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Prepared For the U.S. Department of Energy, Assistant Secretary for Environmental Management
By Washington River Protection Solutions, LLC., PO Box 850, Richland, WA 99352
Contractor For U.S. Department of Energy, Office of River Protection, under Contract DE-AC27-08RV14800

Release Stamp

DATE: Oct 20,2021 HANFORD RELEASE

1. **Doc No:** RPP-40149-VOL2 **Rev.** 06

2. **Title:**
Integrated Waste Feed Delivery Plan Volume 2-Campaign Plan

3. **Project Number:** ☒N/A

4. **Design Verification Required:** ☐Yes ☒No

5. **USQ Number:** ☒ N/A RPP-27195

6. **PrHA Number** **Rev.** ☒ N/A

Clearance Review Restriction Type: public

7. **Approvals**

Title	Name	Signature	Date
Checker	Nguyen, Vinh C	*Nguyen, Vinh C*	10/13/2021
Clearance Review	Ayers, Lynn M	*Ayers, Lynn M*	10/20/2021
Document Control Approval	Meinecke, Kathryn R	*Meinecke, Kathryn R*	10/19/2021
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Responsible Manager	Benson, Peter A	*Benson, Peter A*	10/13/2021

8. **Description of Change and Justification**

Major revision

9. **TBDs or Holds** ☒N/A

10. **Related Structures, Systems, and Components**

a. **Related Building/Facilities** ☒N/A
b. **Related Systems** ☒N/A
c. **Related Equipment ID Nos. (EIN)** ☒N/A

11. **Impacted Documents – Engineering** ☒N/A

Document Number	Rev.	Title

12. **Impacted Documents (Outside SPF):**

ORP-11242 Rev. 9

13. **Related Documents** ☐N/A

Document Number	Rev.	Title
RPP-40149-VOL1	04B	Integrated Waste Feed Delivery Plan Volume 1-Process Approach
RPP-40149-VOL3	04	Integrated Waste Feed Delivery Plan Volume 3-Project Plan
RPP-47172	01	WASTE FEED DELIVERY SYSTEM DESCRIPTION
RPP-PLAN-58003	02	One System River Protection Project Integrated Flowsheet Maturation Plan
RPP-RPT-48103	08	Derivation of Best-Basis Inventory for Tank 241-AP-107 as of April 1, 2016
RPP-RPT-57991	01	One System River Protection Project Integrated Flowsheet
RPP-RPT-58649	01	Waste Acceptance Criteria for the Low Activity Waste Pretreatment System
RPP-RPT-58985	01	Direct Feed Low-Activity Waste: First Feed Flowsheet
RPP-RPT-59314	00	Integrated DFLAW Feed Qualification Program Description
RPP-RPT-59586	00	Evaluation of Risks to the DFLAW Mission from Solids in East Area Double-Shell Tanks

14. **Distribution**

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RPP-40149-VOL2
Revision 6

Integrated Waste Feed Delivery Plan: Volume 2 – Campaign Plan

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Date Published
October 2021

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an amentum-led company

Prepared for the U.S. Department of Energy
Office of River Protection

Contract No. DE-AC27-08RV14800

Printed in the United States of America

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TERMS

Abbreviations and Acronyms

BOM	balance of mission
CD	critical decision
CH-TRU	contact-handled transuranic
DFLAW	direct-feed low-activity waste
DOE	U.S. Department of Energy
DST	double-shell tank
EM	effluent management
EMF	Effluent Management Facility
ETF	Effluent Treatment Facility
FS&S	Feed Selection and Sequencing
FY	fiscal year
HLW	high-level waste
ICD	interface control document
IHLW	immobilized high-level waste (canisters)
ILAW	immobilized low-activity waste (containers)
ILST	Interim Low-Activity Waste Storage Tank
IXC	ion exchange column
IWFDP	Integrated Waste Feed Delivery Plan
LAW	low-activity waste
LAWPS	Low-Activity Waste Pretreatment System
LAWST	Low-Activity Waste Supplemental Treatment
LERF	Liquid Effluent Retention Facility
MYOP	Multi-Year Operating Plan
Na	sodium
ORP	U.S. Department of Energy, Office of River Protection
PT	pretreatment, specifically pretreatment within WTP
RPP	River Protection Project
SHSV	Standard High-Solids Vessel(s)
SST	single-shell tank
TFPT	Tank Farm Pretreatment
TOC	Tank Operations Contract
TRU	transuranic
TSCR	Tank Side Cesium Removal
TWCS	Tank Waste Characterization and Staging
WAC	waste acceptance criteria
WFD	waste feed delivery
WRPS	Washington River Protection Solutions, LLC
WTP	Hanford Tank Waste Treatment and Immobilization Plant
WTP-HLW	Hanford Tank Waste Treatment and Immobilization Plant High-Level Waste Vitrification Facility
WTP-LAW	Hanford Tank Waste Treatment and Immobilization Plant Low-Activity Waste Vitrification Facility
WTP-PT	Hanford Waste Treatment and Immobilization Plant Pretreatment Facility

Units

gal	gallon
in.	inch
kg	kilogram
kgal	thousand gallons
M	molar
MCi	megacurie, one million curies
Mgal	million gallons
MT	metric ton
wt%	weight percent

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1.0 INTRODUCTION

The U.S. Department of Energy (DOE), Office of River Protection (ORP) manages the River Protection Project (RPP) at the Hanford Site. The RPP mission is to manage the nuclear waste stored in 177 underground tanks safely and responsibly. Selected tanks that contain legally designated transuranic (TRU) waste are presumed to be retrieved, treated and packaged for disposal at the Waste Isolation Pilot Plant (WIPP) or other approved disposal facility. DOE has not made a final decision on TRU tank waste treatment and disposition, so any discussion herein related to TRU tank waste is strictly provisional. The remainder (and majority) of the waste will be treated at (a) the Hanford Tank Waste Treatment and Immobilization Plant (WTP) where waste is converted into borosilicate glass waste forms prior to final disposition or (b) a Low-Activity Waste Supplemental Treatment (LAWST) capability (treatment technology not yet designated, but assumed to be borosilicate glass for planning purposes).

WTP has three waste processing sub-facilities that are phased in over time to facilitate early treatment of waste: low-activity waste vitrification (WTP-LAW), pretreatment (WTP-PT), and high-level waste vitrification (WTP-HLW).

Disposition of Immobilized Low-Activity Waste (ILAW) containers generated by Low-Activity Waste (LAW) treatment is provided on the Hanford Site at the Integrated Disposal Facility (IDF). Immobilized High-Level Waste (IHLW) canisters are interim stored on the Hanford Site pending final resolution of the IHLW disposal pathway by DOE.

Specifically, the waste feed delivery (WFD) mission is to manage, prepare to specification, and deliver the tank waste to the WTP and the LAWST. The Integrated Waste Feed Delivery Plan (IWFDP) is a three-volume document describing the commissioning, infrastructure upgrades, and near-term and long-term waste transfer/pre-process operations necessary to provide Hanford tank waste feed to the WTP. The IWFDP is based on a phased-approach concept for performing the RPP mission, in accordance with guidance provided by ORP and in alignment with RPP-RPT-57991, *One System River Protection Project Integrated Flowsheet*. The IWFDP focuses on feed delivery in support of the startup, commissioning, and initial operating phase of the WTP-LAW as projected by a Tank Operations Contract (TOC) life-cycle planning tool (MR-50695, Rev 1, *Integrated Waste Feed Delivery Plan, Rev 6 modeling*). Specific to this volume (Volume 2 – Campaign Plan), the focus of this update is the direct-feed low-activity waste (DFLAW) phase of the RPP mission as a function of waste source tanks, campaign preparation tanks, new pretreatment facilities and delivery path, schedule sequence, and feed chemistry. Preliminary discussion of balance of mission (BOM) operations and waste feed delivery activities beyond 2033 is included, as appropriate, although this scope will evolve[1] substantially over the intervening years prior to BOM.

