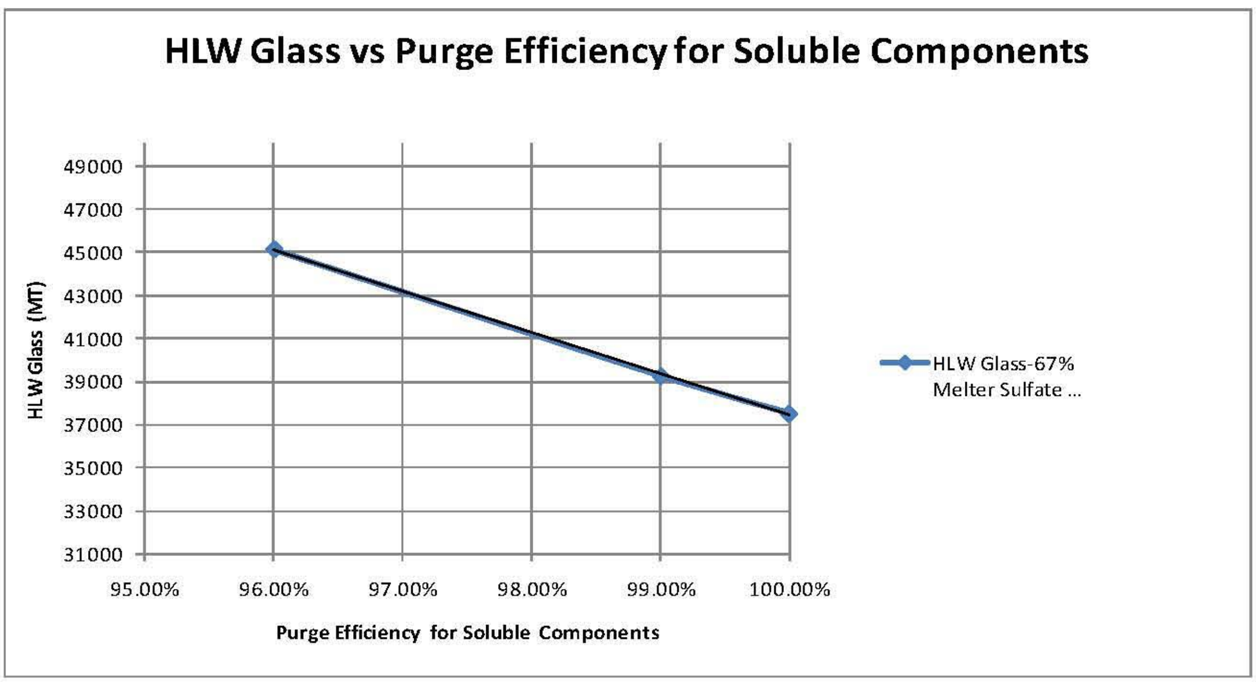


Table 7-3. Effect of Washing Efficiency on Batch by Batch Glass Quantities. (4 pages)

Spreadsheet:	SVF-MAR05 HLW Glass Batch Blend Results Summary						
Run Number	090818-3	**090818-1**	090831-2	90818-2	090818-3	090831-2	90818-2
Wash Efficiency	100%	**95%**	90%	80%	100%	90%	80%
Average Purge Efficiency	100%	**99% (Base Case)**	98%	96%	100%	98%	96%
Batch	HLW Glass kg				Ratio of Glass Mass to Base Case (95% Wash Efficiency)		
1	731465	**731465**	731,465	731465	1.000	1.000	1.000
2	3590	**3590**	3,590	3590	1.000	1.000	1.000
3	43908	**46018**	48,035	51975	0.954	1.044	1.129
4	269728	**269728**	269,728	269728	1.000	1.000	1.000
5	1068541	**1067848**	1,067,153	1065757	1.001	0.999	0.998
6	1717209	**1816964**	1,922,287	2145267	0.945	1.058	1.181
7	988968	**1015550**	1,042,178	1095580	0.974	1.026	1.079
8	1908960	**1907940**	1,906,919	1904872	1.001	0.999	0.998
9	801976	**862635**	923,345	1075823	0.930	1.070	1.247
10	77630	**81372**	84,949	91937	0.954	1.044	1.130
11	407755	**415806**	424,184	441230	0.981	1.020	1.061
12	82804	**87783**	92,546	101855	0.943	1.054	1.160
13	702107	**783355**	861,071	1012971	0.896	1.099	1.293
14	409348	**467371**	522,872	631349	0.876	1.119	1.351
15	44911	**44911**	44,911	44911	1.000	1.000	1.000
16	298412	**327442**	355,434	410387	0.911	1.085	1.253
17	44587	**45360**	46,098	47543	0.983	1.016	1.048
18	32272	**32272**	32,272	32272	1.000	1.000	1.000
19	684499	**724940**	765,431	846551	0.944	1.056	1.168
20	656798	**678945**	701,797	747570	0.967	1.034	1.101
21	39671	**39671**	39,671	39671	1.000	1.000	1.000
22	45308	**47238**	49,084	52692	0.959	1.039	1.115
23	95321	**103694**	111,703	127357	0.919	1.077	1.228
24	53635	**58291**	62,743	71447	0.920	1.076	1.226
25	99988	**100149**	107,093	122381	0.998	1.069	1.222
26	1095261	**1113322**	1,131,390	1167543	0.984	1.016	1.049
27	43296	**44824**	46,287	49150	0.966	1.033	1.097
28	468454	**497458**	525,201	579426	0.942	1.056	1.165
29	737722	**749248**	760,777	783846	0.985	1.015	1.046
30	36027	**36787**	37,514	38934	0.979	1.020	1.058
31	1,188,601	**1,215,876**	1,243,164	1297,778	0.978	1.022	1.067
32	365,668	**366,246**	366,824	367,982	0.998	1.002	1.005
33	188,297	**202,919**	217,571	246,966	0.928	1.072	1.217
34	660,133	**708,073**	756,421	854,366	0.932	1.068	1.207

Table 7-3. Effect of Washing Efficiency on Batch by Batch Glass Quantities. (4 pages)

Spreadsheet:	SVF-MAR05 HLW Glass Batch Blend Results Summary						
Run Number	090818-3	**090818-1**	090831-2	90818-2	090818-3	090831-2	90818-2
Wash Efficiency	100%	**95%**	90%	80%	100%	90%	80%
Average Purge Efficiency	100%	**99% (Base Case)**	98%	96%	100%	98%	96%
Batch	**HLW Glass kg**				Ratio of Glass Mass to Base Case (95% Wash Efficiency)		
35	1,375,927	**1,397,070**	1,418,221	1,460,552	0.985	1.015	1.045
36	68,744	**73,478**	78,005	86,851	0.936	1.062	1.182
37	961,521	**973,666**	985,815	1,010,125	0.988	1.012	1.037
38	97,900	**104,470**	111,046	124,214	0.937	1.063	1.189
39	161,532	**164,200**	166,868	178,853	0.984	1.016	1.089
40	299,686	**302,179**	304,673	309,669	0.992	1.008	1.025
41	349,996	**354,323**	358,652	367,320	0.988	1.012	1.037
42	1,048,801	**1,065,844**	1,082,895	1,117,011	0.984	1.016	1.048
43	35,035	**35,035**	35,035	35,035	1.000	1.000	1.000
44	159,772	**164,708**	178,710	224,226	0.970	1.085	1.361
45	200,340	**205,418**	213,187	252,556	0.975	1.038	1.229
46	35,181	**36,016**	36,814	38,375	0.977	1.022	1.066
47	77,408	**81,053**	84,539	91,352	0.955	1.043	1.127
48	16,685	**16,758**	16,829	16,966	0.996	1.004	1.012
49	453,732	**465,274**	476,839	552,525	0.975	1.025	1.188
50	269,888	**275,023**	280,158	290,431	0.981	1.019	1.056
51	166,017	**170,395**	205,239	284,960	0.974	1.204	1.672
52	199,778	**208,198**	216,629	233,521	0.960	1.040	1.122
53	60,777	**61,347**	61,917	63,057	0.991	1.009	1.028
54	644,336	**657,852**	671,373	698,424	0.979	1.021	1.062
55	1,300,169	**1,329,676**	1,359,198	1,418,278	0.978	1.022	1.067
56	259,655	**261,974**	264,292	268,930	0.991	1.009	1.027
57	264,892	**268,470**	272,048	279,204	0.987	1.013	1.040
58	1,138,330	**1,209,464**	1,280,634	1,423,088	0.941	1.059	1.177
59	42,019	**43,993**	45,881	49,571	0.955	1.043	1.127
60	148,958	**150,317**	151,678	174,762	0.991	1.009	1.163
61	626,431	**639,978**	653,529	680,641	0.979	1.021	1.064
62	91,574	**93,987**	**99,827**	113,039	0.974	1.062	1.203
63	533,794	**560,306**	586,859	640,096	0.953	1.047	1.142
64	26,422	**26,916**	27,388	28,310	0.982	1.018	1.052
65	30,061	**30,823**	31,552	32,976	0.975	1.024	1.070
66	196,234	**200,120**	204,009	243,908	0.981	1.019	1.219
67	427,015	**443,386**	459,774	492,601	0.963	1.037	1.111
68	516,503	**533,661**	550,841	586,541	0.968	1.032	1.099

Table 7-3. Effect of Washing Efficiency on Batch by Batch Glass Quantities. (4 pages)

Spreadsheet:	SVF-MAR05 HLW Glass Batch Blend Results Summary						
Run Number	090818-3	**090818-1**	090831-2	90818-2	090818-3	090831-2	90818-2
Wash Efficiency	100%	**95%**	90%	80%	100%	90%	80%
Average Purge Efficiency	100%	**99% (Base Case)**	98%	96%	100%	98%	96%
Batch		**HLW Glass kg**			Ratio of Glass Mass to Base Case (95% Wash Efficiency)		
69	429,340	**466,409**	503,576	578,200	0.921	1.080	1.240
70	376,870	**386,763**	396,675	416,553	0.974	1.026	1.077
71	924,973	**947,459**	969,952	1,014,966	0.976	1.024	1.071
72	58,957	**61,852**	64,859	71,301	0.953	1.049	1.153
73	276,871	**288,771**	307,658	386,502	0.959	1.065	1.338
74	17,445	**17,517**	17,587	17,722	0.996	1.004	1.012
75	420,024	**425,802**	431,599	538,275	0.986	1.014	1.264
76	27,711	**27,732**	27,752	27,792	0.999	1.001	1.002
77	411,519	**420,324**	429,142	446,821	0.979	1.021	1.063
78	26,247	**26,264**	26,281	26,313	0.999	1.001	1.002
79	292,099	**338,912**	386,211	482,302	0.862	1.140	1.423
80	27,031	**27,867**	28,666	30,229	0.970	1.029	1.085
81	85,072	**88,370**	91,670	98,274	0.963	1.037	1.112
82	448,911	**495,620**	540,297	627,622	0.906	1.090	1.266
83	33,136	**34,600**	36,003	38,744	0.958	1.041	1.120
84	27,699	**27,703**	27,708	27,716	1.000	1.000	1.000
85	25,989	**25,991**	25,993	25,996	1.000	1.000	1.000
86	21,474	**21,654**	21,827	22,164	0.992	1.008	1.024
87	628,822	**690,778**	753,459	881,049	0.910	1.091	1.275
88	26,759	**27,443**	28,098	29,378	0.975	1.024	1.071
89	338,436	**409,737**	481,928	629,053	0.826	1.176	1.535
90	27,161	**27,542**	27,906	28,618	0.986	1.013	1.039
91	29,860	**34,878**	39,901	49,961	0.856	1.144	1.432
92	26,659	**26,659**	26,659	26,659	1.000	1.000	1.000
93	453,631	**466552**	481,936	559,444	0.972	1.033	1.199
94	396,025	**456869**	518,568	644,606	0.867	1.135	1.411
95	4877	**5565**	6254	7635	0.876	1.124	1.372
96	1428	**1532**	1632	1827	0.932	1.065	1.192
97	6710	**6803**	6893	7068	0.986	1.013	1.039
98	311	**317**	322	333	0.981	1.018	1.053
99	881	**904**	925	968	0.975	1.024	1.071
100	268	**282**	288	308	0.950	1.022	1.091
101	484,813	**626,009**	768,336	1056,438	0.774	1.227	1.688
102	642,148	**720,669**	799,255	956,622	0.891	1.109	1.327

Table 7-3. Effect of Washing Efficiency on Batch by Batch Glass Quantities. (4 pages)

Spreadsheet:	SVF-MAR05 HLW Glass Batch Blend Results Summary						
Run Number	090818-3	**090818-1**	090831-2	90818-2	090818-3	090831-2	90818-2
Wash Efficiency	100%	**95%**	90%	80%	100%	90%	80%
Average Purge Efficiency	100%	**99% (Base Case)**	98%	96%	100%	98%	96%
Batch	**HLW Glass kg**				Ratio of Glass Mass to Base Case (95% Wash Efficiency)		
103	135,847	**168,888**	202,208	269,700	0.804	1.197	1.597
104	542,867	**558,740**	574,636	626,545	0.972	1.028	1.121
105	167,814	**176,454**	185,389	204,207	0.951	1.051	1.157
106	169,612	**170,622**	171,634	173,660	0.994	1.006	1.018
107	3,541	**3,635**	4,378	6078	0.974	1.204	1.672
108	8,963	**9,086**	9,210	11,486	0.986	1.014	1.264
109	216,236	**253,263**	299,984	393,486	0.854	1.184	1.554
110	22,145	**22,583**	23,022	27,524	0.981	1.019	1.219
111	279,207	**341,261**	403,711	529,813	0.818	1.183	1.553
112	42,521	**44,965**	51,653	65,149	0.946	1.149	1.449
113	36	**37**	39	45	0.972	1.033	1.199
114	439,821	**469,346**	498,925	558,248	0.937	1.063	1.189
115	17,956	**17,956**	17,956	17,956	1.000	1.000	1.000
116	73,600	**73,600**	73,600	74,919	1.000	1.000	1.018
Total glass (kg)	37,498,282	**39,243,052**	41,064,826	45,136,420	0	1.046	1.146

HLW = high-level waste.

7.1.2 Melter Sulfate Retention

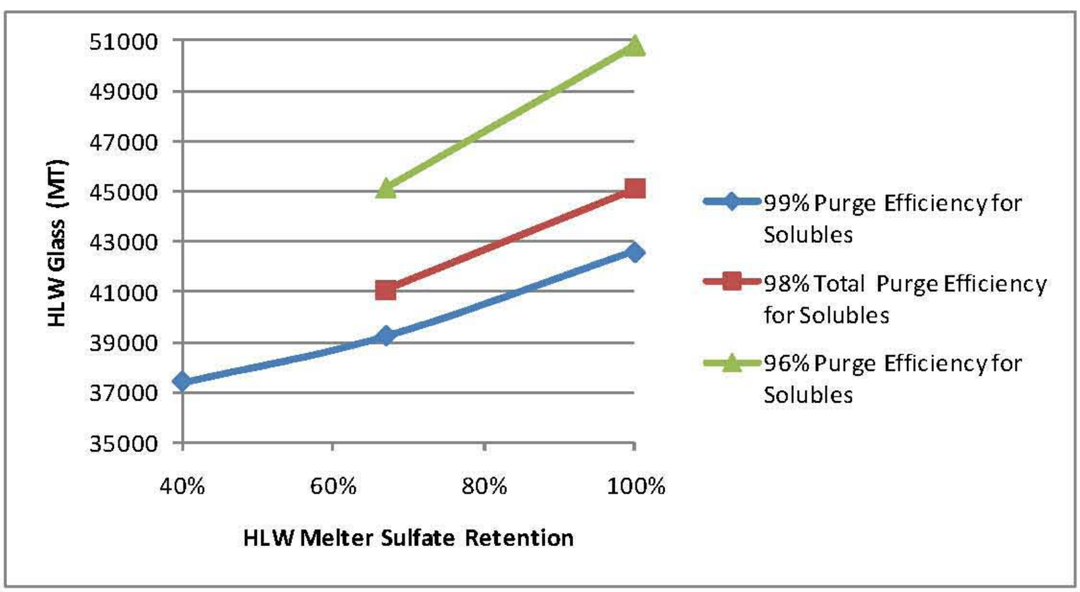
During heating and melting of melter feed a portion of the sulfate is driven off and reports to the melter offgas as semi-volatile and gaseous sulfur compounds. Most of the sulfur compounds are removed from the offgas by the submerged bed scrubber, electrostatic precipitator, and demister, and report to the submerged bed scrubber condensate stream. Because sulfate content of HLW glass may limit waste loading, fractional sulfate retention in the glass in an important parameter for estimating required HLW glass quantity. Table 7-4 and Figure 7-3 summarize the results of calculated HLW glass quantity versus melter sulfate retention for the 116 macro batch base case. The case with 98% average overall purge efficiency for soluble components and 100% HLW melter sulfate retention corresponds approximately to the System Plan Unconstrained Case HTWOS calculation. The most recent WTP flowsheet (24590-WTP-RPT-PT-02-005) indicates the expected average melter sulfate retention is 67%.

Table 7-4. Effect of Melter Sulfate Retention on High-Level Waste Glass Quantity.

	116 batch no blend						
Leached Solids Wash Efficiency	80%	80%	90%	90%	95%	**95%**	95%
Average Overall Purge Efficiency	96%	96%	98%	98%	99%	**99%**	99%
HLW Sulfate Retention	100%	67%	100%	67%	100%	**67%**	40%
HLW Glass quantity	50,800	45,100	45,100	41,100	42,600	**39,200**	37,400

HLW = high-level waste.

Figure 7-3. Effect of Melter Sulfate Retention and Purge Efficiency on High-Level Waste Glass Quantity.



7.1.3 Base Case Results

For the current study, an unblended base case for comparisons is established with the following key characteristics:

- 116 macro batches of waste transferred to WTP based on consolidation from 450 feed vector batches for the System Plan Draft Revision 4 Unconstrained Case.
- 95% leached solids slurry wash efficiency. Overall purge efficiency for soluble components varies by batch and typically averages about 99% with 95% wash efficiency.
- 67% sulfate retention for the HLW melter.

Estimated total IHLW glass for the base case is 39,200 MT.

7.1.4 Waste Treatment and Immobilization Plant Incidental Blending

The 56 macro batch case was developed to simulate incidental blending due to parallel processing of HLW and LAW in the WTP (see Section 6.2). HLW glass quantity results for the 56 macro batch case are shown in Table 7-5 and compared with the original 116 macro batch base case. Combining the LAW and HLW batches results in about 7% decrease in estimated HLW glass. This is partly because of blending of solids in the LAW with solids in the HLW, and partly because of blending sodium from cesium ion eluate with the HLW solids.

Table 7-5. Comparison of 56 and 116 Macro Batch Case
High-Level Waste Glass Quantities.

Macro Batch Case	56 Macro Batch[a]	116 Macro Batch[b]
HLW Melter Sulfate Retention	67%	67%
Solids Washing Efficiency	95%	95%
HLW Glass Quantity (MT)	36,400	39,200

[a]091207-1-SVF-1817 Mission Analysis Glass Batch Blend Results Summary Rev. A.xlsm
[b]091204-1-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. D.xlsm
HLW = high-level waste.
MT = metric tons.

7.2 BLENDING OF WASTE BATCHES IN TANK FARMS

Blending of waste batches in tank farms involves targeted mixing of waste batches in tank farms to prepare blended batches for transfer to WTP. This approach was found to allow a significant reduction in HLW quantity as discussed in Section 7.2.1. Preliminary assessment of impacts to tank farms is discussed in Section 0.

7.2.1 Effect of Blending Waste Batches on High-Level Waste Quantity

Results of initial blending evaluations are summarized in Table 7-6,

Figure 7-4, and Figure 7-5. Three tank farm blending cases were developed for comparison with 116 and 56 macro batch cases:

- **Single Macro Batch-Total Blend:** For this case, all 450 feed vector batches were combined into a single total blend. With base case process performance factors the estimated HLW glass quantity is reduce to about 29,000 MT, a 26% reduction compared to the 116 macro batch base case.

- **23 Macro Match Blend:** Limiting components for the 116 macro batch case were reviewed and potentially attractive blending groups were selected based on the planned batch delivery dates shown in the Unconstrained Case feed vector. For each blending group the time between the earliest and latest planned delivery date was limited to approximately two years. No blending was performed on the first four batches or first two years of operations. This blending case resulted in an approximate 20% HLW glass reduction compared to the 116 macro batch base case and about 7% more than the single macro batch total blend.

- **21 Macro Batch Blend:** Similar to the 23 macro batch case except the waste delivery window was reduced to about 18 months. Estimated HLW glass quantity is essentially the same as the 23 macro batch case.

The 23 and 21 macro batch cases were developed by identifying components or properties that limit waste loading for each of the 116 macro batches. Then, by inspection, potentially attractive blending combinations within the time window were identified and macro batches were grouped for blending. Only a first pass was made; that is, there was no attempt to examine results and identify or test other combinations to optimize the overall blending result. Additional reductions in HLW glass quantity may be possible by further analysis, testing of alternative combinations, and making adjustments to better optimize blending results. Note that because of the way the waste batches were grouped, most of the benefit of WTP incidental blending is also captured by the 23 and 21 macro batch cases.

Table 7-6. Summary of Initial Tank Farm Blending Results.

	116 Macro Batch-No Blending			56 Macro Batch-WTP Incidental Blend	23 Macro Batch Blend		21 Macro Batch Blend	Single Macro Batch (Total Blend)
Wash Efficiency	100%	**95%**	80%	95%	95%	80%	95%	95%
Average Overall Purge Efficiency	100%	**99%**	96%	99%	99%	96%	99%	99.3%
HLW Glass (MT)	37,500	**39,200**	45,100	36,400	31,100	35,800	30,900	29,000

HLW = high-level waste.
MT = metric tons.
WTP = Waste Treatment and Immobilization Plant.

Figure 7-4. Effect of Blending and Purge Efficiency on High-Level Waste Glass.

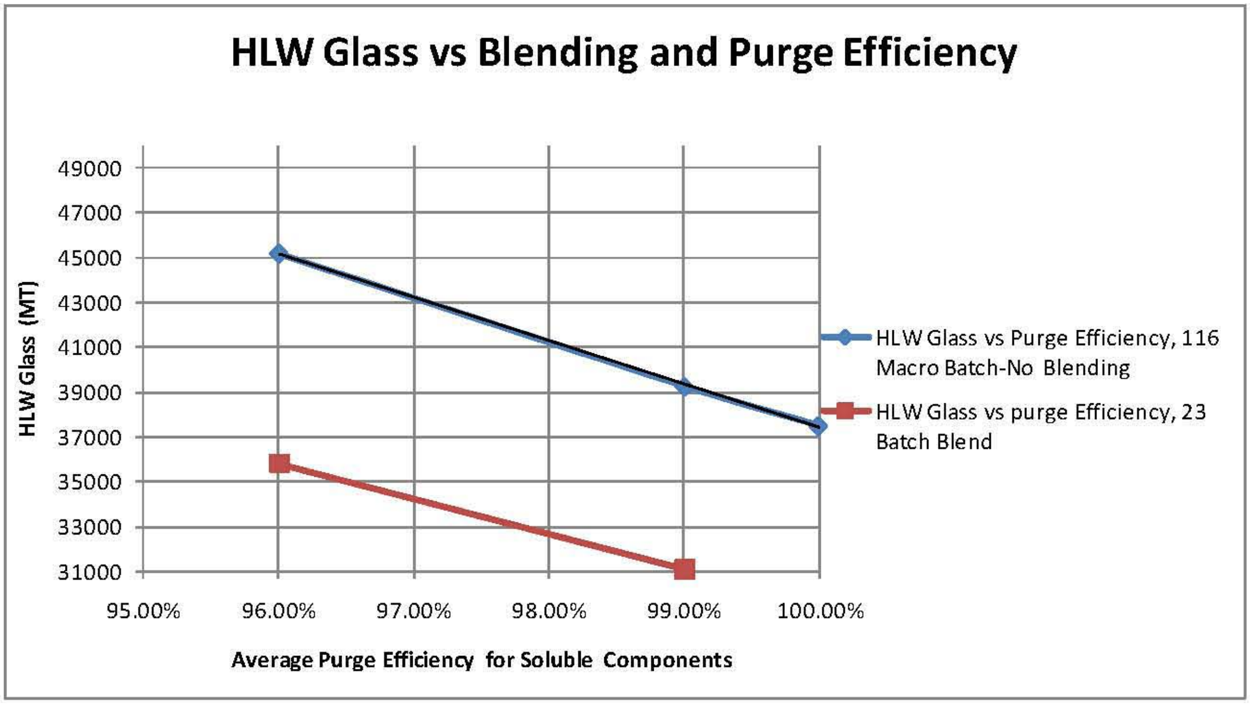
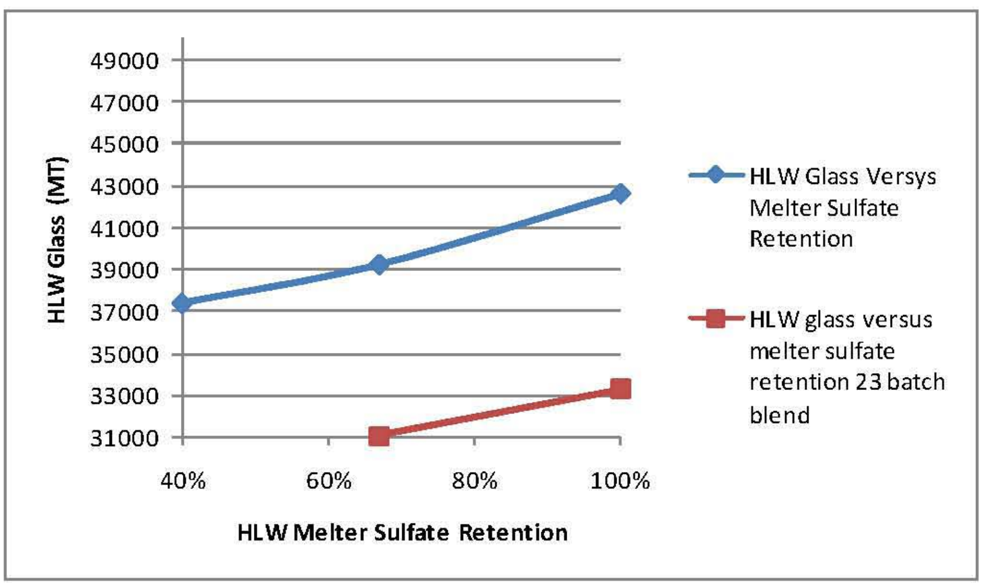


Figure 7-5. Effect of Blending and Sulfate Retention on High-Level Waste Glass Quantity.



7.2.2 Potential Impacts to Tank Farm Operations

There are likely to be a number of impacts to tank farms from implementing a strategy to blend groups of tank waste batches. Potential impacts identified include the following:

- An increase in required tank farm waste transfers can generally be expected from any tank farm blending strategy.

- Increased sampling may be required. The amount of additional sampling may vary significantly with the blending scenario and with tank waste sampling requirements, which have not yet been fully defined.

- Some impact to timing or need dates for retrieval and transfer system upgrades can be expected in order to facilitate blending.

Additional Tank Farm Waste Transfers

In order to assess the magnitude of additional tank farm waste transfers, a simplified example is developed below based on the 23 macro batch blending case discussed in Section 7.2.1. This scenario assumes blending to prepare each blended batch involves a number of waste batches initially staged in tank farm source tanks. The source tanks are numbered Tank 1, 2, 3, etc. There is an additional tank numbered Tank 0 that serves as a WTP waste feed transfer tank. It is assumed that Tank 1 is also set up to serve as a WTP waste feed transfer tank. It is assumed that Tank 0 is initially empty after transferring its contents to WTP. Two and three source tank batch blend scenarios are as follows.

Two Source Tank Scenario

Tank 0 is initially empty after transferring its contents to WTP. Tank 1 and 2 each transfer half of their contents to Tank 0. Contents of Tank 0 are mixed to prepare the first portion of the blended batch and readied for transfer to WTP. The Tank 0 contents are then transferred to WTP. Because of the 160,000 gallon limit on HLW transfers to WTP, about six transfers are required to transfer the batch to WTP assuming a nominal 1 Mgal batch size.

After transferring half of its contents to Tank 0, Tank 2 transfers its remaining contents to Tank 1. Contents of Tank 1 are then mixed and transferred to WTP, again requiring about six transfers because of the 160,000 gallon transfer limit. It is assumed that two transfers are required to empty Tank 2, one transfer for the first half to Tank 0, and one transfer for the second half to Tank 1. After transfer to Tank 1, Tank 2 is empty and ready to receive waste.

If the assumed no-blending alternative involves transfer of Tank 1 and then Tank 2 directly to WTP, total transfers are 12 (six per tank batch). The above scenario results in 15 total transfers-12 to WTP and three between tank farm tanks. This is three additional transfers compared to the no blend case. If Tank 2 cannot directly transfer to WTP and its contents must be first transferred to Tank 0 or Tank 1, then the no blend scenario requires one additional transfer between tank farm tanks. In this case the blending scenario results in two additional transfers. For the current analysis the first assumption is used (results in maximum calculated additional transfers).

Three Source Tank Scenario

Tank 0 is initially empty after transferring its contents to WTP. Tanks 1, 2, and 3 each transfer one-third of their contents to Tank 0. Contents of Tank 0 are then mixed and transferred to WTP.

Tank 3 then transfers half its remaining contents to Tank 1 and half to Tank 2. Tank 3 is now empty and ready to receive waste. Tank 1 and 2 contents are then handled in the same way as the two tank scenario above.

If the assumed no-blending scenario involves transfer of Tank 0, then Tank 1, then Tank 2, then Tank 3 directly to WTP, the above scenario results in eight additional tank farm transfers. If Tank 2 or 3 cannot directly transfer to WTP and must be first transferred to Tank 0 or 1, the scenario results in fewer additional transfers. For this analysis the first case assumption is used (results in maximum calculated additional transfers).

Extension to Larger Numbers of Source Tanks

Extension of the above analysis to additional numbers of source tanks gives the results show in Table 7-7. In all cases the number of additional transfers shown is based on the assumption that any of the source tanks can transfer directly to WTP, which results in the minimum number of transfers for the no-blend case and the maximum number of additional transfers for the blending case.

Table 7-7. Impact of Tank Farm Blending on Required Waste Transfers.