Waste feed delivery will be implemented through programs that coordinate and integrate across multiple Hanford Site prime contractor work scopes. The Flowsheet Integration/Waste Feed Delivery and Operations Planning organization, which leads and performs planning, analysis,

[1] For example, an initiative that is currently under consideration to move away from source-based classification of tank waste to activity-based classification could reduce the volume of high-level waste requiring treatment, and radically improve the IHLW canister forecast during BOM.

and integration activities, develops and updates the IWFDP, as required, and has responsibility for maintaining the plan.

Waste feed delivery operations will support LAW vitrification in the direct-feed mode for more than ten years prior to commencement of HLW pretreatment in the WTP-PT. The DFLAW approach is implemented via two low-activity waste pretreatment systems. Initially, Phase 1 DFLAW involves processing tank farms supernate through the Tank Side Cesium Removal (TSCR) system. TSCR is a short-term technology demonstration intended to provide the first five years of pretreatment for WTP-LAW operations. TSCR installation and acceptance testing has been completed with initial operations commencing within months of this writing (September 2021). The TSCR Demonstration commences in November 2021. Phase 2 DFLAW pretreatment commences approximately November 2026 in a to-be-determined (TBD)[2] facility (possibly parallel TSCRs, or a higher capacity version of TSCR) that has throughput[3] sufficient to support the maximum production rate at WTP-LAW. Post-TSCR feed preparation has been designated Tank Farms Pretreatment (TFPT). Lessons learned from TSCR will be beneficial for designing TFPT.

Supernate qualified to be TSCR feed satisfies all WTP-LAW acceptance criteria except solids and Cs-137. DFLAW pretreatment removes solids and cesium[4] from supernate via filtration and ion exchange, respectively. Captured solids are returned to the tank farms (AP-108[5]) via filter backflushes. Spent ion exchange columns (IXCs) loaded with cesium are discharged to interim storage pending conversion to IHLW[6] canisters.

Pre-treated DFLAW feed accumulates in AP-106 awaiting batch transfer to WTP-LAW. Waste feed delivery infrastructure upgrades that provide DFLAW pumps in AP-106 and pipelines up to Interface Node 13 for ICD 30 (24590-WTP-ICD-MG-01-030, 2015, *ICD 30 – Interface Control Document for Direct LAW Feed*) were completed. Continuation of the DFLAW pipeline beyond Interface Node 13 to WTP-LAW is constructed by the WTP project.

Secondary liquid waste streams generated during the vitrification process are routed to the Effluent Management Facility[7] (EMF). From EMF, concentrate is recycled to WTP-LAW as feed, and condensate is routed to the Liquid Effluent Retention Facility (LERF) for subsequent treatment in the Effluent Treatment Facility (ETF). The total projected volumetric flow requires the WFD planning process to coordinate across the entire double-shell tank (DST) system and with 200 East and 200 West Area single-shell tank (SST) retrievals during the DFLAW phase.

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[2] The TBD nature of TFPT is not a detriment to campaign planning. Although TFPT processing is faster than TSCR, campaign preparation in the designated DFLAW tank system is essentially the same throughout both phases of DFLAW.

[3] TFPT throughput averaging 185 kg Na per hour or more is anticipated, compared to TSCR averaging 100 kg Na per hour. Ultimately it will depend on the maximum capacity at WTP-LAW demonstrated during DFLAW Phase 1.

[4] Cesium is not the only ionic component captured by ion exchange, but it is the only ionic component out of specification for WTP-LAW feed.

[5] The “241-” prefix of tanks and farms is omitted throughout this plan (e.g., 241-AP Farm is referred to as AP Farm).

[6] Treatment of spent CST to IHLW is a programmatic assumption, although not currently modeled.

[7] After transition to BOM, WTP-LAW effluents are routed to WTP-PT; EMF discontinues operations.

All campaign planning information presented in the following discussion is derived from the results of MR-50695 (Case 14517) of the TOPSim life-cycle planning model. With the exception of one additional requirement that prevents Case 14517 from creating DFLAW campaigns with high K concentration, Case 14517 requirements are identical to Case 13495 (which itself is a special case of the MR-50639, *2021 Baseline Planning Basis Modeling Scenario*). These results are subject to change as WFD planning continues to evolve.

The cumulative total of qualified DFLAW feed from AP-107 processed through TSCR/TFPT is about 21.6 Mgal over the DFLAW phase, and about 20.3 Mgal of that pretreated feed is processed at WTP-LAW. During the DFLAW period, campaign preparation entails transferring about 20.2 Mgal into AP-105, consisting of 14.3 Mgal of as-is waste with 5.9 Mgal of dilution and flush water added to reach the target sodium molarity of TSCR feed (typically 5 to 6 M based on RPP-RPT-60636, *Waste Acceptance Criteria for the Low Activity Waste Pretreatment Systems*.) Note that this does not include the waste already in AP-105 nor the qualified waste in AP-107.

Process returns from TSCR and TFPT consist of the filter backflush discharged while the process is operating, and system purge associated with the outage for column replacement. The total volume of process returns consequently depends on the actual frequency of filter backflush and column replacement which could vary depending on campaign feed characteristics. The model estimate for planning purposes is 0.7 Mgal of process returns over the 24 campaigns of the DFLAW period. DFLAW processing activity results in 13.7 Mgal net volume reduction in the tank farms (Table 1-1).

Table 1-1 Net Volume Change in Tank Farm from Direct Feed Low-Activity Waste Processing

Source	Volume Out (Mgal)	Volume In (Mgal)
Feed to WTP-LAW	20.3	-
Dilution Water*		5.9
Process Returns		0.7
Net Tank Farm Volume Reduction	**13.7 Mgal**	

*Includes flush volumes after supernate is transferred to AP-105.
Note that 5.9 Mgal does not include ~0.4 Mgal that was added previously to dilute Campaign 1.

1.1 PURPOSE, SCOPE, AND OBJECTIVES

The purpose of the IWFDP is to describe how the Tank Operations Contractor will retrieve, prepare, and deliver qualified Hanford tank waste to the WTP under DOE guidance and to meet contractual requirements identified in the TOC (DE-AC27-08RV14800, *Tank Operations Contract*) to integrate with life-cycle modeling.

With regard to the IWFDP as a whole (DE-AC27-08RV14800):

> *The Contractor shall prepare, submit for DOE-ORP approval, and implement an Integrated Waste Feed Delivery Plan (IWFDP) (Deliverable C.2.3.1-2) to provide optimum and reliable pretreatment (if needed), blending/mixing, retrieval and delivery of feed to DOE-ORP treatment facilities. This Plan shall include the needs of commissioning, near-term, and long-term operations and projected waste transfer/pretreatment operations. It should provide adequate information so that infrastructure requirements and upgrades can be identified.*

Volume 1 - Process Approach of the IWFDP summarizes the waste feed delivery process. Volume 2 – Campaign Plan of the IWFDP screens projected feed against the waste acceptance criteria (WAC)[8], to the extent feasible with available methodologies, to identify necessary refinements and systematic concerns. The IWFDP includes the projected waste transfer, staging, and pretreatment operations necessary for more detailed operational planning.

Volume 2 has three primary objectives:

1. Describe the planning bases for the initial DFLAW campaigns.
2. Project the variability of key waste feed components during the DFLAW phase of the mission.
3. Describe the planning bases for the HLW and LAW campaigns supporting completion of the RPP mission.

To meet these objectives, this volume presents the DFLAW phase as a function of source tank(s), delivery path, schedule sequence, and feed chemistry in the context of the DST system for the duration of the RPP mission and DFLAW operations. Waste staging and preparation, followed by the transfer paths necessary to deliver feed to the TSCR/TFPT are described per life-cycle modeling to support the DFLAW program. Waste volume management and tank farms activities (e.g., DST-to-DST transfers, evaporator campaigns, and retrieval activities) are also described. The relative concentrations (normalized against sodium) of key vitrification process constituents – sulfate, chloride, fluoride, and phosphate – are provided for the duration of the DFLAW phase of the mission (Section 5.1).

Infrastructure upgrades and projects in support of the planned start of TSCR in early FY2022 have been completed or will be completed prior to operations. A few DFLAW feed delivery projects that are not required to operate TSCR remain to be completed prior to the start of WTP-LAW hot commissioning.

Volume 3 – Project Plan lays out these and all other project and infrastructure work necessary to carry out the campaign plan.

Revision of Volume 1 – Process Approach and Volume 3 – Project Plan of the IWFDP is not warranted at this time.

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[8] The IWFDP has to consider the WAC for feed to TSCR and TFPT (which incorporates WTP-LAW feed acceptance criteria of ICD-30), and WTP-PT feed acceptance criteria of ICD-19. Facilities like TWCS and LAWST that are still highly conceptual do not yet have feed acceptance criteria.

2.0 CAMPAIGN PLANNING

The broad responsibilities of the Hanford Tank Operations Contractor have historically included the ongoing operations to retrieve waste from inactive SSTs into DSTs and to manage the volume and safely store this retrieved waste along with the waste that is already in DSTs, and to execute projects to maintain the physical waste tank system in a state that is compliant with the tank farm safety basis. More recently, TOC responsibilities expanded to include all the tank farm preparations necessary to stage, qualify and pretreat DFLAW campaigns, and then deliver the pre-treated waste feed to the Hanford Tank Waste Treatment and Immobilization Plant (WTP) where it is treated by vitrification and made into a borosilicate glass waste form for disposal.

The Waste Feed Delivery and Operations Planning organization serves as the site authority for the identification and implementation of related requirements and resolution of technical issues in these areas of waste feed selection and waste feed qualification. Associated with this authority comes the responsibility to establish the methodology and selection criteria for future feed batches. In order to address this responsibility, the Waste Feed Delivery and Operations Planning organization has established an objective to formalize and implement a Feed Selection & Sequencing (FS&S) Strategy.

The strategy provides a framework for feed selection by analyzing, identifying, and targeting feed for future campaigns in a manner that focuses on advantageous utilization of waste. The FS&S Strategy aims to address potential bottlenecks concerning performance parameters for pretreatment and vitrification which could result in processing delay or glass products that do not meet the product quality requirements. Furthermore, the FS&S Strategy looks at the waste inventory to ensure that considerations are made for ease of processing and effective use of waste in the long term. The strategy strives to utilize and sequence feed in a manner that alleviates latent issues as more complex waste is targeted for feed.

Once developed, the FS&S Strategy will be an interactive desktop tool that first categorizes feed according to the following criteria:

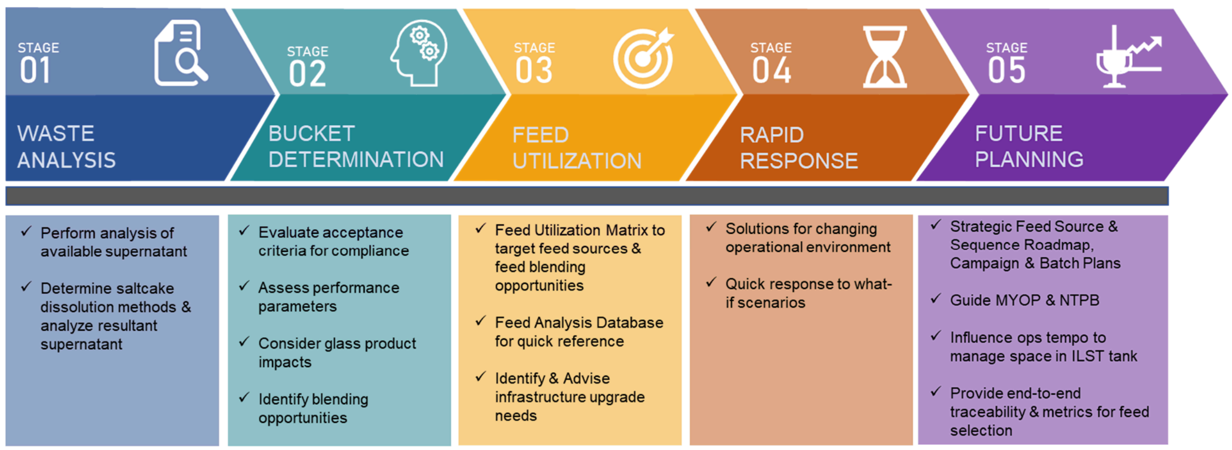
- Compliance with all required acceptance criteria
- Performance parameters for pretreatment systems, such as the Tank Side Cesium Removal (TSCR) system, and the Immobilized Low-Activity Waste (ILAW) glass algorithm used at WTP.

Based on the categorization, possible blending combinations of waste will be identified in order to optimize the feed in regard to the performance parameters. To ensure accessibility, data and analysis results will be stored in a database allowing for quick reference to allow for a more rapid response against ever changing operational scenarios.

This improved planning effort for Tank Farm feed to WTP has many advantages across the Hanford mission including a consistently managed waste feed delivery (WFD) process, minimizing generation and storage of ILAW containers, better prioritization of tank farm infrastructure upgrades, and a realistic estimation for mission completion and cost. Reduction of treated feed variability also minimizes risk associated with processing off-normal feeds.

The initial focus of the FS&S Strategy will be upon the Direct Feed LAW (DFLAW) mission and will target supernate selection. Figure 2-1 below provides an overview of the planned development of the FS&S Strategy for DFLAW.

Figure 2-1 DFLAW FS&S Strategy Development



Future versions of the strategy will include saltcake dissolution, as well as HLW sludge selection criteria.

Waste feed campaigns will be prepared in the DST system by delivering feed to the respective preparation, pretreatment, or treatment system to support final treatment and disposition. The following sections describe the source, preparation, sampling, qualification, and delivery of waste feed during each phase of RPP mission execution.

Campaigns originate from:

- supernate waste currently in DSTs,
- supernate derived from recently retrieved SST saltcake,
- supernate derived from remediated Waste Group A DSTs and other DST saltcake,
- supernate derived from TSCR process returns to AP-108 (minor source).

Each campaign is adjusted (typically dilution with water to a target sodium concentration) and recirculated for a prescribed time to approach homogeneity prior to qualification.

The Integrated Direct Feed Low-Activity Waste (DFLAW) Feed Qualification Program (RPP-RPT-59314) establishes the process for demonstrating, through analytical evaluation, that a DFLAW campaign will meet feed acceptance and processability requirements of the TSCR System and the WTP-LAW Facility. The program ensures adherence to the applicable safety, permitting, and technical bases of the TSCR System and WTP-LAW Facility.

The program is predicated on a specified set of analyses, calculations, and processability testing conducted on a set of qualification waste samples to predict process outcomes. The integrated approach focuses on a single sampling event for collecting six supernate samples at different depths from a single riser in the designated campaign preparation DST. The samples are analyzed to obtain feed acceptance data and tested for processability before qualifying a new campaign.

The program provides assurance that the feed acceptance criteria and qualification requirements are met for the authorized transfer of waste feed to the TSCR System for pretreatment followed by the transfer of pre-treated feed to the WTP-LAW Facility for immobilization into a glass waste form.

Treatment of LAW feed in a direct-feed mode at TSCR is scheduled to begin in November 2021. Preparation of the waste in AP-107 for Campaign 1 has been in progress for several years, and the qualification package (RPP-RPT-63182) is complete as of this writing. After removal of entrained solids via filtration and cesium capture via ion exchange at TSCR, the pre-treated Campaign 1 will be stored in the Interim Low-Activity Waste Storage Tank ILST (AP-106) prior to being vitrified in the WTP-LAW. For all subsequent campaigns, pretreatment proceeds in parallel with feeding the glass plant (i.e., the inventory in AP-106 is dynamic). Subsequent feed campaigns will be staged, recirculated, sampled, and qualified in other DSTs, usually AP-105, prior to transfer to AP-107. DFLAW planning is based on operating TSCR for the first five years, to be replaced by TFPT thereafter.