Number of Source Tanks	Additional Transfers
1	0
2	3
3	8
4	15
5	24
6	35

Table 7-8 illustrates application of the above scenarios to the 23 macro batch blending case. For the 23 macro batch case discussed in Section 7.2.1, there are 16 macro batches that involve blending of HLW batches. For each of these batches, the number of additional transfers required is shown based on the number of HLW batches included in the blended batch and the results shown in Table 7-7. Additional transfers are not expected to be required for blending the HLW fraction of LAW batches (<3.8 wt% solids) with the HLW solids, because these are expected to be blended in WTP without the need for additional tank farm transfers. As shown in Table 7-8, applying the simplified analysis above to the 23 macro batch blending case results in 208 additional tank farm transfers for the life of the project. This is considered to be a conservative number, because in the later stages of the program it should be feasible to accomplish much of the blending as the source tank batches are prepared and staged (e.g., from 200 West Area tanks and SST retrievals). Based on a conservative allowance of $192,000 average per transfer (email from Shuford, D., to aemconsult1@aol.com, “Cost Basis for transfers,” [Shuford, D., 2009-09-08]) and 208 additional transfers the estimated cost for additional transfers is $40 million.

Table 7-8. Additional Tank Farm Transfers for
23 Macro Batch Blending Case.

Blended Macro Batch Number	Number of HLW Batches in Blended Macro Batch	Increased Transfers
1	1	0
2	0	0
3	0	0
4	1	0
5	3	5
6	2	3
7	4	15
8	2	3
9	1	0
10	6	35
11	4	15
12	5	24
13	1	0
14	3	5
15	1	0
16	3	5
17	4	15
18	5	24
19	2	3
20	2	3
21	2	3
22	4	15
23	6	35
Total	62	208

HLW = high-level waste.

7.3 BLENDING OF PARTIAL BATCHES IN WASTE FEED TANKS

This section summarizes initial results for the concept of blending partial batches in tank farm feed tanks used to transfer batches of waste to WTP. To illustrate the potential benefits from this approach, the effect on HLW glass are presented in Section 0 for one simplified feed tank blending case. Section 7.3.2 discusses potential tank farm impacts from feed tank blending.

7.3.1 Blending Half Batches in the Feed Transfer Tanks

Initial work showed that the 116 macro batch grouping and sequence was not well suited to the feed tank blending evaluation. This grouping includes low solids/LAW batches and high solids/HLW batches. Arrangement in the original sequence frequently results in a half of a high solids HLW batch being blended with half of a low solids LAW batch, which differs from the intended blending approach. Therefore the 56 macro batch grouping that roughly simulates incidental blending in WTP was used as the starting point for feed tank blending. To assess the impact of blending in a WTP feed tank, a simplified blending model was developed by assuming tank farm tanks used for transfers to WTP ("feed tanks") are only partially emptied before being refilled. Therefore, the incoming waste batch is always blended with part of the prior batch. The following describes the assumed scenario:

- One half of the first feed batch is transferred to WTP, and then one half the second waste batch is transferred to the feed tank and blended with the residual waste from the first batch. One half the blended feed batch is then transferred to WTP. The balance of the second batch is then blended with remaining contents of the feed tank. The source tank is now empty and ready to receive waste. One half the blended feed batch is then transferred to WTP and it is then refilled with one half the next source batch, and so on.

The 56 macro batch set was used as the starting point. These batches were blended as described above to yield 112 blended macro batches. The feed vector processing sequence was used without attempting to further improve or optimize the processing sequence. Results are shown in Table 7-9 and compared with the 56 macro batch case, the 116 macro batch base case, the 23 macro batch tank farm blending case discussed in Section 7.2, and a total blend of all tank waste. The feed tank blending case shows approximately 11% glass reduction compared to the 56 batch case or 17% reduction compared to the no blend 116 macro batch base case. The feed tank blend case is about 4% higher than the 23 macro batch tank farm blending case and almost 12% higher than the total blend.

While blending to reduce HLW quantity is the main focus of the current study, the modeling results also produced data on LAW glass impacts. LAW glass data is provided for information in Table 7-9 and shows that blending is expected to yield small but significant reductions in LAW glass quantity.

Feed tank blending performance could be further improved by using slightly more complex concepts such as:

- Use two or more source tanks in parallel. For example transfer one half batch from feed tank, then refill from source tank 1 and blend, transfer one half batch from feed tank, then refill from source tank 2. Then either switch back to source tank 1 or transfer the contents of one source tank into the other source tank.

- Use two or more source tanks in series. For example transfer half batch from feed tank, then refill with half batch from source tank 1, then refill source tank 1 from source tank 2.

- Optimization of the waste feed sequence. For example alternate source tanks with opposite limiting components.

- Combine feed tank blending with tank farm blending.

While the above concepts have not been formally analyzed, they are likely to result in significant additional improvement over the simpler feed tank blending scenario results presented in Table 7-9.

Table 7-9. Summary of Blending Results.

Run Identification*	091207-1	091208-1	**091204-1**	090818-6	090819-1
Macro Batch Case	56 Macro Batch	112 Macro Batch Blends	**116 Macro Batch**	23 Macro Batch Blend	Single Macro Batch
Blending scenario	Combine HLW and LAW batches	Feed tank, ½ batch blending	**None**	Tank Farm Blending	Total Blend
HLW Melter Sulfate Retention	67%	67%	**67%**	67%	67%
Average Purge Efficiency for Soluble Components	99%	99%	**99%**	99%	99%
HLW Glass Quantity (MT)	36,400	32,400	**39,200**	31,100	29,000
LAW Glass Quantity (MT)	543,000	532,000	**561,000**	529,000	517,000

*Run Number for SVF-1817 Mission Analysis Glass Batch Blend Results Summary Rev. A.xlsm or MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm. See Appendix A for Glass Run Summary Sheets.
HLW = high-level waste.
LAW = low-activity waste.
MT = metric tons.

7.3.2 Potential Impacts to Tank Farm Operations

There are likely to be a number of impacts to tank farms from implementing a strategy to blend waste in the WTP feed transfer tanks. Potential impacts identified include the following:

- An increase in required tank farm waste transfers can generally be expected from any tank farm blending strategy.

- Increased sampling may be required. The amount of additional sampling will vary with the blending scenario and with tank waste sampling requirements, which have not yet been fully defined.

- There may be some impact to timing/need dates for retrieval and transfer system upgrades to facilitate blending.

Additional Tank Farm Waste Transfers

Estimating the number of additional transfers for feed tank blending depends in part on assumptions concerning transfers from the source tanks directly to WTP. If one assumes that a the same feed tank is generally used for HLW transfers to WTP, then about seven transfers are required to transfer a nominal 1 Mgal batch from each source tank to WTP (one transfer from the source tank to the feed tank and six transfers from the feed tank to WTP). However, if it is assumed that each source tank transfers directly to WTP, then only six transfers are required per source tank. For the feed tank blending scenario eight transfers are required per source tank: six transfers from the feed tank to WTP plus two transfers from the source tank to the feed tank, assuming half of the source tank contents are transferred each time. The additional transfers per source tank batch are then either 1 or 2. Using the larger number (2) and assuming 56 HLW source tank batches, 112 additional transfers are required.

Feed tank blending could also be considered for LAW batches. If it were applied to all 116 HLW and LAW source tank batches, and a conservative value of two extra transfers per batch is assumed, 232 additional transfers are required.

Based on a cost allowance of $192,000 average per transfer (Shuford, D., 2009-09-08,) the estimated maximum cost for additional transfers is $22 million for 112 transfers to $45 million for 232 transfers (likely near the low end of this range).

Sampling and Retrieval System Impacts

The impact to tank waste sampling depends on the interpretation of sampling requirements and the overall blending scenario. There is no apparent effect on the amount of tank farm sampling and analysis required if it is assumed that when the initial feed tank batch and each source tank batch are sampled and qualified the subsequent feed tank blend does not have to be resampled. On the other hand if the feed tank must be resampled and qualified each time it is blended then it appears that the required amount of sampling and analysis could roughly double for the batches that are blended. If each of the 112 sludge batch blends must be sampled rather than the 56 sludge source batches, 56 additional sampling events would be required. If the blending and sampling logic is also applied to the low solids LAW batches up to 116 additional sampling events could be required.

Sampling of the source tanks prior to blending appears to be clearly the preferred approach if resampling the feed tank after blending can be avoided. Besides reducing the number of sampling events, it should improve overall staging and transfer logistics.

Tank farm blending may result in a modest acceleration of the need dates for retrieval systems and source tank sampling. For example, with no blending the second tank would not need to make a transfer until the first tank was empty. With the example feed tank blending approach, the second tank would need to transfer to the feed tank when it is only half empty. Therefore, the need date for transfers from second tank is moved up by the amount of time required to process half the contents of the first tank.

7.4 QUALITATIVE ASSESSMENT OF BLENDING ALTERNATIVES

The blending concepts presented herein were subjected to a qualitative assessment against each of the seven criterion briefly described below.

- **Safety** – Safety factors include, but are not limited to, criticality safety, radiological safety, and industrial safety.
- **Regulatory** – The assessment considers any issues that might create unusual difficulties associated with permitting, regulatory agency acceptance, or stakeholder acceptance.
- **Technical Maturity** – An assessment of the concepts/technology robustness.
- **Operability and Maintainability** – Potential operability and maintainability issues including, but not limited to, complexity of process control and operations, and generation of secondary wastes.
- **Programmatic Risk** – An assessment of the programmatic risk including compatibility with the RPP System (e.g., the effect on immobilized waste volume) and the potential acceptance of the technology by Management (WRPS, U.S. Department of Energy Office of River Protection, etc.) and stakeholders.
- **Schedule** – Positive or negative impact to the RPP mission schedule.
- **Cost** – Positive or negative impact to the RPP mission lifecycle cost.

Table 7-10 presents a qualitative assessment for tank blending alternatives presented in this study. Cost and schedule impacts are summarized in the table. Additional cost and schedule details are provided in subsequent sections.

Table 7-10. Qualitative Assessments of Tank Blending Alternatives.

Criterion	Assessment Conclusions
Safety	Worker safety risk may be increased due to increased number of tank farm transfers, but decreased by shortened mission duration and reduced number of glass filled canisters to handle and ship.
Regulatory	Blending does not require any additional permitting.
Technical Maturity	Transfers are a relatively robust technology (TRL > 6).
Operability and Maintainability	Additional waste transfers may minimally increase the maintenance required on the waste transfer system. Blending provides a more uniform feed to WTP, which is expected to improve operations.
Programmatic Risk	Reducing the quantity of HLW reduces overall schedule risk. No issues were identified that increase programmatic risks.
Schedule	Blending is expected to decrease mission duration.
Cost	Blending increases tank farms operating costs, while reducing costs for WTP operations and immobilized HLW transportation and disposal. Overall mission costs are expected to be significantly reduced by blending.

HLW = high-level waste.
TRL = Technology Readiness Level.
WTP =Waste Treatment and Immobilization Plant.

7.4.1 Schedule Impact

Blending will reduce the amount of HLW produced thereby shortening the lifecycle of the HLW treatment facility. It is estimated that 2 to 3 years of WTP operations can be eliminated by the blending options, assuming that other portion of the project keep up with HLW processing.

7.4.2 Cost Impact

Costs to implement blending are expected to be modest and primarily involve an increased number of tank farm transfers. Based on a cost allowance of $192,000 average per transfer (Shuford, D., 2009-09-08) the estimated cost range for additional transfers is from $22 million for 112 transfers to $45 million for 232 transfers (likely near the low end of this range). Cost savings are expected to result from reduced IHLW canisters to be stored, transported and disposed; and reduced operating duration for the WTP. Table 7-11 shows the calculation of potential cost savings for tank farm blending and feed tank blending as compared to WTP incidental blending. Blending is also expected to result in some reduction in immobilize LAW and improvement in plant operations due to a more uniform feed. These potential benefits are not counted in the projected cost savings calculations shown in Table 7-11.

Blending is expected to improve WTP operations by providing more consistent and predictable waste feed material that avoids extremes of composition. The increased average waste loading resulting from blending will allow for faster waste processing. Impacts to tank space vary with scenario and time. With the blending scenarios presented, tank space impacts in the early years are expected to be small. Based on expected faster waste processing rates, tank space may be increased in the later years.

Table 7-12 shows the impact of tank blending study on RPP mission requirements.

Table 7-11. Cost Savings for Blending Scenarios.

Blending Case	**112 Macro Batch Blends**	**56 Macro Batch (Base)**	**23 Macro Batch Blend**
Blending scenario	**Feed tank, ½ batch blending**	**WTP Incidental Blending**	**Tank Farm Blending**
Added Tank Farm Costs (millions)[a]	$45	$0	$40
HLW Glass Quantity (MT)	32,400	36,400	31,100
56 Macro Batch HLW Glass Quantity (MT)	36,400	36,400	36,400
HLW Glass Reduction (MT)	4,000	0	5,300
HLW Production Days Reduction (days)[b]	762	0	1,009
HLW Production Years Reduction (years)	2.09	0.0	2.77
HLW Production Savings (millions)[c]	$900	$0	$1,190
HLW Canister Reduction[d]	1,315	0	1,743
HLW Canister Savings (millions)[e]	$1,580	$0	$2,090
Total HLW Blending Savings (millions, rounded)	$2,435	$0	$3,240

[a] Maximum number of transfers times $192,000/transfer.
[b] Based on glass production rate of 5.25 MT/day from ORP-11242, 2009, *River Protection Project System Plan,* Rev. 4, Office of River Protection, U.S. Department of Energy, Richland, Washington.
[c] Equal to the number of years times $430 million/year.
[d] Based on HLW canister glass capacity of 3.04 MT from ORP-11242.
[e] Based on $1.2 million cost per HLW canister for offsite transportation and disposal.

HLW = high-level waste. MT = metric tons.

Table 7-12. Qualitative Assessment of Tank Blending against River Protection Project Mission Requirements.

MAR Criterion*	Assessment Conclusions
RPP Mission Success Criteria	Allows early WTP mission completion.
No new capital project work before 2014	No capital equipment.
WTP Pretreatment Facility	No impact
WTP LAW Vitrification Facility	No significant impact.
WTP HLW Vitrification Facility	Decreases mission duration for HLW vitrification facility.
Supplemental Pretreatment Facility	Increases capacity required for supplemental pretreatment to support reduced HLW vitrification duration.
Second LAW Facility	Increases capacity required for second LAW Facility to support reduced HLW vitrification duration. Partly offset by small reduction in total LAW glass required.
Supplemental CH-TRU Treatment and Packaging Facility	No impact
Waste Disposal Quantities	Reduces the amount of IHLW and ILAW.
DST Space	Varies with scenario. Impact not large.
Secondary Waste Quantities	No impact to quantity, but increases the capacity required to support reduced tank waste processing mission duration
Closure	No impact

* Section 2.0 in RPP-RPT-41742, 2009, *River Protection Project Mission Analysis Report*, Rev. 0, Washington River Protection Solutions, Richland, Washington.

CH-TRU = contact-handled transuranic (waste).
DST = double-shell tank.
HLW = high-level waste.
IHLW = immobilized high-level waste.
ILAW = immobilized low-activity waste.
LAW = low-activity waste.
MAR = mission analysis report.
RPP = River Protection Project.
WTP = Waste Treatment and Immobilization Plant.