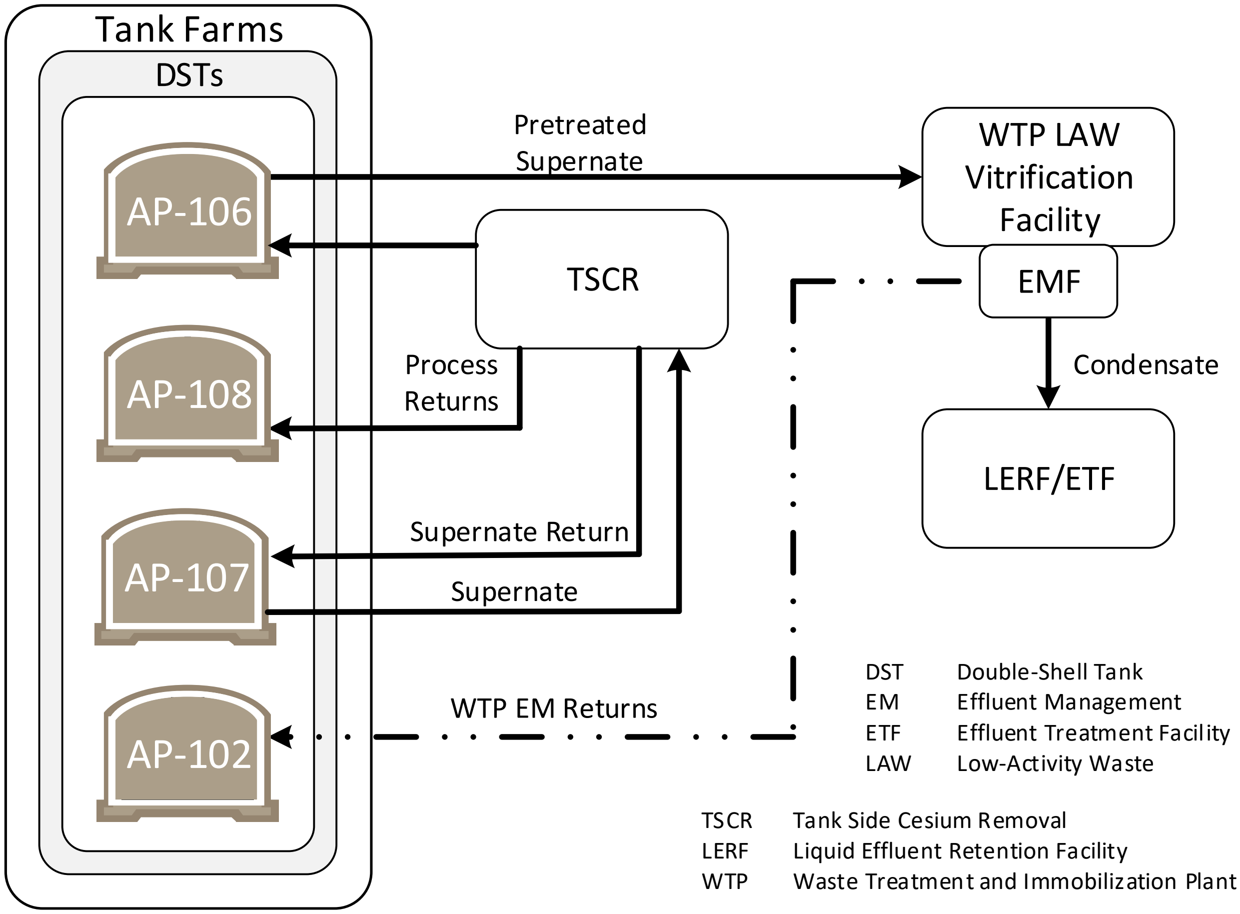
BOM operations consist of preparation of HLW and LAW feed campaigns to be pretreated within the WTP system. HLW feed will be delivered to TWCS, where the waste will undergo blending, sampling, chemical adjustment (as necessary), and qualification before delivery to the WTP-PT. In addition, DFLAW campaigns will continue to be staged, prepared, sampled, and qualified within the DFLAW system tanks prior to delivery to TFPT.

2.1 DIRECT-FEED LOW-ACTIVITY WASTE CAMPAIGN 1

The initial feed campaign for the DFLAW phase has already been prepared in AP-107. The contents of AP-107 are protected TSCR commissioning feed per the HNF-SD-WM-OCD-015, *Tank Farms Waste Transfer Compatibility Program* feed control list. Figure 2-2 illustrates the simplified process flow for Campaign 1, which is unique in that the waste is already staged and qualified in AP-107.

Figure 2-2 also applies to all subsequent DFLAW campaigns once they are staged, qualified, and transferred to AP-107.

Figure 2-2. Process Flow Diagram for the First DFLAW Campaign



For other early campaigns see Figure 2-3 which shows the feed preparation and mixing process before staging the campaign into AP-107. After mixing via recirculation, the waste undergoes sampling and feed qualification activities in AP-105 prior to delivery to AP-107 to feed TSCR and then to the WTP-LAW.

2.1.1 Source of Waste

The current inventory of AP-107 is documented in RPP-RPT-48103 Rev. 12, *Derivation of Best-Basis Inventory for Tank 241-AP-107 as of May 01, 2021*. The qualification sample results for Campaign 1 are documented in RPP-RPT-63204, *241-AP-107 Grab Sample Results for Qualification of Direct Feed Low Activity Waste (DFLAW) Unit Operations Testing, 2021*.This composition meets the WAC for TSCR (RPP-RPT-60636) per the feed qualification report (RPP-RPT-63182). The current contents of AP-107 are also predicted to have an acceptable waste oxide loading (WOL), which is a quantitative measure of the amount of pretreated waste that can be incorporated into a unit mass of glass. WOL for Campaign 1 is predicted to be around 17 wt%.

2.1.2 Delivery to Tank Side Cesium Removal

The initial transfer of feed from AP-107 to TSCR is planned for November 2021. The initial DFLAW campaign includes a TSCR Demonstration period. The TSCR Demonstration, processing about 315 kgal of Campaign 1, is the final task of the TSCR Demonstration Project. The remainder of Campaign 1 is pre-treated and accumulated in ILST (AP-106) prior to feeding WTP-LAW. For subsequent campaigns, ILST (AP-106) is simultaneously feeding WTP-LAW while receiving treated supernate from TSCR.

A campaign is considered over when there is insufficient supernate left in AP-107 to start and complete another ion exchange loading cycle. This 'end of campaign' rule was established to avoid changing feed chemistry in the middle of a loading cycle, and so that AP-107 refills could occur when TSCR is already down for column changeout.

2.1.3 Tank Side Cesium Removal Returns to Tank Farms

TSCR generates three types of returns to tank farms: feed returns, treated feed returns, and process returns (or secondary waste). TSCR receives feed from AP-107 in excess of the 5 gpm instantaneous TSCR processing rate. Excess feed recycles to AP-107. Treated feed returns to AP-106, about 21.6 Mgal of supernate processed over the DFLAW phase based on Case 14517. Operation of the TSCR unit generates two kinds of process returns: filter backflush containing captured solids and IX column flush, both of which are routed to AP-108. The estimate of process returns during the DFLAW phase is 0.7 Mgal.

2.1.4 Delivery to Waste Treatment and Immobilization Plant Low-Activity Waste Vitrification Facility

Pretreated DFLAW supernate is ready for transfer from ILST (AP-106) to the concentrate receipt vessels at the WTP-LAW (LCP-VSL-00001/-00002) in nominally 6,430 gal increments via the rerouted feed transfer line (AP-106 to WTP-EMF to WTP-LAW) starting in December 2022 or January 2023. Because the DFLAW feed loses its identity as a discrete campaign upon entering ILST (AP-106), an AP-106 composition tool[9] keeps track of the changing feed composition. The WTP-EMF also recycles concentrates, as needed, via the same line to the concentrate receipt vessels. WFD has flexibility to deliver whatever batch size WTP requests. WTP is responsible for requesting the volume of DFLAW feed that makes an acceptable melter feed batch taking the recycled EMF concentrates into consideration. The DFLAW feed transfer to WTP-LAW is a daily occurrence so the line is not flushed unless an extended outage at WTP-LAW is planned.

2.1.5 Waste Treatment and Immobilization Plant Low-Activity Waste Vitrification Facility Returns to Tank Farms

As returns from WTP-EMF *to Tank Farms* are considered an off-normal event, TOPSim does not model EMF effluent returns (i.e., there is not an EMF returns stream in the model). The WTP EMF will filter and concentrate melter offgas condensate and other secondary effluents, and normally return the concentrate to the WTP-LAW concentrate receipt vessel. During actual

[9] The AP-106 composition tool is a work in progress that will eventually be issued as RPP-PLAN-63581.