7.5 APPLICATION TO HANFORD TANK WASTE OPERATION SIMULATOR MODELING

Blending options should be considered in developing future system plan updates to support improved feed staging plans and related program and project activities. Transfer rules, batch selection algorithms, or other methods could be developed to allow HTWOS to define waste batch staging scenarios that minimize required glass volumes. Or alternatively, the blending strategy could be supplied as an input to HTWOS. Based on experience during development of the current study the following ideas are offered as a starting point.

- The glass models are an effective tool for identifying potentially attractive batches to be blended. Typically, attractive blending candidates have glass compositions with different primary limiting components or properties. Ideally, the secondary limiting components of each batch should also be different than the primary and secondary limiting components of the other batch. Primary limiting components or properties are defined as the components or properties that actually limit waste loading for a given waste batch. Secondary limiting components or properties are those that are near but below their limits with the optimized glass formulation.

- A method is needed to convert raw waste compositions into estimated melter feed/glass compositions to provide waste feed input data for the glass models. The Process Stream Calculator worksheet has proven to be useful for this purpose in the current study and does not require complex iterative calculations. A similar approach could be considered to assist in selecting candidate feed blending batches for HTWOS. Alternatively the existing HTWOS or WTP G2 models could be used.

- Implementation of a feed transfer tank blending strategy into HTWOS may be relatively straight forward if it is based on simply accepting the waste staging sequence that is presented rather than attempting to also optimize the retrieval and staging sequence based on blending. The concept of leaving substantial heels in tanks prior to refilling could also be applied further back in the staging supply chain to accomplish additional incidental blending.

- Development of a computer routine to allow HTWOS to automatically select an optimized staging, blending, and transfer sequence could prove to be fairly complex. An alternative is to perform waste blending optimization studies and provide the results as input to HTWOS in order to support System Plan updates. This could involve identification of attractive candidate blend sets based on glass models and limiting components; trial runs with HTWOS to help refine the candidate blend sets; and input from tank farms, project, and program personnel as to waste staging and sequence alternatives that are likely to be practical.

- The preferred approach may involve implementation of some automatic calculation features into HTWOS coupled with targeted blending studies to support major System Plan updates.

8.0 REFERENCES

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SVF-1663, *Balance_Graphic_SP4_PC_2009_03_30_at_20_02_39.xls, SP4 Planning Case-3.0-8.4r0-2009-03-30-at-20-02-39*, Rev 1, April 2, 2009, Washington River Protection Solutions, LLC, Richland, Washington.

APPENDIX A - HIGH-LEVEL WASTE GLASS RUN SUMMARIES

High Level Waste Glass Run Summaries

Index of Glass Runs			
Glass Results File	Comments	Stream Calculator File	Description
090818-1	LAW glass 5.61E+08 kg HLW Glass (MT) 3.92E+04	090817-1	Base case 116 macro batch
090818-2	HLW Glass (MT) 4.51E+04	090817-2	Low wash efficiency 116 macro batch
090818-3	HLW Glass (MT) 3.75E+04	090817-3	High Wash Efficiency 116 macro batch
090818-4	HLW Glass (MT) 4.26E+04	090817-4	100% melter sulfate retention 116 macro batch
090818-6	LAW Glass 5.29E+08 kg HLW Glass (MT) 3.11E+04	090818-1	Base case 23 macro batch
090818-7	HLW Glass (MT) 3.58E+04	090818-2	Low (80%) wash efficiency23 macro batch
090818-8	HLW Glass (MT) 3.33E+04	090818-3	100% melter sulfate retention, otherwise base case, 23 macro batch
090818-9	HLW Glass (MT) 4.15E+04	090818-4	100% sulfate retention and low (80%) wash eff. 23 macro batch
090819-1	LAW Glass 5.17E+08 kg HLW Glass (MT) 2.90E+04	090818-5	Base case single macro batch Also includes washing study on feed stream calculator sheet LAG
090819-2	HLW Glass (MT) 2.91E+04	090818-6	100% melter sulfate retention single macro batch
090819-3	HLW Glass (MT) 3.74E+04	090819-1	Low (40%) melter sulfate retention, otherwise Base case 116 macro batch
090819-4	HLW Glass (MT) 5.08E+04	090819-2	100% sulfate retention and low wash eff. 116 macro batch
090820-1	LAW Glass 5.29E+08kg HLW Glass (MT)3.09E+04	090820-1	Base Case 21 Macro batch
090831-1	HLW Glass (MT) 4.51E+04	090831-1	90% Wash Efficiency, 100% sulfate retention, 116 macro batch
090831-2	HLW Glass (MT) 4.11E+04	090831-2	90% Wash Efficiency, 67% melter sulfate retention 116 macro batch
091204-1	HLW Glass (MT)3.924E+04 LAW Glass (MT) 5.613E+05	091204-1	Base case 116 macro batch (repeat run of glass run 090818-1 with finalized versions of spreadsheets)
091207-1-	HLW Glass (MT)3.64E+04 LAW Glass (MT) 5.434E+05	091204-1	56 Macro Batch-WTP Incidental Blending. 95% Wash Efficiency, 67% melter sulfate retention
091208-1	HLW Glass (MT)3.24E+04 LAW Glass (MT) 5.32E+05	091208-1	56 Macro Batch-WTP Incidental Blending. Blended to 112 batches by transferring half the batch then refilling feed transfer tank.

	HLW GLASS PRODUCTION ESTIMATE SUMMARY RESULTS				
BASE CASE					
Case Description:					
090818-1-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm					
Waste feed:					
090813-1 SVF-MAR03 - Feed Vector to Macro Batch Calculator - Rev G.xlsm					
SP4 Unconstrained Case Feed Vector Batches - 116 macro batches					
090817-1-SVF-MAR04 Macro Batch to Process Stream Calculator Rev. D.xlsm					
WTP Process					
Base Case Run 116 macro batch					
Base Case Run 116 macro batch					
Selected		Symbol	Value	Symbol	Value
Parameters		PNa,LAT,15	1.500	PS,29a,19	0.3300
		Pwash,S	0.050	IXNa	235
		PNa(aq),19b,15LSol	0.023	Pwash,Al	0.050
Glass Model:		YYMMDD_N HLW Glass SVF-1623 Rev. 0-A			
Glass Limits		Reference case limits from RPP-MA SP3_HLW_Glass_Limit - Rev A			
Summary resu	090818-1-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm				
	Base Case Run 116 macro batch				
	YYMMDD_N HLW Glass SVF-1623 Rev. 0-A				
Limiting	Number of	Waste oxide	Glass Mas	Ave Waste	Percent of
Component	Feed Batches	MT	MT	Loading	Glass mass
SO3	18	1.56E+03	5.80E+03	26.82%	14.77%
P2O5	5	2.95E+02	1.03E+03	28.61%	2.63%
Cr2O3	1	1.17E+02	2.53E+02	46.01%	0.65%
Al2O3	14	3.18E+03	1.25E+04	25.50%	31.82%
Fe2O3	4	3.57E+02	1.09E+03	32.69%	2.78%
Na2O	34	1.26E+03	3.31E+03	38.17%	8.42%
Zr	2	3.50E+02	2,976	11.75%	7.58%
Other	38	5.40E+03	1.23E+04	43.91%	31.34%
Total	116	1.25E+04	3.92E+04	31.90%	100%

	HLW GLASS PRODUCTION ESTIMATE SUMMARY RESULTS				
Low Washing Efficiency					
Case Description:					
090818-2-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm					
Waste feed:					
090813-1 SVF-MAR03 - Feed Vector to Macro Batch Calculator - Rev G.xlsm					
SP4 Unconstrained Case Feed Vector Batches - 116 macro batches					
090817-2-SVF-MAR04 Macro Batch to Process Stream Calculator Rev. D.xlsm					
WTP Process					
Low (80 %) wash efficiency, otherwise Base Case Run					
Evaluate low wash efficiency with 116 macro batch					
Selected		Symbol	Value	Symbol	Value
Parameters		PNa,LAT,15	1.500	PS,29a,19	0.3300
		Pwash,S	0.200	IXNa	235
		PNa(aq),19b,15LSol	0.088	Pwash,Al	0.200
Glass Model:		YYMMDD_N HLW Glass SVF-1623 Rev. 0-A			
Glass Limits		Reference case limits from RPP-MA SP3_HLW_Glass_Limit - Rev			
Summary results:	090818-2-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm				
	Low (80 %) wash efficiency, otherwise Base Case Run				
	YYMMDD_N HLW Glass SVF-1623 Rev. 0-A				
Limiting	Number of	Waste oxide	Glass Mass	Ave Waste	Percent of
Component	Feed Batches	MT	MT	Loading	Glass mass
SO3	29	2.84E+03	1.02E+04	27.97%	22.52%
P2O5	5	5.76E+02	1.53E+03	37.68%	3.39%
Cr2O3	1	1.48E+02	3.93E+02	37.70%	0.87%
Al2O3	12	3.68E+03	1.30E+04	28.24%	28.87%
Fe2O3	3	3.78E+02	1.02E+03	37.12%	2.26%
Na2O	41	2.20E+03	5.48E+03	40.22%	12.14%
Zr	2	349.585319	2970.628857	11.77%	6.58%
Other	23	4.77E+03	1.06E+04	45.22%	23.38%
Total	116	1.49E+04	4.51E+04	33.12%	100%

	HLW GLASS PRODUCTION ESTIMATE SUMMARY RESULTS				
100% Washing Efficiency					
Case Description:					
090818-3-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm					
Waste feed:					
090813-1 SVF-MAR03 - Feed Vector to Macro Batch Calculator - Rev G.xlsm					
SP4 Unconstrained Case Feed Vector Batches - 116 macro batches					
090817-3-SVF-MAR04 Macro Batch to Process Stream Calculator Rev. D.xlsm					
WTP Process					
100 % wash efficiency, otherwise Base Case Run					
Evaluate very high wash efficiency with 116 macro batch					
Selected		Symbol	Value	Symbol	Value
Parameters		PNa,LAT,15	1.500	PS,29a,19	0.3300
		Pwash,S	0.000	IXNa	235
		PNa(aq),19b,15LSol	0.000	Pwash,Al	0.000
Glass Model:		YYMMDD_N HLW Glass SVF-1623 Rev. 0-A			
Glass Limits		Reference case limits from RPP-MA SP3_HLW_Glass_Limit - Rev A			
Summary results:	090818-3-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm				
	100 % wash efficiency, otherwise Base Case Run				
	YYMMDD_N HLW Glass SVF-1623 Rev. 0-A				
Limiting	Number of	Waste oxide	Glass Mass	Ave Waste	Percent of
Component	Feed Batches	MT	MT	Loading	Glass mass
SO3	17	1.43E+03	5.10E+03	28.05%	13.61%
P2O5	5	2.82E+02	1.02E+03	27.73%	2.71%
Cr2O3	0	0.00E+00	0.00E+00	N/A	0.00%
Al2O3	14	2.94E+03	1.21E+04	24.21%	32.37%
Fe2O3	4	3.38E+02	1.09E+03	30.92%	2.91%
Na2O	34	1.16E+03	2.96E+03	39.12%	7.89%
Zr	2	349.585319	2977.501046	11.74%	7.94%
Other	40	5.18E+03	1.22E+04	42.40%	32.57%
Total	116	1.17E+04	3.75E+04	31.13%	100%

	HLW GLASS PRODUCTION ESTIMATE SUMMARY RESULTS				
100 % sulfate retention					
Case Description:					
090818-4-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm					
Waste feed:					
090813-1 SVF-MAR03 - Feed Vector to Macro Batch Calculator - Rev G.xlsm					
SP4 Unconstrained Case Feed Vector Batches - 116 macro batches					
090817-4-SVF-MAR04 Macro Batch to Process Stream Calculator Rev. D.xlsm					
WTP Process					
100 % HLW melter sulfate retention otherwise Base Case Run					
Evaluate sensitivity to 100% sulfate retention 116 macro batch					
Selected		Symbol	Value	Symbol	Value
Parameters		PNa,LAT,15	1.500	PS,29a,19	0.0000
		Pwash,S	0.050	IXNa	235
		PNa(aq),19b,15LSol	0.023	Pwash,Al	0.050
Glass Model:		YYMMDD_N HLW Glass SVF-1623 Rev. 0-A			
Glass Limits		Reference case limits from RPP-MA SP3_HLW_Glass_Limit - Rev			
Summary results:	090818-4-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm				
	100 % HLW melter sulfate retention otherwise Base Case Run				
	YYMMDD_N HLW Glass SVF-1623 Rev. 0-A				
Limiting	Number of	Waste oxide	Glass Mass	Ave Waste	Percent of
Component	Feed Batches	MT	MT	Loading	Glass mass
SO3	32	2.52E+03	1.11E+04	22.66%	26.16%
P2O5	4	2.43E+02	8.67E+02	28.01%	2.04%
Cr2O3	1	1.17E+02	2.53E+02	46.04%	0.59%
Al2O3	12	3.02E+03	1.20E+04	25.10%	28.23%
Fe2O3	4	3.58E+02	1.09E+03	32.73%	2.57%
Na2O	32	1.17E+03	3.10E+03	37.79%	7.28%
Zr	2	349.585319	2975.497942	11.75%	6.99%
Other	29	4.77E+03	1.11E+04	42.88%	26.15%
Total	116	1.26E+04	4.26E+04	29.48%	100%

	HLW GLASS PRODUCTION ESTIMATE SUMMARY RESULTS				
Case Description:					
090818-6-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm					
Waste feed:					
09-08-13-2 SVF-MAR03 - Feed Vector to Macro Batch Calculator - Rev G.xlsm					
SP4 Unconstrained Case Feed Vector Batches - 23 Batch blending evaluation					
090818-1-SVF-MAR04 Macro Batch to Process Stream Calculator Rev. D.xlsm					
WTP Process					
Base Case run 23 macro batch blend					
evaluate effect of partial blending					
Selected		Symbol	Value	Symbol	Value
Parameters		PNa,LAT,15	1.500	PS,29a,19	0.3300
		Pwash,S	0.050	IXNa	235
		PNa(aq),19b,15LSol	0.023	Pwash,Al	0.050
Glass Model:		YYMMDD_N HLW Glass SVF-1623 Rev. 0-A			
Glass Limits		Reference case limits from RPP-MA SP3_HLW_Glass_Limit - Rev A			
Summary results:	090818-6-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm				
	Base Case run 23 macro batch blend				
	YYMMDD_N HLW Glass SVF-1623 Rev. 0-A				
Limiting	Number of	Waste oxide	Glass Mass	Ave Waste	Percent of
Component	Feed Batches	MT	MT	Loading	Glass mass
SO3	3	1.45E+03	3.63E+03	39.86%	11.68%
P2O5	1	1.10E+02	3.17E+02	34.78%	1.02%
Cr2O3	0	0.00E+00	0.00E+00	N/A	0.00%
Al2O3	2	6.39E+02	1.99E+03	32.19%	6.39%
Fe2O3	2	3.22E+02	1.00E+03	32.18%	3.22%
Na2O	1	1.33E+00	3.59E+00	37.02%	0.01%
Zr	1	6.57E+02	1,883	34.88%	6.06%
Other	13	9.29E+03	2.23E+04	41.71%	71.63%
Total	23	1.25E+04	3.11E+04	40.10%	100%