DFLAW operations, any WTP EMF concentrate that cannot be internally recycled will be sent to the tank farms (AP-102) or off-loaded into tanker trucks for disposal.

2.2 SUBSEQUENT DIRECT-FEED LOW-ACTIVITY WASTE CAMPAIGNS

LAW will be treated in direct-feed mode until the WTP-PT startup. With current assumptions (Case 14517), the life-cycle modeling tool estimates 24 DFLAW campaigns processed through TSCR/TFPT prior to startup of the WTP-PT/HLW, and 27 more campaigns during BOM (BOM campaigns are routed to treatment at LAWST). However, the exact number of campaigns during the DFLAW phase is subject to change dependent on the startup date of WTP-PT as well as the TSCR/TFPT and WTP-LAW performance assumptions. Whether TSCR can support the WTP-LAW production rate ramp up from 9 MTG/day to 18 MTG/day to 21 MTG/day depends on glass formulation performance. Figure 4-1 includes the chart for ILST (AP-106) inventory confirming that TSCR/TFPT is capable of keeping WTP-LAW in feed pursuant to the current modeling assumptions. During the first 5 years of pretreatment, modeling indicates that TSCR production occasionally trails somewhat behind feed consumption at the glass plant. However, beginning in the 6^{th} year of pretreatment, the transition to TFPT resolves that issue. TSCR is capable of supporting up to 16 MTG/day[10] before ILST (AP-106) inventory draw down during the time frame when Na_2O loading in glass is expected to be ~15 wt%. TFPT, on the other hand, can be designed for uninterrupted feed to WTP-LAW operating at any glass production even when 20 wt% Na_2O is the typical loading performance.

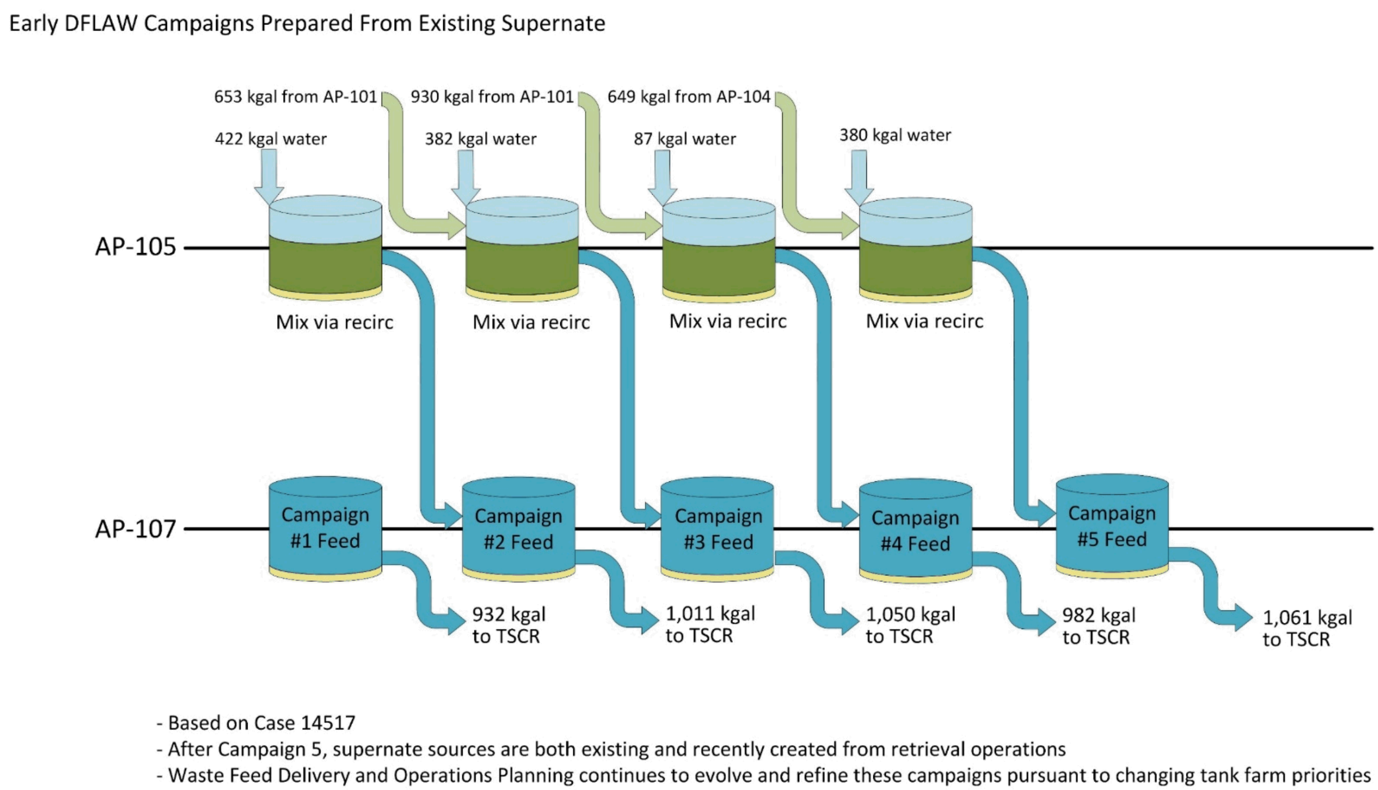
Until startup of the WTP-PT, LAW feed will be processed according to the process flow diagram shown in Figure 2-2. Supernate is transferred from AP-107 to pretreatment in TSCR/TFPT before vitrification at the WTP-LAW, with WTP-LAW effluent streams being handled by the WTP-EMF, and WTP-EMF condensate by LERF/ETF.

Figure 2-3 depicts the transfers and dilutions that occur in preparation of the first five of eleven as-prescribed-for-modeling DFLAW feed campaigns. Campaign 1 in AP-107 is already prepared. Campaign 2 entails decanting some current supernate from AP-105 to AP-104. The remaining supernate in AP-105 is then topped off with 422 kgal water, mixed via recirculation, sampled, and qualified. After Campaign 1 has been processed through TSCR, Campaign 2 is transferred from AP-105 to AP-107. All subsequent campaigns are prepared by decanting an appropriate volume of supernate from a proximate source tank(s) to AP-105, topping off with water to the target sodium molarity (if necessary, occasionally campaigns don't require water), and completing the mix, sample, and qualify routine as layed out in RPP-RPT-59314.

The source tanks for DFLAW Campaigns 1 and 2 have been administratively reserved. These two early campaigns have the highest degree of certainty to be executed as diagrammed. Beyond Campaign 2, campaigns are likely to be impacted by precedent transfers that happen differently from what was prescribed in modelling space. Even at this writing, changes to these near-term campaigns are under consideration. Waste Feed Delivery and Operations Planning works to evolve (then confirm) campaigns pursuant to the most recent inventories, to the transfers that have (or will have) actually transpired, and to shifting tank farm priorities.

[10] Underlying assumptions: TSCR has no downtime other than 10-day column outage and 20 wt% Na_2O loading. TSCR can keep up with 21 MTG/day only if WTP-LAW formulates ILAW to 15 wt% Na_2O loading. WTP-LAW could also elect to run at less than the maximum rate during the TSCR phase to avoid running out of feed.

Figure 2-3. Preparation of the Early Direct Feed Low-Activity Waste Campaigns



With respect to Figure 2-3, it should be understood that the farther out the campaign is, the more likely it is that competing tank farm priorities (that have yet to be recognized) will require changes. Beyond a 5-campaign horizon, campaigns are very speculative. Also, the sequence is one of multiple possible permutations that could generate WAC compliant campaigns

Original source tracking *on an aggregate basis* through the first 24 DFLAW campaigns is discussed below. Recognize that original source tracking is a product of modeling, and reliable to the extent that actual transfer sequence follows the modeled transfer sequence.

Figure 2-4 shows the aggregate original sourcing of 24 DFLAW campaigns on a dry wt% basis. DFLAW is 77.22 wt% *original-sourced from DSTs*, with AP Farm, AW Farm, and AN Farm contributing the largest portions (34.04 wt%, 16.71 wt% and 10.72 wt%, respectively). Smaller portions come from AY/AZ Farms (7.92 wt%), and SY Farm (7.83 wt%). DFLAW feed is 22.78 wt% *original-sourced from SST retrievals*, A/AX Farms and S/SX Farms (11.63 wt% and 11.15 wt%, respectively).

Figure 2-5 shows about 15.55 wt% of DFLAW is from Waste Group A mitigations.

Figure 2-4. Feed Sources for DFLAW Campaigns by Farm

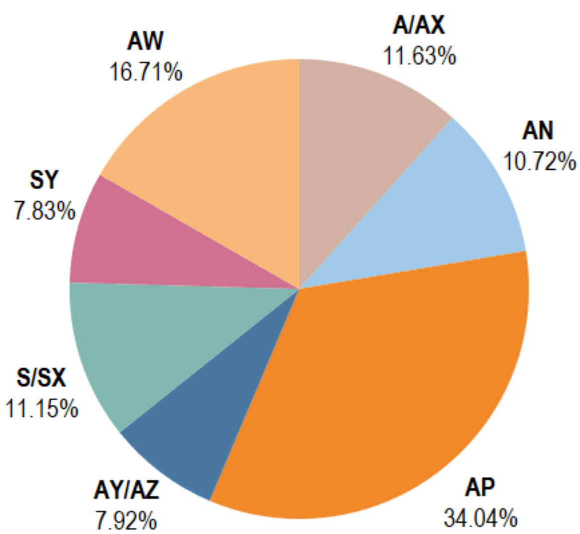
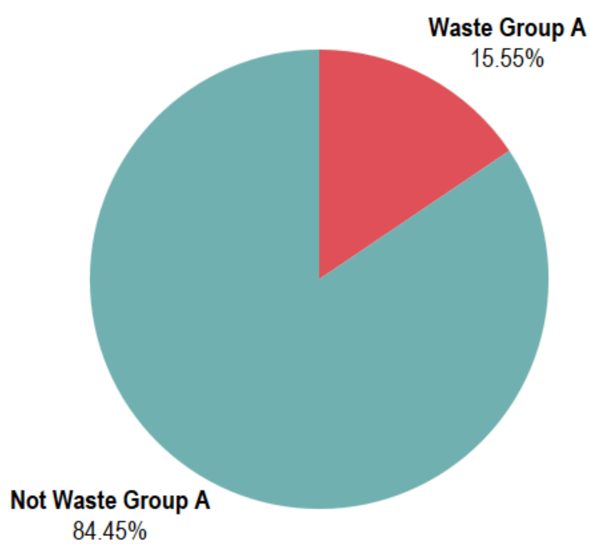


Figure 2-5. Waste Group A in DFLAW Campaigns



2.2.1 Feed Preparation

Following the first campaign, DFLAW campaigns will typically be prepared in the staging and characterization tank (AP-105) as diagrammed in Figure 2-3. The majority of supernate waste in the 200 East Area DSTs at the start of DFLAW operations has been concentrated beyond 6 M Na by the 242-A Evaporator. The waste will therefore require dilution to meet the WAC for

TSCR/TFPT. The basis used for life-cycle modeling is that dilution will be made to a nominal concentration of 5.5 M Na, although actual campaign planning may consider the pros and cons of preparing campaigns that are between 5 M and 6 M. This dilution and recirculation will occur prior to qualification sampling activities. Some campaigns may also require the addition of caustic if there is potential for precipitation of aluminum during feed preparation or processing through the TSCR/TFPT.

As the DFLAW treatment rate ramps up over the DFLAW phase, other campaign preparation DSTs (e.g., AP-103, AP-104) could be enlisted to facilitate qualification if needed. Campaign modeling to date has not indicated a need for additional campaign preparation tanks.

Feed preparation through the DFLAW tank system provides incidental blending of campaigns in several ways. First, with passage of time proximate source tanks typically receive waste from multiple original sources. Second, many campaigns are prepared from more than one proximate source tank. Third, supernate staged into AP-105 blend with any residual heel from the previous campaign. Fourth, qualified campaigns transferred to AP-107 are blended into the residual heel from the previous campaign. Fifth, pretreated LAW feed entering ILST (AP-106) at 5 gpm blends continuously into the large volume of interim-stored LAW feed. ILST (AP-106) operating in semi-continuous mode moderates changes in concentration that would be more abrupt in a batch process. This smoothing can be seen in the TSCR/TFPT feed tracking chart vs. the LAW feed chart. Incidental blending is almost always positive because it dampens composition extremes.

2.2.2 Sampling

The diluted, prepared feed in AP-105 will be sampled to verify waste compatibility, qualify the feed, and provide for process control planning. Five samples (plus one duplicate) will be taken from varying depths of a single riser, as documented in RPP-RPT-59314, *Integrated DFLAW Feed Qualification Program Description*. The sample depths are spaced to be representative of equal volume portions of the prepared supernate. Near uniformity from top to bottom is expected based on previous sampling and qualification of AP-107.

Each six-sample qualification sampling event will occur during a 14-day window, where the contents of a staging and characterization tank are mixed via recirculation, and samples are pulled from varying depths of a single riser (RPP-RPT-59314). The sample will be analyzed for process control, waste compatibility, and feed qualification purposes.

2.2.3 Feed Qualification

The dwell time for feed qualification is estimated by subject matter experts to be 98 days (RPP-RPT-59453, *Direct Feed Low Activity Waste Rapid Improvement Event #3: Direct Feed Low Activity Waste Feed Qualification*), plus the above mentioned 14 days for mixing and sampling, for a total of 112 days. Samples from AP-105 will be analyzed against the limits defined in the WAC for TSCR RPP-RPT-60636 which also incorporates all the requirements of 24590-WTP-ICD-MG-01-030, *ICD 30 – Interface Control Document for Direct LAW Feed* (ICD-30).

As previously discussed, the expected minimum dwell time for feed qualification is 98 days, exclusive of the 14 days for waste mixing and sampling. The life-cycle model projects that the window available for sampling and feed qualification is always greater than the time required. The qualification window is compressed in later campaigns after the glass production rate has ramped to maximum; sometimes there is only one month of float between the end of qualification and feeding TSCR. Based on these projections, feed qualification is not expected to bottleneck WFD. If qualification ever becomes constraining, any tank capable of providing well-mixed supernate and having appropriate process controls in place can be used as an additional staging and characterization tank.

The 222-S Laboratory has been chosen as the feed qualification laboratory for DFLAW operations. The lab completes both composition analyses and processability testing (TSCR and WTP-LAW).

2.2.4 Delivery to the TSCR/TFPT

DFLAW campaign size averages 0.98 Mgal over the eleven currently prescribed DFLAW campaigns. DFLAW campaigns beyond Campaign 11 are model-created and will continue to be delivered to the TFPT until the integrated WTP facilities come online. Long-term model results are indicative only. Case 14517 models nominally 24 campaigns over the DFLAW phase continuing until approximately December 2033. After the DFLAW phase ends, TFPT continues to prepare feed for Supplemental Treatment in Campaigns 25 through 51.

After the initial administratively stipulated campaigns, all campaigns are subject to scrutiny, refinement and confirmation by the Waste Feed Delivery and Operations Planning organization. However, only campaigns within the 5-campaign horizon should receive a high degree of scrutiny. Campaigns beyond the 5-campaign horizon are a lesser priority because they are tentative (over a few years, tank farm transfer activity can alter inventories in unanticipated ways, tank farm priorities change). Longer term model-created campaigns do not deserve much attention from Waste Feed Delivery because they are highly speculative. The objective is to have a thorough understanding of the next few campaigns, and a general idea of where campaigns are coming from after the 5-campaign horizon.

2.2.5 TSCR/TFPT Process Returns to Tank Farms

AP-108 is dedicated to receiving TSCR/TFPT process returns. During DFLAW operations, AP-108 receives about 0.7 Mgal of TSCR/TFPT process returns. Returns are generated by the system flush at the end of the IX column loading cycle, and by the daily backflush of the TSCR/TFPT filters.