	HLW GLASS PRODUCTION ESTIMATE SUMMARY RESULTS				
23 Batch Low wash efficiency					
Case Description:					
090818-7-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm					
Waste feed:					
09-08-13-2 SVF-MAR03 - Feed Vector to Macro Batch Calculator - Rev G.xlsm					
SP4 Unconstrained Case Feed Vector Batches - 23 Batch blending evaluation					
090818-2-SVF-MAR04 Macro Batch to Process Stream Calculator Rev. D.xlsm					
WTP Process					
Low wash eff (80%) otherwise Base Case run					
Low wash efficiency, 23 Macro Batch blending					
Selected		Symbol	Value	Symbol	Value
Parameters		PNa,LAT,15	1.500	PS,29a,19	0.3300
		Pwash,S	0.200	IXNa	235
		PNa(aq),19b,15LSol	0.088	Pwash,Al	0.200
Glass Model:		YYMMDD_N HLW Glass SVF-1623 Rev. 0-A			
Glass Limits		Reference case limits from RPP-MA SP3_HLW_Glass_Limit - Rev A			
Summary results:	090818-7-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm				
	Low wash eff (80%) otherwise Base Case run				
	YYMMDD_N HLW Glass SVF-1623 Rev. 0-A				
Limiting	Number of	Waste oxide	Glass Mass	Ave Waste	Percent of
Component	Feed Batches	MT	MT	Loading	Glass mass
SO3	5	2.76E+03	7.81E+03	35.29%	21.81%
P2O5	1	1.25E+02	3.35E+02	37.26%	0.94%
Cr2O3	0	0.00E+00	0.00E+00	N/A	0.00%
Al2O3	1	3.80E+02	1.17E+03	32.51%	3.26%
Fe2O3	2	3.71E+02	1.00E+03	37.07%	2.80%
Na2O	2	1.84E+01	5.56E+01	33.14%	0.16%
Zr	1	7.49E+02	1,883	39.80%	5.26%
Other	11	1.03E+04	2.35E+04	43.85%	65.78%
Total	23	1.47E+04	3.58E+04	41.13%	100%

	HLW GLASS PRODUCTION ESTIMATE SUMMARY RESULTS				
23 Batch 100 % melter sulfate retention					
Case Description:					
090818-8-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm					
Waste feed:					
09-08-13-2 SVF-MAR03 - Feed Vector to Macro Batch Calculator - Rev G.xlsm					
SP4 Unconstrained Case Feed Vector Batches - 23 Batch blending evaluation					
090818-3-SVF-MAR04 Macro Batch to Process Stream Calculator Rev. D.xlsm					
WTP Process					
100 % HLW melter sulfate retention otherwise base case					
high melter sulfate retention, 23 Macro Batch blending					
Selected		Symbol	Value	Symbol	Value
Parameters		PNa,LAT,15	1.500	PS,29a,19	0.0000
		Pwash,S	0.050	IXNa	235
		PNa(aq),19b,15LSol	0.023	Pwash,Al	0.050
Glass Model:		YYMMDD_N HLW Glass SVF-1623 Rev. 0-A			
Glass Limits		Reference case limits from RPP-MA SP3_HLW_Glass_Limit - Rev A			
Summary results:	090818-8-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm				
	100 % HLW melter sulfate retention otherwise base case				
	YYMMDD_N HLW Glass SVF-1623 Rev. 0-A				
Limiting	Number of	Waste oxide	Glass Mass	Ave Waste	Percent of
Component	Feed Batches	MT	MT	Loading	Glass mass
SO3	4	1.84E+03	6.62E+03	27.73%	19.89%
P2O5	1	1.11E+02	3.17E+02	34.86%	0.95%
Cr2O3	0	0.00E+00	0.00E+00	N/A	0.00%
Al2O3	2	6.41E+02	1.99E+03	32.27%	5.96%
Fe2O3	2	3.23E+02	1.00E+03	32.22%	3.01%
Na2O	1	1.33E+00	3.59E+00	37.02%	0.01%
Zr	1	6.57E+02	1,883	34.92%	5.66%
Other	12	8.93E+03	2.15E+04	41.57%	64.52%
Total	23	1.25E+04	3.33E+04	37.54%	100%

	HLW GLASS PRODUCTION ESTIMATE SUMMARY RESULTS				
Case Description:					
090818-9-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm					
Waste feed:					
09-08-13-2 SVF-MAR03 - Feed Vector to Macro Batch Calculator - Rev G.xlsm					
SP4 Unconstrained Case Feed Vector Batches - 23 Batch blending evaluation					
090818-4-SVF-MAR04 Macro Batch to Process Stream Calculator Rev. D.xlsm					
WTP Process					
Low wash eff (80%), 100 % HLW melter sulfate retention					
Low wash efficiency,high melter sulfate retention, 23 Macro Batch blending					
Selected		Symbol	Value	Symbol	Value
Parameters		PNa,LAT,15	1.500	PS,29a,19	0.0000
		Pwash,S	0.200	IXNa	235
		PNa(aq),19b,15LSol	0.088	Pwash,Al	0.200
Glass Model:		YYMMDD_N HLW Glass SVF-1623 Rev. 0-A			
Glass Limits		Reference case limits from RPP-MA SP3_HLW_Glass_Limit - Rev A			
Summary results:	090818-9-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm				
	Low wash eff (80%), 100 % HLW melter sulfate retention				
	YYMMDD_N HLW Glass SVF-1623 Rev. 0-A				
Limiting	Number of	Waste oxide	Glass Mass	Ave Waste	Percent of
Component	Feed Batches	MT	MT	Loading	Glass mass
SO3	10	7.43E+03	2.38E+04	31.30%	57.24%
P2O5	1	1.25E+02	3.35E+02	37.39%	0.81%
Cr2O3	0	0.00E+00	0.00E+00	N/A	0.00%
Al2O3	1	3.81E+02	1.17E+03	32.61%	2.82%
Fe2O3	2	3.72E+02	1.00E+03	37.14%	2.41%
Na2O	2	1.84E+01	5.55E+01	33.17%	0.13%
Zr	1	7.50E+02	1,883	39.84%	4.54%
Other	6	5.70E+03	1.33E+04	42.89%	32.05%
Total	23	1.48E+04	4.15E+04	35.63%	100%

	HLW GLASS PRODUCTION ESTIMATE SUMMARY RESULTS				
Case Description:					
090819-1-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm					
Waste feed:					
090818-1 SVF-MAR03 - Feed Vector to Macro Batch Calculator - Rev G.xlsm					
SP4 Unconstrained Case Feed Vector Batches - Single Macro Batch					
090818-5-SVF-MAR04 Macro Batch to Process Stream Calculator Rev. D.xlsm					
WTP Process					
Base Case Single Macro Batch					
Single macro batch or total blend base case run					
Selected		Symbol	Value	Symbol	Value
Parameters		PNa,LAT,15	1.500	PS,29a,19	0.3300
		Pwash,S	0.050	IXNa	235
		PNa(aq),19b,15LSol	0.023	Pwash,Al	0.050
Glass Model:		YYMMDD_N HLW Glass SVF-1623 Rev. 0-A			
Glass Limits		Reference case limits from RPP-MA SP3_HLW_Glass_Limit - Rev A			
Summary results:	090819-1-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm				
	Base Case Single Macro Batch				
	YYMMDD_N HLW Glass SVF-1623 Rev. 0-A				
Limiting	Number of	Waste oxide	Glass Mass	Ave Waste	Percent of
Component	Feed Batches	MT	MT	Loading	Glass mass
SO3	0	0.00E+00	0.00E+00	N/A	0.00%
P2O5	0	0.00E+00	0.00E+00	N/A	0.00%
Cr2O3	0	0.00E+00	0.00E+00	N/A	0.00%
Al2O3	0	0.00E+00	0.00E+00	N/A	0.00%
Fe2O3	0	0.00E+00	0.00E+00	N/A	0.00%
Na2O	0	0.00E+00	0.00E+00	N/A	0.00%
Zr	0	0.00E+00	0	#DIV/0!	0.00%
Other	1	1.24E+04	2.90E+04	42.94%	100.00%
Total	1	1.24E+04	2.898E+04	42.94%	100%

	HLW GLASS PRODUCTION ESTIMATE SUMMARY RESULTS				
Case Description:					
090819-2-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm					
Waste feed:					
090818-1 SVF-MAR03 - Feed Vector to Macro Batch Calculator - Rev G.xlsm					
SP4 Unconstrained Case Feed Vector Batches - Single Macro Batch					
090818-6-SVF-MAR04 Macro Batch to Process Stream Calculator Rev. D.xlsm					
WTP Process					
100% melte sulfate retention, otherwise Base Case Single Macro Batch					
High meler sulfate retention, Single macro batch or total blend					
Selected		Symbol	Value	Symbol	Value
Parameters		PNa,LAT,15	1.500	PS,29a,19	0.0000
		Pwash,S	0.050	IXNa	235
		PNa(aq),19b,15LSol	0.023	Pwash,Al	0.050
Glass Model:		YYMMDD_N HLW Glass SVF-1623 Rev. 0-A			
Glass Limits		Reference case limits from RPP-MA SP3_HLW_Glass_Limit - Rev A			
Summary results:	090819-2-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm				
	100% melte sulfate retention, otherwise Base Case Single Macro Batch				
	YYMMDD_N HLW Glass SVF-1623 Rev. 0-A				
Limiting	Number of	Waste oxide	Glass Mass	Ave Waste	Percent of
Component	Feed Batches	MT	MT	Loading	Glass mass
SO3	0	0.00E+00	0.00E+00	N/A	0.00%
P2O5	0	0.00E+00	0.00E+00	N/A	0.00%
Cr2O3	0	0.00E+00	0.00E+00	N/A	0.00%
Al2O3	0	0.00E+00	0.00E+00	N/A	0.00%
Fe2O3	0	0.00E+00	0.00E+00	N/A	0.00%
Na2O	0	0.00E+00	0.00E+00	N/A	0.00%
Zr	0	0.00E+00	0	#DIV/0!	0.00%
Other	1	1.25E+04	2.91E+04	42.90%	100.00%
Total	1	1.25E+04	2.91E+04	42.90%	100%

	HLW GLASS PRODUCTION ESTIMATE SUMMARY RESULTS				
40 % Sulfate Retention, otherwise base case					
Case Description:					
090819-3-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm					
Waste feed:					
090813-1 SVF-MAR03 - Feed Vector to Macro Batch Calculator - Rev G.xlsm					
SP4 Unconstrained Case Feed Vector Batches - 116 macro batches					
090819-1-SVF-MAR04 Macro Batch to Process Stream Calculator Rev. D.xlsm					
WTP Process					
40 % HLW melter sulfate retention otherwise Base Case Run					
Evaluate sensitivity to low melter sulfate retention 116 macro batch					
Selected		Symbol	Value	Symbol	Value
Parameters		PNa,LAT,15	1.500	PS,29a,19	0.6000
		Pwash,S	0.050	IXNa	235
		PNa(aq),19b,15LSol	0.023	Pwash,Al	0.050
Glass Model:		YYMMDD_N HLW Glass SVF-1623 Rev. 0-A			
Glass Limits		Reference case limits from RPP-MA SP3_HLW_Glass_Limit - Rev A			
Summary results:	090819-3-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm				
	40 % HLW melter sulfate retention otherwise Base Case Run				
	YYMMDD_N HLW Glass SVF-1623 Rev. 0-A				
Limiting	Number of	Waste oxide	Glass Mass	Ave Waste	Percent of
Component	Feed Batches	MT	MT	Loading	Glass mass
SO3	8	5.90E+02	1.79E+03	32.98%	4.78%
P2O5	6	4.69E+02	1.65E+03	28.46%	4.41%
Cr2O3	1	1.16E+02	2.53E+02	45.99%	0.68%
Al2O3	14	3.18E+03	1.25E+04	25.47%	33.38%
Fe2O3	4	3.57E+02	1.09E+03	32.66%	2.92%
Na2O	37	1.31E+03	3.41E+03	38.38%	9.12%
Zr	2	349.585319	2976.026909	11.75%	7.95%
Other	44	6.12E+03	1.38E+04	44.50%	36.76%
Total	116	1.25E+04	3.74E+04	33.39%	100%

	HLW GLASS PRODUCTION ESTIMATE SUMMARY RESULTS				
100% Sulfur Retention , low Washing efficiency					
Case Description:					
090819-4-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm					
Waste feed:					
090813-1 SVF-MAR03 - Feed Vector to Macro Batch Calculator - Rev G.xlsm					
SP4 Unconstrained Case Feed Vector Batches - 116 macro batches					
090819-2-SVF-MAR04 Macro Batch to Process Stream Calculator Rev. D.xlsm					
WTP Process					
100 % HLW melter sulfate retention, Low (80%) wash efficiency					
Evaluate sensitivity to 100% sulfate retention + wash efficiency					
Selected		Symbol	Value	Symbol	Value
Parameters		PNa,LAT,15	1.500	PS,29a,19	0.0000
		Pwash,S	0.200	IXNa	235
		PNa(aq),19b,15LSol	0.088	Pwash,Al	0.200
Glass Model:		YYMMDD_N HLW Glass SVF-1623 Rev. 0-A			
Glass Limits		Reference case limits from RPP-MA SP3_HLW_Glass_Limit - Rev A			
Summary results:	090819-4-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm				
	100 % HLW melter sulfate retention, Low (80%) wash efficiency				
	YYMMDD_N HLW Glass SVF-1623 Rev. 0-A				
Limiting	Number of	Waste oxide	Glass Mass	Ave Waste	Percent of
Component	Feed Batches	MT	MT	Loading	Glass mass
SO3	42	4.98E+03	2.01E+04	24.80%	39.54%
P2O5	4	2.73E+02	9.02E+02	30.32%	1.77%
Cr2O3	1	1.49E+02	3.93E+02	37.75%	0.77%
Al2O3	12	3.68E+03	1.30E+04	28.28%	25.65%
Fe2O3	2	3.72E+02	1.00E+03	37.15%	1.97%
Na2O	35	1.52E+03	4.18E+03	36.41%	8.23%
Zr	2	3.50E+02	2,970	11.77%	5.85%
Other	18	3.67E+03	8.24E+03	44.52%	16.22%
Total	116	1.50E+04	5.08E+04	29.53%	100%

	HLW GLASS PRODUCTION ESTIMATE SUMMARY RESULTS				
21 Macro batch blend Base Case					
Case Description:					
090820-1-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm					
Waste feed:					
090820-1 SVF-MAR03 - Feed Vector to Macro Batch Calculator - Rev G.xlsm					
SP4 Unconstrained Case Feed Vector Batches - 21 Macro Batch Blend					
090820-1-SVF-MAR04 Macro Batch to Process Stream Calculator Rev. D.xlsm					
WTP Process					
Base Case Run 21 Macro Batch					
Evaluate 21 Macro Batch Blending Case					
Selected		Symbol	Value	Symbol	Value
Parameters		PNa,LAT,15	1.500	PS,29a,19	0.3300
		Pwash,S	0.050	IXNa	235
		PNa(aq),19b,15LSol	0.023	Pwash,Al	0.050
Glass Model:		YYMMDD_N HLW Glass SVF-1623 Rev. 0-A			
Glass Limits		Reference case limits from RPP-MA SP3_HLW_Glass_Limit - Rev A			
Summary results:	090820-1-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm				
	Base Case Run 21 Macro Batch				
	YYMMDD_N HLW Glass SVF-1623 Rev. 0-A				
Limiting	Number of	Waste oxide	Glass Mass	Ave Waste	Percent of
Component	Feed Batches	MT	MT	Loading	Glass mass
SO3	3	9.90E+02	2.52E+03	39.33%	8.16%
P2O5	0	0.00E+00	0.00E+00	N/A	0.00%
Cr2O3	0	0.00E+00	0.00E+00	N/A	0.00%
Al2O3	2	1.06E+03	3.20E+03	33.26%	10.36%
Fe2O3	2	3.22E+02	1.00E+03	32.19%	3.24%
Na2O	2	9.09E+02	1.90E+03	47.73%	6.17%
Zr	1	1.05E+03	2,842	36.91%	9.21%
Other	11	8.13E+03	1.94E+04	41.90%	62.86%
Total	21	1.25E+04	30868	40.38%	100%