2.2.6 Delivery to the Waste Treatment and Immobilization Plant Low-Activity Waste Vitrification Facility

The last transfer to the WTP-LAW during DFLAW operations is projected to occur in October 2033 to prepare for operational tie-ins to the WTP-PT; however, the WTP-LAW is expected to operate until the feed is vitrified before shutting down.

2.2.7 Waste Treatment and Immobilization Plant Low-Activity Waste Vitrification Facility Returns to Tank Farms

As discussed in Section 2.1.5 any effluent generated in the WTP-LAW that cannot be internally recycled will be routed to the tank farms via the WTP EMF. Routing of effluent to the tank farms is considered an off-normal event and is not currently included in the life-cycle model.

2.3 BALANCE OF MISSION

During the BOM phase of the RPP mission, HLW feed and LAW feed are processed in parallel through facilities with different processing capabilities. Section 3.2 and the RPP Integrated Flowsheet (RPP-RPT-57991) provide additional detail on the BOM phase.

Treatment of HLW can begin following startup of TWCS, the WTP-PT, and WTP-HLW. The new TWCS (conceptually a vault of six large tanks with capabilities yet to be finalized) facilitates small volume[11] slurry transfers to the WTP-PT. When operational, slurry from the DST system will be staged, blended, conditioned, sampled and qualified in the TWCS tanks before being transferred to the WTP-PT for treatment prior to delivery to the WTP-HLW for vitrification. Transfer of waste from the tank farms to TWCS will begin several months prior to startup of the WTP-PT to get feed into the HLW supply line.

LAW continues to be treated, with two pathways available during integrated WTP-PT facility operations. At the completion of the DFLAW phase, TFPT operations are suspended for six years, then resume to prepare direct feed to LAW Supplemental Treatment. For the BOM, nearly equal volumes of LAW feed from the tank farms are delivered to the TFPT and WTP-PT for pretreatment. The WTP-PT will also process the much larger volume of LAW feed generated from HLW preparation and treatment.

However, in view of the lack of finality in TWCS, WTP-PT and WTP-HLW facility design (there are only competing modeling assumptions at this point), the general high state of uncertainty in how HLW processing is going to proceed, and BOM being 12 years in the future, Waste Feed Delivery and Operations Planning has elected to discuss HLW campaign planning in concept rather than in detail for this Campaign Plan revision.

2.3.1 Source of Waste

The sludge in AP-102 is the designated HLW hot commissioning feed. Conceptually, AP-102 sludge would source the first of many slurry transfers from DSTs to TWCS to create nominal 500 kgal HLW campaigns in the TWCS tanks. The total number of HLW campaigns created in TWCS depends on the total amount of tank farm solids requiring conveyance, assuming that HLW feed slurry is prepared to a consistent solids concentration. HLW campaign planning will undoubtedly go through multiple evolutions over the next twelve years, but the total number of

[11] Small slurry transfers from DSTs direct to WTP-PT are not plausible in view of the technical difficulties of suspending slurry in Mgal tanks too frequently, and also in view of the infeasible flush volume that would be required in making many small slurry transfers direct from DSTs. There are currently competing concepts for what is meant by “small volume” TWCS to WTP-PT transfer. There is the older concept which entails making a few 143 kgal TWCS to WTP-PT transfers and a new Standard High Solids Vessel (SHSV) concept that entails many 45 kgal TWCS to WTP-PT transfers that split into three SHSV vessels. The lack of finality in the TWCS/WTP-PT/WTP-HLW process train makes it difficult to say anything definitive about HLW campaign plans.

HLW campaigns should be relatively independent of any specific campaign plan. For the assumptions used by lifecycle modeling, no more than 200 HLW campaigns is a reasonable working number for current purposes.

As most DSTs are 1.2 Mgal and the conceptual TWCS tank is projected to be 500 kgal, it is entirely feasible to stage the volume of a HLW campaign all at once in a single DST. However, it is also feasible to create campaigns in TWCS with smaller transfers from multiple DSTs, which could be useful and necessary when blending sludge campaigns to a better composition is beneficial.

2.3.2 Feed Preparation

Other than some intentional blending of high fissile U and high Zr sludge, no special conditioning is currently planned for HLW while in the DST system. The HLW slurry (comprised mostly of carrier liquid with a fixed concentration of sludge solids) will be mobilized in the DST system, mixed with existing tank supernate as necessary, and transferred to TWCS for further preparation prior to delivery to the WTP-PT.

For the BOM LAW feed, it can be prepared, sampled, and characterized in any qualification-capable DST and transferred directly from the DST system to the WTP-PT through existing Project W-211lines. After a six-year hiatus, the DFLAW system tanks and TFPT also resume qualification and pretreatment, the TFPT pre-treated LAW intended for immobilization in LAWST. The beginning of LAWST operations is the driver for resumption of TFPT operations, but start of LAWST operations may change between life-cycle modeling cases.

2.3.3 Tank Waste Characterization and Staging

As described in the Mission Need Statement, TWCS is assumed to consist of six double-contained underground storage tanks, each with an operating volume of 500 kgal. Specific functionality required of TWCS is still under development but could include blending, mixing, and yet-to-be-determined conditioning of sludge solids. Clearly there will be sampling to support campaign qualification. There are no current plans for any return streams from TWCS to the tank farms.

Actual design of the TWCS facility has not progressed at all. In fact, TWCS capabilities cannot be designed without better understanding of the slurries and a fully defined process. For example, what is the practical slurry solids concentration (as opposed to a mere modeling assumption), what are the settling characteristics of slurries, what is the frequency and size of transfers to WTP-PT, and the mixing/suspension capabilities required to support that? Further clarity on these and other questions will be necessary before and during design of the TWCS capability.

HLW feed originating in the DST system will be delivered to one of the TWCS tanks using existing WTP transfer lines, as described in Section 3.2 and the IWFDP Volume 3 – Project Plan.

TWCS tanks will be designed to expedite representative sampling of slurry. The samples will be analyzed for the WAC and the reportable-only parameters identified in 24590-WTP-ICD-MG-01-019, *ICD 19 – Interface Control Document for Waste Feed* (ICD-19), within the 180-day minimum dwell time.

Following qualification of the feed in a TWCS tank, the tank will be mixed to mobilize solids and the slurry feed will then be transferred to the WTP-PT. One of the current challenges to describing HLW campaigning is the uncertainty in how the qualified feed in TWCS makes the transfer to WTP-PT. A recent, new concept in HLW campaigning is to transfer from a TWCS tank to the HLP-VSL-00022A/B/C/D receipt vessels in the WTP-PT in nominal 15.5-kgal batches (the so-called SHSV flowsheet, which is assumed in Case 14517). This is considerably different from the historical concept of transferring from TWCS tanks to WTP-PT in three 143 kgal increments.

In summary, the current state of HLW feed delivery process definition makes HLW campaign planning difficult.

2.3.4 Waste Treatment and Immobilization Plant Pretreatment Facility

Within the WTP-PT, slurry from TWCS will be separated into a high-level fraction and a low-activity fraction. The high-level fraction is sent to the WTP-HLW. The low-activity fraction will be combined with LAW supernate transferred from tank farms, where the waste was previously sampled and characterized. The combined LAW feed stream can be immobilized in either the WTP-LAW or LAWST. The supernate pretreatment capacity of WTP-PT is expected to be greater than the capacity of WTP-LAW, the excess pretreated supernate being treated at LAWST. The intent during BOM is to keep WTP-LAW operating at full capacity with excess LAW feed going to LAWST.

2.3.5 Waste Treatment and Immobilization Plant High-Level Waste Facility

The WTP-HLW receives pretreated slurry from the WTP-PT. The concentrated HLW slurry is combined with glass formers and vitrified into IHLW canisters. Expected cumulative production of canisters is shown in Figure 3-5 (Section 3.3). As illustrated in that figure, the WTP-HLW produces far fewer canisters of IHLW than the ILAW containers produced by the WTP-LAW and LAWST. The projected amount of curies treated to IHLW is ~48 MCi, with an additional 9 MCi when spent IXCs are eventually vitrified to IHLW.