	HLW GLASS PRODUCTION ESTIMATE SUMMARY RESULTS				
Case Description:					
090831-1-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm					
Waste feed:					
090813-1 SVF-MAR03 - Feed Vector to Macro Batch Calculator - Rev G.xlsm					
SP4 Unconstrained Case Feed Vector Batches - 116 macro batches					
090831-1-SVF-MAR04 Macro Batch to Process Stream Calculator Rev. D.xlsm					
WTP Process					
90% 2nd stage wash efficiency, 100% ,melter sulfate retention					
90% 2nd stage wash efficiency, 100% ,melter sulfate retention					
Selected		Symbol	Value	Symbol	Value
Parameters		PNa,LAT,15	1.500	PS,29a,19	0.0000
		Pwash,S	0.100	IXNa	235
		PNa(aq),19b,15LSol	0.045	Pwash,Al	0.100
Glass Model:		YYMMDD_N HLW Glass SVF-1623 Rev. 0-A			
Glass Limits		Reference case limits from RPP-MA SP3_HLW_Glass_Limit - Rev A			
Summary results:	090831-1-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm				
	90% 2nd stage wash efficiency, 100% ,melter sulfate retention				
	YYMMDD_N HLW Glass SVF-1623 Rev. 0-A				
Limiting	Number of	Waste oxide	Glass Mass	Ave Waste	Percent of
Component	Feed Batches	MT	MT	Loading	Glass mass
SO3	35	3.33E+03	1.39E+04	23.96%	30.80%
P2O5	4	2.53E+02	8.78E+02	28.81%	1.95%
Cr2O3	1	1.27E+02	3.00E+02	42.46%	0.67%
Al2O3	12	3.24E+03	1.24E+04	26.24%	27.40%
Fe2O3	4	3.76E+02	1.09E+03	34.45%	2.42%
Na2O	32	1.26E+03	3.41E+03	37.03%	7.56%
Zr	2	3.50E+02	2.97E+03	11.76%	6.59%
Other	26	4.44E+03	1.02E+04	43.53%	22.62%
Total	116	1.34E+04	4.51E+04	29.67%	100%

	HLW GLASS PRODUCTION ESTIMATE SUMMARY RESULTS				
Case Description:					
090831-2-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm					
Waste feed:					
090813-1 SVF-MAR03 - Feed Vector to Macro Batch Calculator - Rev G.xlsm					
SP4 Unconstrained Case Feed Vector Batches - 116 macro batches					
090831-2-SVF-MAR04 Macro Batch to Process Stream Calculator Rev. D.xlsm					
WTP Process					
90 % 2nd stage wash eff, 67% ,melter sulfate retention					
90% wash eff, otherwise Base Case Run 116 macro batch					
Selected		Symbol	Value	Symbol	Value
Parameters		PNa,LAT,15	1.500	PS,29a,19	0.3300
		Pwash,S	0.100	IXNa	235
		PNa(aq),19b,15LSol	0.045	Pwash,Al	0.100
Glass Model:		YYMMDD_N HLW Glass SVF-1623 Rev. 0-A			
Glass Limits		Reference case limits from RPP-MA SP3_HLW_Glass_Limit - Rev A			
Summary results:	090831-2-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. C.xlsm				
	90 % 2nd stage wash eff, 67% ,melter sulfate retention				
	YYMMDD_N HLW Glass SVF-1623 Rev. 0-A				
Limiting	Number of	Waste oxide	Glass Mass	Ave Waste	Percent of
Component	Feed Batches	MT	MT	Loading	Glass mass
SO3	21	1.91E+03	6.98E+03	27.31%	16.99%
P2O5	5	3.08E+02	1.05E+03	29.43%	2.55%
Cr2O3	1	1.27E+02	3.00E+02	42.42%	0.73%
Al2O3	14	3.42E+03	1.28E+04	26.65%	31.26%
Fe2O3	4	3.76E+02	1.09E+03	34.40%	2.66%
Na2O	35	1.32E+03	3.55E+03	37.22%	8.64%
Zr	2	3.50E+02	2,974	11.75%	7.24%
Other	34	5.53E+03	1.23E+04	45.01%	29.93%
Total	116	1.33E+04	4.11E+04	32.48%	100%

	HLW GLASS PRODUCTION ESTIMATE SUMMARY RESULTS				
Case Description:					
091204-1-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. D.xlsm					
Description: 116 macro batch base case					
Waste feed:					
091204-1 SVF-1768 - Macro Batch Calculator - UC - Rev B.xlsm					
SP4 Unconstrained Case Feed Vector Batches - 116 Macro Batch					
091204-1-SVF-1767 Mission Analysis Process Stream Calculator Rev. A.xlsm					
WTP Process					
116 macro batch base case					
rerun of 116 macro batch base case					
Selected		Symbol	Value	Symbol	Value
Parameters		PNa,LAT,15	1.500	PS,29a,19	0.3300
		Pwash,S	0.050	IXNa	235
		PNa(aq),19b,15LSol	0.023	Pwash,Al	0.050
Glass Model:		SVF-1623			
Glass Limits		Reference case limits from RPP-MA SP3_HLW_Glass_Limit - Rev A			
Summary results:	091204-1-SVF-MAR05 HLW Glass Batch Blend Results Summary Rev. D.xlsm				
	116 macro batch base case				
	SVF-1623				
Limiting	Number of	Waste oxide	Glass Mass	Ave Waste	Percent of
Component	Feed Batches	MT	MT	Loading	Glass mass
SO3	18	1.56E+03	5.80E+03	26.82%	14.77%
P2O5	5	2.95E+02	1.03E+03	28.61%	2.63%
Cr2O3	1	1.17E+02	2.53E+02	46.00%	0.65%
Al2O3	14	3.18E+03	1.25E+04	25.50%	31.82%
Fe2O3	4	3.57E+02	1.09E+03	32.69%	2.78%
Na2O	35	1.26E+03	3.31E+03	38.17%	8.42%
Zr	2	3.50E+02	2,976	11.75%	7.58%
Other	37	5.40E+03	1.23E+04	43.91%	31.34%
Total	116	1.25E+04	3.924E+04	31.90%	100%

	HLW GLASS PRODUCTION ESTIMATE SUMMARY RESULTS				
Case Description:					
091207-1-SVF-1817 Mission Analysis Glass Batch Blend Results Summary Rev. A.xlsm					
Description: 56 Batch Base Case					
Waste feed:					
090911-1 SVF-1757 - Feed Vector to Macro Batch Calculator - Rev A.xlsx					
SP4 Unconstrained Case Feed Vector Batches - 56 Macro Batch					
091204-2-SVF-1767 Mission Analysis Process Stream Calculator Rev. A.xlsm					
WTP Process					
56 Macro Batch Blend Base Case					
56 Macro Batch Blend Base Case					
Selected		Symbol	Value	Symbol	Value
Parameters		PNa,LAT,15	1.500	PS,29a,19	0.3300
		Pwash,S	0.050	IXNa	235
		PNa(aq),19b,15LSol	0.023	Pwash,Al	0.050
Glass Model:		SVF-1623			
Glass Limits		Reference case limits from RPP-MA SP3_HLW_Glass_Limit - Rev A			
Summary results:	091207-1-SVF-1817 Mission Analysis Glass Batch Blend Results Summary Rev. A.xl:				
	56 Macro Batch Blend Base Case				
	SVF-1623				
Limiting	Number of	Waste oxide	Glass Mass	Ave Waste	Percent of
Component	Feed Batches	MT	MT	Loading	Glass mass
SO3	10	1731	5544	31.23%	15.25%
P2O5	0	0	0	N/A	0.00%
Cr2O3	1	129	260	49.51%	0.71%
Al2O3	9	2425	8980	27.00%	24.70%
Fe2O3	4	374	1094	34.18%	3.01%
Na2O	5	1034	2645	39.07%	7.28%
Zr	2	350	2974	11.75%	8.18%
Other	25	6439	14856	43.34%	40.87%
Total	56	12481	36353	34.33%	100%

	HLW GLASS PRODUCTION ESTIMATE SUMMARY RESULTS				
Case Description:					
091208-1-SVF-1817 Mission Analysis Glass Batch Results Summary Rev. A.xlsm					
Description: 56 macro batch blended to 112 macro batch using feed transfer tank blend					
Waste feed:					
091208-1-SVF-MAR15 Feed Tank Blending Blended Macro Batch Calculator Rev. A.xlsm					
Feed tank 1/2 Batch Blending 56 macro batches blended to give 112 blended macro batches					
091208-1-SVF-1767 Mission Analysis Process Stream Calculator Rev. A.xlsm					
WTP Process					
112 macro batch feed tank blending base case					
56 macro batches blended to 112 in feed tank					
Selected		Symbol	Value	Symbol	Value
Parameters		PNa,LAT,15	1.500	PS,29a,19	0.3300
		Pwash,S	0.050	IXNa	235
		PNa(aq),19b,15LSol	0.023	Pwash,Al	0.050
Glass Model:		SVF-1623			
Glass Limits		Reference case limits from RPP-MA SP3_HLW_Glass_Limit - Rev A			
Summary results:	091208-1-SVF-1817 Mission Analysis Glass Batch Results Summary Rev. A.xlsm				
	112 macro batch feed tank blending base case				
	SVF-1623				
Limiting	Number of	Waste oxide	Glass Mass	Ave Waste	Percent of
Component	Feed Batches	MT	MT	Loading	Glass mass
SO3	16	1.504E+03	3.967E+03	37.90%	12.24%
P2O5	0	0.000E+00	0.000E+00	N/A	0.00%
Cr2O3	1	5.225E+01	1.026E+02	50.90%	0.32%
Al2O3	14	1.966E+03	6.335E+03	31.03%	19.55%
Fe2O3	3	2.683E+02	8.091E+02	33.16%	2.50%
Na2O	8	9.272E+02	2.050E+03	45.24%	6.32%
Zr	5	2.946E+02	2.552E+03	11.54%	7.88%
Other	65	7.454E+03	1.659E+04	44.93%	51.19%
Total	112	1.247E+04	3.241E+04	38.47%	100%

APPENDIX B - BLENDING STUDY FEED VECTOR BATCHES AND SOURCE TANKS

APPENDIX B- BLENDING STUDY FEED VECTOR BATCHES AND SOURCE TANKS

A primary objective of the blending study analysis was to calculate the amount of high-level waste (HLW) glass resulting from blending the feed vectors into specific macro batches. This Appendix provides traceability between macro batches used for the various blending cases and the feed vector for the Unconstrained Case.

B1.0 116 MACROBATCH CASE

The 450 feed vectors from the System Plan (ORP-11242 Revision 4) Unconstrained Case, were converted into 116 macro batches in 090813-1 MAR03 – Feed Vector to Macro Batch Calculator – Rev G.xlsm. Feed vector batches with the same composition and/or same source tank identification were combined to yield the 116 macro batches.

Table B-1: Cross Reference for the 116 Macro Batches contains two columns, one column lists the macro batch number and the other column lists the feed vector batches combined to produce each 116 macro batch. Table B-2 shows the source tanks for the solids and liquids in each of the 116 macro batches.

B2.0 56 MACROBATCH CASE

The 450 feed vectors from the System Plan Unconstrained Case, were converted into 56 macro batches in 090911-1 SVF-1757 – Feed Vector to Macro Batch Calculator – Rev A.xlsm. This macro batch calculator run identifies the sludge/HLW batches and combines the sludge/HLW batches with low solids/LAW batches that are scheduled for delivery in the roughly the same time frame. This combination results in 56 macro batches.

Table B-3 provides cross references for the 56 Macro Batch case. It contains three columns, one column lists the corresponding 116 macro batch numbers that are included in each of the 56 macro batches, and the other column lists the feed vectors combined to produce each macro batch.

B3.0 23 AND 21 MACROBATCH CASES

The 450 feed vectors from the System Plan Unconstrained Case, were converted into 23 macrobatches in 09-08-13-2 SVF-MAR03 – Feed Vector to Macro Batch Calculator – Rev G.xlsm. This set of macro batches was developed by combining feed vector batches that appear potentially attractive blending candidates and which are currently planned to be delivered to the Waste Treatment and Immobilization Plant (WTP) within about two years of each other.
Table B-4 provides the cross reference for the 23 Macro Batch case. The three columns list batch number for the 23 macro batch case, the corresponding 116 macro batch numbers in each, and the feed vectors combined to produce each of the 23 macro batches.

The 450 feed vectors from the System Plan Unconstrained Case, were converted into 21 macro batches in 090820-1 SVF-MAR03 – Feed Vector to Macro Batch Calculator – Rev G.xlsm. Table B-5 provides the cross reference for the 21 Macro Batch case. The three columns list batch number for the 21 macro batch case, the corresponding 116 macro batch numbers, and the feed vectors combined to produce each of the 21 macro batches.

Table B-1. Cross Reference for the 116 Macro Batches.

116 Macro Batch Number	Feed Vector Range	116 Macro Batch Number (cont.)	Feed Vector Range (cont.)	116 Macro Batch Number (cont.)	Feed Vector Range (cont.)
1	1-6	40	163-169	79	328-331, 333-334
2	7-8, 10	41	170-176	80	332
3	9	42	177-178, 180-183	81	335
4	11-15	43	179	82	336-341, 343
5	16-22	44	184-190	83	342
6	23-37	45	191-197	84	344
7	38-44	46	198	85	345
8	45-51	47	199	86	346
9	52, 54-61	48	200	87	347-352
10	53	49	201-202, 204-207	88	353
11	62-65, 67-68	50	203	89	354-360
12	66	51	208-214	90	361
13	69-74	52	215-221	91	362
14	75-76, 78-82	53	222	92	363
15	77	54	223-228	93	364-371
16	83, 85-90	55	229-232, 234, 236-237	94	372-373, 377-378, 382-385
17	84	56	233	95	374
18	91	57	235	96	375
19	92	58	238-242, 244-246	97	376
20	93-96, 98-99	59	243	98	379
21	97	60	247-252	99	380
22	100	61	253-258, 260	100	381
23	101	62	259	101	386-393
24	102	63	261-266	102	394-401
25	103-107	64	267	103	402-409
26	108-114	65	268	104	410-417
27	115	66	269-275	105	418
28	116-122	67	276-282	106	419
29	123-127, 129	68	283-288, 290	107	420
30	128	69	289	108	421
31	130-133, 135-137	70	291-296	109	422-429
32	134	71	297-300, 302-304	110	430
33	138	72	301	111	431-436
34	139-145	73	305, 307-311	112	437-440
35	146-148, 150-153	74	306	113	441
36	149	75	312-315, 317-319	114	442-448
37	154-155, 157-160, 162	76	316	115	449
38	156	77	320-323, 325-327	116	450
39	161	78	324		

Table B-2. Trace-Back from Macro Batch Number to Source Tanks for the 116 Macro Batches.

Batch Number	Liquid/Solid	Source Tanks and Percentage Batch Contributed by Each Source Tank (Minor sources <5% omitted)																			
1	Liquid	AY-102	100.0%																		
1	Solids	AY-102	100.0%																		
2	Liquid	A-101	18.7%	AX-101	52.0%	BY-102	14.9%														
2	Solids	0																			
3	Liquid	AP-101	6.4%	AP-103	90.5%																
3	Solids	AP-103	99.8%																		
4	Liquid	A-101	18.2%	AX-101	53.2%	BY-102	13.8%														
4	Solids	AZ-102	93.3%	BY-102	5.6%																
5	Liquid	AN-106	5.1%	AW-105	29.2%	AZ-101	45.2%	AX-101	13.3%												
5	Solids	AW-105	99.9%																		
6	Liquid	AN-106	37.7%	AY-101	11.6%	A-101	29.9%	BY-112	8.5%												
6	Solids	AY-101	22.9%	C-101	12.4%	C-105	26.1%	C-107	24.1%												
7	Liquid	AN-101	11.8%	AY-101	12.9%	AZ-101	33.2%	C-102	14.6%	C-112	6.6%										
7	Solids	C-104	66.7%	C-111	16.5%	C-112	16.0%														
8	Liquid	AW-103	93.8%																		
8	Solids	AW-103	100.0%																		
9	Liquid	AN-106	6.9%	AP-101	29.1%	AP-107	19.3%	AW-106	19.9%	AZ-101	9.3%	C-110	5.6%								
9	Solids	AZ-101	14.7%	C-102	85.2%																
10	Liquid	AP-108	99.9%																		
10	Solids	AP-108	100.0%																		
11	Liquid	AN-106	12.9%	A-101	10.2%	BY-102	26.1%	BY-110	16.7%	BY-112	33.4%										
11	Solids	AN-106	22.6%	A-103	6.3%	A-104	5.5%	A-105	5.2%	A-106	9.3%	BY-102	7.2%	BY-110	5.0%	BY-112	14.5%	C-110	15.4%		
12	Liquid	AN-103	98.4%																		
12	Solids	AN-103	48.2%	AN-107	51.8%																
13	Liquid	AN-104	9.6%	SY-103	78.3%	SX-105	8.1%														
13	Solids	AN-104	25.1%	AY-101	7.2%	SY-103	42.5%	C-105	8.2%	C-107	7.6%										
14	Liquid	AN-102	98.2%																		
14	Solids	AN-102	26.7%	AN-107	54.0%	AP-102	19.4%														
15	Liquid	AN-101	5.8%	AP-105	35.7%	AP-107	27.6%	AW-106	12.6%	C-104	7.4%										
15	Solids	0																			
16	Liquid	AN-102	25.7%	AN-107	14.5%	SY-102	14.1%	SY-103	27.0%	SX-105	6.2%										
16	Solids	AN-104	8.8%	SY-102	68.9%	SY-103	14.8%														
17	Liquid	AP-101	16.5%	AP-106	6.2%	AP-107	11.0%	AW-106	11.3%	AX-101	23.7%	AX-103	9.1%								

Table B-2. Trace-Back from Macro Batch Number to Source Tanks for the 116 Macro Batches.

Batch Number	Liquid/Solid	Source Tanks and Percentage Batch Contributed by Each Source Tank (Minor sources <5% omitted)																			
17	Solids	AP-104	86.7%	AW-102	10.2%																
18	Liquid	AP-106	54.1%	A-103	19.7%	AX-101	9.8%														
18	Solids	0																			
19	Liquid	AW-106	66.1%	A-103	20.7%																
19	Solids	AW-106	99.7%																		
20	Liquid	SY-102	6.6%	SX-105	54.8%	SX-112	15.0%														
20	Solids	SY-102	23.0%	SY-103	9.4%	C-102	12.6%	SX-105	8.8%	SX-110	8.4%	SX-112	34.1%								
21	Liquid	AP-101	17.0%	AP-104	35.1%	AW-102	42.6%														
21	Solids	0																			
22	Liquid	AN-101	74.7%	AP-103	18.2%																
22	Solids	AP-103	99.8%																		
23	Liquid	AN-104	73.2%	BY-102	6.7%	BY-110	7.1%	BY-112	11.5%												
23	Solids	AN-104	18.8%	AN-106	7.9%	BY-102	11.3%	BY-110	12.0%	BY-112	30.4%	C-110	5.4%								
24	Liquid	AN-104	95.0%																		
24	Solids	AN-104	24.6%	AW-105	11.1%	AY-102	64.3%														
25	Liquid	AN-105	94.4%																		
25	Solids	AN-104	15.7%	AN-105	37.5%	SY-103	26.5%	C-105	5.2%												
26	Liquid	AP-108	38.1%	SX-103	50.7%																
26	Solids	SY-102	8.5%	SX-103	43.4%	SX-110	12.7%	SX-112	13.0%	SX-114	14.9%										
27	Liquid	AN-107	16.5%	AP-102	67.9%																
27	Solids	C-104	66.7%	C-111	16.5%	C-112	16.0%														
28	Liquid	AN-103	16.9%	AN-105	65.5%	BY-101	6.3%	BY-111	5.9%												
28	Solids	AN-105	79.7%	BY-101	5.5%	BY-111	6.8%														
29	Liquid	AN-105	25.2%	SX-102	59.5%	SX-106	8.0%														
29	Solids	SX-102	9.7%	SX-111	76.1%																
30	Liquid	AN-101	7.3%	AN-103	55.7%	AP-105	7.2%	A-101	8.9%	BY-110	6.3%										
30	Solids	AN-103	100.0%																		
31	Liquid	AN-102	10.0%	SX-101	17.6%	SX-103	5.5%	SX-106	44.6%	SX-114	17.9%										
31	Solids	SX-101	6.4%	SX-103	19.8%	SX-110	6.4%	SX-114	50.7%												
32	Liquid	AN-102	13.5%	AN-107	67.7%	AP-102	17.0%														
32	Solids	AW-103	100.0%																		
33	Liquid	AN-102	27.5%	AN-107	18.9%	BY-102	7.4%	BY-110	12.9%	BY-112	25.6%										
33	Solids	AN-106	9.1%	BY-102	8.8%	BY-110	15.1%	BY-112	46.7%	C-110	6.2%										
34	Liquid	BY-104	36.7%	BY-106	35.6%	BY-111	14.5%														
34	Solids	BY-101	10.8%	BY-103	31.4%	BY-109	27.2%	BY-111	21.1%												
35	Liquid	AP-108	5.4%	SX-102	17.5%	SX-103	7.7%	SX-106	7.3%	SX-107	10.1%	SX-109	44.0%								
35	Solids	SX-107	34.2%	SX-109	34.7%	SX-111	11.9%	SX-114	7.3%												
36	Liquid	AW-101	98.2%																		

Table B-2. Trace-Back from Macro Batch Number to Source Tanks for the 116 Macro Batches.

Batch Number	Liquid/Solid	Source Tanks and Percentage Batch Contributed by Each Source Tank (Minor sources <5% omitted)																			
36	Solids	AW-101	100.0%																		
37	Liquid	AP-102	17.9%	SX-104	34.2%	SX-109	30.2%														
37	Solids	SX-102	5.2%	SX-104	29.8%	SX-107	18.2%	SX-109	39.3%												
38	Liquid	AN-101	10.4%	AP-102	5.8%	AP-105	10.1%	A-101	12.6%	AX-101	6.4%	BY-110	16.0%	BY-112	5.3%						
38	Solids	AP-105	26.7%	BY-109	9.2%	BY-110	42.9%	BY-112	14.0%												
39	Liquid	AP-105	9.0%	AP-106	5.6%	AP-107	6.9%	SY-103	5.1%	BY-101	8.9%	BY-102	10.0%	BY-109	8.1%	BY-110	7.1%	BY-112	5.3%	SX-105	15.4%
39	Solids	BY-101	21.5%	BY-102	15.6%	BY-109	33.3%	BY-110	10.5%	BY-112	11.0%										
40	Liquid	AN-107	6.0%	BX-107	15.4%	BX-109	18.0%	BY-104	7.4%	BY-106	9.9%	BY-107	28.9%								
40	Solids	BX-107	50.7%	BX-109	32.5%	BY-107	16.0%														
41	Liquid	AW-101	8.7%	BX-107	5.2%	BY-105	8.1%	BY-107	12.0%	SX-104	37.5%										
41	Solids	BX-105	6.2%	BX-107	69.9%	BY-104	5.5%	BY-107	7.9%	BY-111	6.4%										
42	Liquid	S-106	32.3%	S-110	47.5%	SX-104	14.8%														
42	Solids	S-110	19.9%	SX-104	61.3%	SX-109	6.6%														
43	Liquid	AP-106	5.2%	AW-106	6.9%	BY-101	5.6%	BY-103	22.8%	BY-109	20.0%	SX-105	14.2%								
43	Solids	0																			
44	Liquid	AW-101	31.0%	BY-105	14.9%	S-106	26.2%	SX-104	5.4%												
44	Solids	AW-101	15.5%	BX-103	22.7%	BX-104	27.3%	BX-106	5.2%	BX-107	11.3%	BY-105	10.7%								
45	Liquid	BY-105	33.0%	S-106	9.7%	S-110	19.8%														
45	Solids	BX-103	7.9%	BX-104	49.4%	BX-105	8.6%	BX-112	6.6%	BY-105	21.2%										
46	Liquid	AP-104	8.0%	AW-102	9.7%	BY-101	5.7%	BY-103	12.1%	SX-103	28.6%	SX-105	6.4%								
46	Solids	AN-104	8.8%	SY-102	68.9%	SY-103	14.8%														
47	Liquid	AN-105	9.3%	BY-101	10.9%	BY-103	12.3%	BY-111	7.6%	SX-101	34.5%	SX-103	18.1%								
47	Solids	AN-105	81.4%	BY-101	5.6%	BY-111	6.9%														
48	Liquid	AW-104	11.5%	S-103	8.5%	S-108	72.2%														
48	Solids	AW-104	100.0%																		
49	Liquid	B-109	7.5%	BX-110	12.1%	BY-105	24.7%	BY-108	27.3%	S-103	6.9%										
49	Solids	BX-104	8.0%	BX-105	23.8%	BX-112	18.2%	BY-105	25.6%	BY-108	6.5%										
50	Liquid	AN-101	19.7%	BY-101	22.7%	BY-103	18.4%	BY-111	18.4%	SX-101	6.8%										
50	Solids	BY-101	29.8%	BY-103	24.0%	BY-109	9.2%	BY-111	20.2%	SX-112	5.6%										
51	Liquid	AW-104	16.8%	B-108	8.0%	B-109	10.5%	BX-110	26.5%	BY-105	6.8%	BY-108	8.4%								
51	Solids	B-109	54.6%	BX-101	11.7%	BX-110	21.1%														
52	Liquid	AW-104	54.1%	S-108	7.5%	S-109	28.9%														
52	Solids	AW-104	100.0%																		
53	Liquid	BY-101	15.5%	BY-104	8.2%	BY-106	10.2%	BY-111	21.1%	SX-101	24.5%	SX-103	6.2%								
53	Solids	BY-101	56.8%	BY-103	7.5%	BY-111	26.8%														
54	Liquid	S-101	21.3%	S-107	5.8%	S-108	58.2%	S-110	6.1%												
54	Solids	S-101	44.2%	S-107	26.5%	S-108	12.9%	S-110	6.3%												
55	Liquid	S-101	39.4%	S-103	22.0%	S-108	7.1%	S-110	16.1%												

Table B-2. Trace-Back from Macro Batch Number to Source Tanks for the 116 Macro Batches.

Batch Number	Liquid/Solid	Source Tanks and Percentage Batch Contributed by Each Source Tank (Minor sources <5% omitted)																			
55	Solids	S-101	44.9%	S-110	30.6%	SX-104	9.8%														
56	Liquid	BY-101	9.7%	BY-104	14.6%	BY-106	14.8%	BY-111	5.9%	SX-101	7.2%	SX-106	27.5%	SX-111	12.2%						
56	Solids	BY-101	48.4%	BY-111	35.2%																
57	Liquid	BY-104	25.8%	BY-106	18.9%	S-106	22.3%	SX-102	19.6%												
57	Solids	BX-107	6.7%	BY-101	23.3%	BY-103	18.2%	BY-104	16.4%	BY-111	29.5%										
58	Liquid	S-107	31.0%	S-108	24.8%	S-109	23.4%	SX-108	16.1%												
58	Solids	S-107	76.8%	SX-108	13.3%																
59	Liquid	BY-105	34.5%	BY-108	6.1%	S-103	13.9%	S-106	5.5%	S-110	17.2%										
59	Solids	BY-101	21.5%	BY-102	15.6%	BY-109	33.3%	BY-110	10.5%	BY-112	11.0%										
60	Liquid	S-105	54.8%	S-109	5.9%	S-111	7.7%														
60	Solids	B-106	13.8%	B-108	7.2%	B-109	10.3%	BX-101	33.7%	BX-105	5.3%	BY-105	6.5%								
61	Liquid	S-105	66.0%	S-111	19.8%																
61	Solids	S-107	37.1%	S-109	5.1%	S-111	34.6%	SX-108	6.4%	SX-114	7.1%										
62	Liquid	B-104	30.0%	B-106	6.5%	BX-111	6.7%	S-108	8.1%	S-109	24.2%										
62	Solids	BX-103	9.0%	BX-104	11.0%	BY-105	44.8%	BY-108	25.6%												
63	Liquid	S-104	5.3%	S-105	5.8%	T-101	19.1%	T-107	29.4%	TY-102	24.5%										
63	Solids	S-104	16.9%	T-101	16.2%	T-102	9.5%	T-105	15.1%	T-107	28.0%										
64	Liquid	B-104	5.1%	S-109	58.1%	S-111	22.0%														
64	Solids	BY-101	29.8%	BY-103	24.0%	BY-109	9.2%	BY-111	20.2%	SX-112	5.6%										
65	Liquid	B-105	9.3%	B-110	6.7%	BX-111	18.3%	BY-104	5.2%												
65	Solids	BX-102	28.0%	BX-111	8.3%	BY-101	33.0%	BY-111	15.6%												
66	Liquid	TX-102	16.5%	TX-109	16.3%	TX-112	35.2%	TX-118	14.2%												
66	Solids	B-110	24.7%	BX-101	10.9%	BX-102	22.0%	BY-111	5.0%												
67	Liquid	S-101	5.4%	T-109	7.5%	TX-109	18.1%	TX-112	41.4%	TX-118	13.5%										
67	Solids	S-101	7.3%	S-104	5.2%	T-101	6.5%	T-103	12.8%	T-106	6.6%	T-107	13.6%	TX-109	10.6%	TX-112	11.3%	TX-118	7.0%		
68	Liquid	TX-102	16.0%	TX-104	19.8%	TX-112	46.7%														
68	Solids	S-107	12.9%	TX-102	11.4%	TX-109	26.6%	TX-112	28.0%	TX-118	7.0%										
69	Liquid	B-105	22.2%	B-110	10.6%	BY-105	8.1%	TX-112	12.4%	TX-118	13.1%										
69	Solids	B-105	43.7%	B-110	45.2%																
70	Liquid	TX-103	12.2%	TX-106	29.5%	TX-108	19.0%	TX-112	7.7%	TY-101	6.4%	TY-105	19.1%								
70	Solids	TX-106	15.2%	TX-108	7.4%	TX-112	14.9%	TY-101	25.8%	TY-105	18.1%										
71	Liquid	S-104	51.6%	S-105	25.1%	S-111	19.1%														
71	Solids	S-104	88.6%	S-111	7.7%																
72	Liquid	TX-102	11.1%	TX-106	22.3%	TX-108	6.5%	TX-112	25.8%												
72	Solids	BY-105	14.5%	BY-108	8.2%	S-107	24.5%	S-111	22.8%												
73	Liquid	U-102	67.7%	U-105	15.5%																
73	Solids	TX-115	7.0%	TX-116	8.2%	TY-104	7.3%	U-102	15.6%	U-105	39.5%	U-108	5.5%								
74	Liquid	TX-101	11.5%	TX-103	5.4%	TX-106	25.9%	TX-108	7.7%	TX-111	26.1%	TY-105	9.6%								

Table B-2. Trace-Back from Macro Batch Number to Source Tanks for the 116 Macro Batches.

Batch Number	Liquid/Solid	Source Tanks and Percentage Batch Contributed by Each Source Tank (Minor sources <5% omitted)																			
74	Solids	AW-104	100.0%																		
75	Liquid	TX-105	8.5%	TX-115	14.5%	TX-116	21.6%	U-102	11.8%	U-103	5.6%	U-105	10.4%	U-108	23.6%						
75	Solids	B-104	29.3%	B-108	14.8%	BX-101	10.6%	BX-102	16.7%	BX-110	7.1%	BX-111	6.6%								
76	Liquid	TX-103	5.6%	TX-111	18.2%	TX-115	7.3%	TX-116	8.6%	U-105	33.6%										
76	Solids	BX-102	28.0%	BX-111	8.3%	BY-101	33.0%	BY-111	15.6%												
77	Liquid	TX-103	5.1%	TX-111	43.0%	TX-116	12.3%	TY-103	8.3%	U-105	6.9%										
77	Solids	TX-111	22.2%	TY-101	13.5%	TY-103	23.2%	TY-105	10.7%												
78	Liquid	TX-115	9.4%	TX-116	7.0%	U-102	8.3%	U-105	7.0%	U-108	43.7%										
78	Solids	BY-101	29.8%	BY-103	24.0%	BY-109	9.2%	BY-111	20.2%	SX-112	5.6%										
79	Liquid	TX-105	46.5%	TX-116	21.2%	U-109	12.8%	U-111	13.8%												
79	Solids	TX-105	28.2%	TX-115	6.8%	TX-116	22.1%	U-107	5.9%	U-109	25.0%										
80	Liquid	TX-102	6.0%	TX-105	7.6%	TX-106	12.1%	TX-112	14.0%	TX-115	5.5%	U-103	21.0%								
80	Solids	BX-103	9.0%	BX-104	11.0%	BY-105	44.8%	BY-108	25.6%												
81	Liquid	TX-105	16.7%	TX-115	7.3%	TX-116	6.3%	U-103	15.1%	U-107	9.5%	U-108	5.4%	U-109	31.7%						
81	Solids	B-105	43.7%	B-110	45.2%																
82	Liquid	TX-116	6.3%	U-103	8.6%	U-107	70.6%														
82	Solids	TX-105	7.0%	TX-115	8.6%	TX-116	10.6%	U-102	11.0%	U-105	7.4%	U-107	11.2%	U-108	30.7%						
83	Liquid	TX-105	12.3%	TX-116	22.2%	U-103	15.5%	U-108	6.4%	U-109	10.6%										
83	Solids	S-107	36.1%	S-111	33.6%	SX-108	6.3%	SX-114	6.9%												
84	Liquid	TX-105	18.8%	TX-116	24.5%	U-105	5.1%	U-106	13.4%	U-111	18.8%										
84	Solids	BX-102	28.0%	BX-111	8.3%	BY-101	33.0%	BY-111	15.6%												
85	Liquid	TX-105	16.2%	TX-113	13.5%	TX-115	23.9%	TX-116	28.3%	U-111	7.7%										
85	Solids	BY-101	29.8%	BY-103	24.0%	BY-109	9.2%	BY-111	20.2%	SX-112	5.6%										
86	Liquid	TX-113	41.0%	TX-115	24.6%	U-103	5.8%														
86	Solids	BX-103	9.0%	BX-104	11.0%	BY-105	44.8%	BY-108	25.6%												
87	Liquid	TX-110	10.5%	TX-113	19.1%	TX-117	65.1%														
87	Solids	TX-113	48.2%	TX-115	16.7%	TX-117	22.3%														
88	Liquid	TX-110	6.6%	TX-113	64.4%	TX-115	5.8%	TX-117	9.7%												
88	Solids	B-105	43.7%	B-110	45.2%																
89	Liquid	TX-105	10.2%	TX-107	6.0%	TX-113	27.7%	TX-115	29.3%	TX-116	14.7%										
89	Solids	TX-105	21.9%	TX-115	13.3%	TX-116	30.9%	U-109	5.2%	U-111	6.0%										
90	Liquid	TX-105	5.3%	TX-110	28.0%	TX-113	6.2%	TX-116	7.9%	TX-117	32.1%										
90	Solids	S-107	36.1%	S-111	33.6%	SX-108	6.3%	SX-114	6.9%												
91	Liquid	TX-113	51.0%	TX-115	13.4%	TX-117	7.7%														
91	Solids	TX-113	28.5%	TX-115	12.9%	TX-116	5.8%	TX-117	13.2%	U-108	10.9%										
92	Liquid	TX-110	22.8%	TX-114	58.4%	TX-117	7.8%														
92	Solids	BY-101	29.8%	BY-103	24.0%	BY-109	9.2%	BY-111	20.2%	SX-112	5.6%										
93	Liquid	TX-110	20.0%	TX-114	49.3%	TX-117	13.4%														

Table B-2. Trace-Back from Macro Batch Number to Source Tanks for the 116 Macro Batches.

Batch Number	Liquid/Solid	Source Tanks and Percentage Batch Contributed by Each Source Tank (Minor sources <5% omitted)																			
93	Solids	TX-110	6.0%	TX-114	55.0%	U-110	23.1%														
94	Liquid	TX-110	50.5%	TX-114	42.1%																
94	Solids	TX-110	39.5%	TX-113	11.9%	TX-114	11.1%	TX-117	29.8%												
95	Liquid	TX-110	6.9%	TX-113	61.0%	TX-115	5.5%	TX-117	13.8%												
95	Solids	TX-113	45.0%	TX-115	15.6%	TX-117	20.8%														
96	Liquid	TX-113	38.5%	TX-115	23.3%	U-103	6.0%	U-107	6.3%												
96	Solids	TX-105	6.8%	TX-115	8.3%	TX-116	10.2%	U-102	10.6%	U-105	7.1%	U-107	10.9%	U-108	29.6%						
97	Liquid	TX-105	5.3%	TX-110	28.0%	TX-113	6.2%	TX-116	7.9%	TX-117	32.1%										
97	Solids	S-107	36.1%	S-111	33.6%	SX-108	6.3%	SX-114	6.9%												
98	Liquid	TX-110	8.3%	TX-114	85.0%																
98	Solids	BX-103	9.0%	BX-104	11.0%	BY-105	44.8%	BY-108	25.6%												
99	Liquid	TX-110	6.6%	TX-113	64.4%	TX-115	5.8%	TX-117	9.7%												
99	Solids	B-105	43.7%	B-110	45.2%																
100	Liquid	TX-114	89.0%																		
100	Solids	AW-104	100.0%																		
101	Liquid	B-101	22.2%	B-105	6.6%	B-107	39.4%	B-111	15.6%	BY-110	6.0%										
101	Solids	B-101	9.0%	B-107	57.7%	B-111	22.4%														
102	Liquid	TX-114	16.4%	U-110	35.5%	U-112	30.8%														
102	Solids	U-110	88.3%	U-112	8.5%																
103	Liquid	B-107	10.9%	BY-102	20.4%	TX-110	6.0%	TX-114	19.0%	TX-117	25.3%										
103	Solids	B-107	17.3%	BY-102	5.7%	TX-114	8.5%	TX-117	9.1%	U-104	22.6%	U-110	25.2%								
104	Liquid	TX-101	11.5%	TX-103	25.9%	TX-106	5.2%	TX-111	24.9%	TY-103	10.4%	TY-105	9.3%								
104	Solids	TX-101	12.9%	TX-111	9.4%	TY-101	30.3%	TY-103	10.5%	TY-105	21.3%										
105	Liquid	TX-113	12.8%	TX-114	55.5%	U-101	21.3%	U-110	5.8%												
105	Solids	B-105	28.1%	B-110	6.8%	BX-102	18.6%	BX-108	35.0%												
106	Liquid	AW-101	88.3%	BY-104	5.1%																
106	Solids	AW-101	8.4%	BY-104	68.2%	BY-106	15.4%														
107	Liquid	AW-104	16.8%	B-108	8.0%	B-109	10.5%	BX-110	26.5%	BY-105	6.8%	BY-108	8.4%								
107	Solids	B-109	54.6%	BX-101	11.7%	BX-110	21.1%														
108	Liquid	TX-105	8.5%	TX-115	14.5%	TX-116	21.6%	U-102	11.8%	U-103	5.6%	U-105	10.4%	U-108	23.6%						
108	Solids	B-104	29.3%	B-108	14.8%	BX-101	10.6%	BX-102	16.7%	BX-110	7.1%	BX-111	6.6%								
109	Liquid	SY-101	96.3%																		
109	Solids	SY-101	100.0%																		
110	Liquid	TX-102	16.5%	TX-109	16.3%	TX-112	35.2%	TX-118	14.2%												
110	Solids	B-110	24.7%	BX-101	10.9%	BX-102	22.0%	BY-111	5.0%												
111	Liquid	B-101	14.2%	B-103	17.3%	B-105	21.4%	B-110	6.0%	B-111	21.3%	BY-102	7.0%								
111	Solids	B-101	7.3%	B-103	11.4%	B-105	13.7%	B-110	8.2%	B-111	39.0%	BX-102	7.3%								
112	Liquid	BY-105	23.5%	S-106	6.9%	S-110	14.1%	TX-114	9.5%	TX-117	14.6%										

Table B-2. Trace-Back from Macro Batch Number to Source Tanks for the 116 Macro Batches.

Batch Number	Liquid/Solid	Source Tanks and Percentage Batch Contributed by Each Source Tank (Minor sources <5% omitted)																			
112	Solids	BX-104	23.7%	BY-105	10.2%	TX-114	6.7%	TX-117	8.4%	U-104	20.7%	U-110	13.1%								
113	Liquid	TX-110	20.0%	TX-114	49.3%	TX-117	13.4%														
113	Solids	TX-110	6.0%	TX-114	55.0%	U-110	23.1%														
114	Liquid	AP-102	18.8%	TX-113	5.8%	TX-114	42.0%	U-101	8.8%												
114	Solids	AN-106	11.6%	AW-102	41.9%	A-106	13.5%	C-110	7.9%												
115	Liquid	AZ-101	6.2%	TX-110	21.4%	TX-114	54.7%	TX-117	7.3%												
115	Solids	AZ-101	100.0%																		
116	Liquid	S-105	52.1%	S-109	5.6%	S-111	7.3%														
116	Solids	AZ-102	70.2%	BX-101	10.0%																

Table B-3. Cross References for the 56 Macro Batch Case.

56 Macrobatch Number	116 Macrobatch Number	Feed Vector Range	56 Macrobatch Number (cont.)	116 Macrobatch Number (cont.)	Feed Vector Range (cont.)
1	1-2	1-6, 7-8, 10	29	57-58	235, 238-242, 244-246
2	3-4	9, 11-15	30	59-60	243, 247-252
3	5	16-22	31	61-62	253-260
4	6	23-37	32	63-65	261-268
5	7	38-44	33	66-67	269-282
6	8, 10	45-51, 53	34	68-69	283-290
7	9	52, 54-61, 66	35	70, 72	291-296, 301
8	11	62-65, 67-68, 77	36	71	297-300, 302-304, 306
9	13	69-74, 84	37	73	305, 307-311, 316
10	14	75-76, 78-82, 91	38	75	312-315, 317-319, 324
11	16, 21	83, 85-90, 97	39	77, 80	320-323, 325-327, 332
12	19-20, 22-23	92-96, 98-101	40	79	328-331, 333-335
13	24-26	102-114	41	82-84	336-341, 342-344
14	27-28	115-122	42	85-87	345-352
15	29-30	123-129	43	88-89	353-360
16	31-32	130-137	44	90-93	361-371
17	33-34	138-145	45	94-96	372-375, 377-378, 382-385
18	35-36	146-153	46	97, 101	376, 386-393
19	37-38	154-160, 162	47	98, 102	379, 394-401
20	39-40	161, 163-169	48	104	380, 410-417
21	41, 43	170-176, 179	49	105	381, 418
22	42	177-178, 180-183, 198	50	103, 106	402-409, 419
23	44	184-190, 199	51	107-108	420-421
24	45, 48	191-197, 200	52	109-110	422-430
25	49-50	201-207	53	111-112	431-440
26	51-52	208-221	54	113-114	441-448
27	53-54	222-228	55	115	449
28	55-56	229-234, 236-237	56	116	450

Table B-4. Cross References for the 23 Macro Batch Case.

23 Macrobatch Number	116 Macrobatch Number	Feed Vector Range
1	1	1-6
2	2	7-8, 10
3	3	9
4	4	11-15
5	5-7	16-44
6	8, 10, 12-13	45-51, 53, 66, 69-74
7	9, 11, 14-18	52, 54-65, 67-68, 75-91
8	19-22, 24, 25	92-100, 102-107
9	23, 26, 27	101, 108-115
10	28-34	116-145
11	35-41	146-176
12	42-52	177-221
13	53, 54, 60	222-228, 247-252
14	55, 57, 63-65	229-232, 234-237, 261-268
15	56, 62	233, 259
16	58, 59, 66, 67	238-246, 269-282
17	61, 68-70	253-258, 260, 283-296
18	71-79	297-331, 333-334
19	80-87	332, 335-352
20	88-93	353-371
21	94-98, 102	372-379, 394-401
22	94, 99-101, 103-106	380-393, 402-419
23	107-116	420-450

Table B-5. Cross References for the 21 Macro Batch Case.

21 Macrobatch Number	116 Macrobatch Number	Feed Vector Range
1	1	1-6
2	2	7-8, 10
3	3	9
4	4	11-15
5	5-6	16-37
6	7-10	38-61
7	11-18	62-91
8	19-22, 24, 25	92-100, 102-107
9	23, 26, 27	101, 108-115
10	28-34	116-145
11	35-41	146-176
12	42-50	177-207
13	51-56	208-234,236-237
14	57-63	235, 238-266
15	64-71	267-300,302-304
16	72-80	301, 305-334
17	81-87	335-352
18	88-92	353-363
19	93-102	364-401
20	103-106	402-419
21	107-116	420-450