2.3.6 Waste Treatment and Immobilization Plant Low-Activity Waste Vitrification Facility

During BOM, WTP-LAW will vitrify the LAW fraction separated from the feeds to WTP-PT. Excess LAW created by WTP-PT is routed to treatment at LAWST. In combination with the output of LAWST, the anticipated ILAW production is provided in Figure 3-5.

2.3.7 Tank Farms Pretreatment

After a 6-year hiatus, sampling, qualification, and delivery of feed to the TFPT resumes essentially the same as during DFLAW operations, as described in Sections 2.1. However, during the BOM, the TFPT pretreated supernate in ILST (AP-106) will be transferred only to the LAWST.

2.3.8 Low-Activity Waste Supplemental Treatment

LAWST is an additional LAW feed immobilization facility sized to minimize the lifecycle cost of the RPP mission. The waste form produced by the facility is still under consideration. In addition to the output of the WTP-LAW, the expected output of LAWST is provided in Figure 3-6 based on the assumption that the LAWST facility is producing a vitrified waste form.

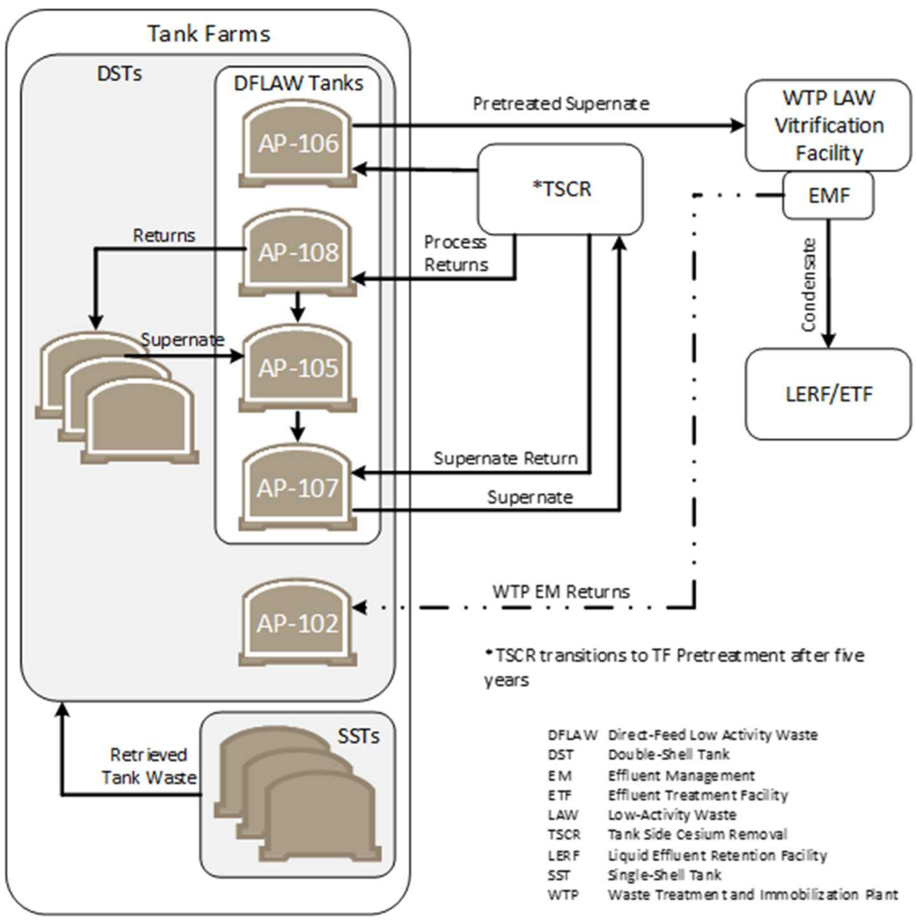
2.3.9 Supplemental Transuranic Treatment Facility

Information on CH-TRU waste processing at the supplemental TRU treatment facility and eventual disposition is provided in the RPP Integrated Flowsheet (RPP-RPT-57991). The treatment process for CH-TRU waste is still being determined. Only selected tank wastes found to be TRU pursuant to a legal determination are processed via this path.

3.0 SUMMARY OF CAMPAIGNS

The WFD campaigns described in this IWFDP volume are consistent with life-cycle model MR-50695 (Case 14517) and with RPP-40149-VOL1, *Integrated Waste Feed Delivery Plan, Volume 1 – Process Approach*, and the *RPP Integrated Flowsheet* (RPP-RPT-57991). When the WTP complex is fully deployed after 2033, the WTP-PT separates tank waste into pretreated LAW and pretreated HLW slurry feed fractions. In the meantime, ORP has directed alternate mission strategies to make progress in treating waste through a phased approach. Phase 1 is near term tank farm operations, and the startup and operation of TSCR. Phase 2 consists of TFPT operations to the end of DFLAW. Phase 1 and 2 are characterized by the staging of supernate campaigns in designated DSTs and the commissioning of tank-side pretreatment facilities TSCR/TFPT that operate until the integrated WTP facilities (WTP-PT, -LAW, -HLW) begin operating in 2034. During Phase 1 and 2, WFD supports only WTP-LAW (while construction continues on the unfinished WTP facilities). Phase 3 (or BOM) begins when the DFLAW phase of operations ends[12] and TWCS and the full capabilities of the integrated WTP facilities become operational. Figure 3-1 shows the process flow during the DFLAW phase.

Figure 3-1. Process Flow Diagram for Direct Feed Low-Activity Waste Operations



[12] The DFLAW phase ends, but TFPT carries on preparing direct feed for LAW Supplemental Treatment.

3.1 DIRECT-FEED LOW-ACTIVITY WASTE CAMPAIGNS

Campaigns for DFLAW operations are defined as nominally 1 Mgal of supernate staged to and qualified in AP-105, which is then bulk transferred into AP-107. AP-105 is dedicated for campaign preparation and qualification, but qualification in other tanks that have similar capabilities is not prohibited. Qualified waste campaigns in AP-107 are then pretreated in TSCR/TFPT, with the pretreated waste accumulating in AP-106. AP-106 is likewise dedicated as the Interim LAW Storage Tank (ILST). In practice, the campaign volume that AP-107 feeds to TSCR/TFPT varies from the qualification campaign volume in AP-105 because considerations at TSCR determine the usable fraction of each campaign. For Case 14517, the 24 DFLAW campaigns average about 0.9 Mgal.

Campaign *original* sourcing[13] is a model capability that is indicative of the degree of beneficial incidental blending that has occurred. More incidental blending is usually a good thing because it dampens composition extremes that may have existed in original sources that could adversely affect processing.

Original sourcing also facilitates diagnosis of the cause of campaign non-compliances when they occur. Campaigns found to be out of compliance with the WAC for TSCR/TFPT (RPP-RPT-60636)[14] will necessitate intentional blending with other sources in conjunction with campaign preparation in AP-105. Figure 3-2 indicates DFLAW campaign *original* sourcing and the creation date of two campaigns for illustration purposes. See Appendix A Figure A-1 for original sourcing of several of the early DFLAW campaigns of Case 14517.

Campaign original sourcing is also useful for getting a general idea of where campaigns are coming from. Thus, Campaign 4 is the first time a campaign is sourced from outside of AP Farm. Campaign 14 is the first to be sourced from outside of 200 East Area.

Campaign original sourcing is simple and certain only for the first three campaigns. Beyond Campaign 3, tracing back the *original* source of campaigns becomes complicated because ongoing tank farm volume management has moved waste (possibly multiple times) from its original Best Basis Inventory BBI location before it becomes associated with a specific campaign. For example, AP-101 is the proximate source for Campaign 4, but by that date AP-101 has received supernate from AZ-102 and from SST retrieval.

Caveat on original sourcing: Original sourcing depends on a model conducting a specific sequence of many transfers over the space of many years. In real life, it is not unusual for immediate tank farm priorities to necessitate actual transfers that depart from modeling (i.e., a transfer to facilitate SST retrieval). Consequently, the accuracy of original sourcing as a predictive tool is dependent on actual transfers mirroring what was modeled in a specific case. Original sourcing does not remain accurate over the long-term without frequent updating.

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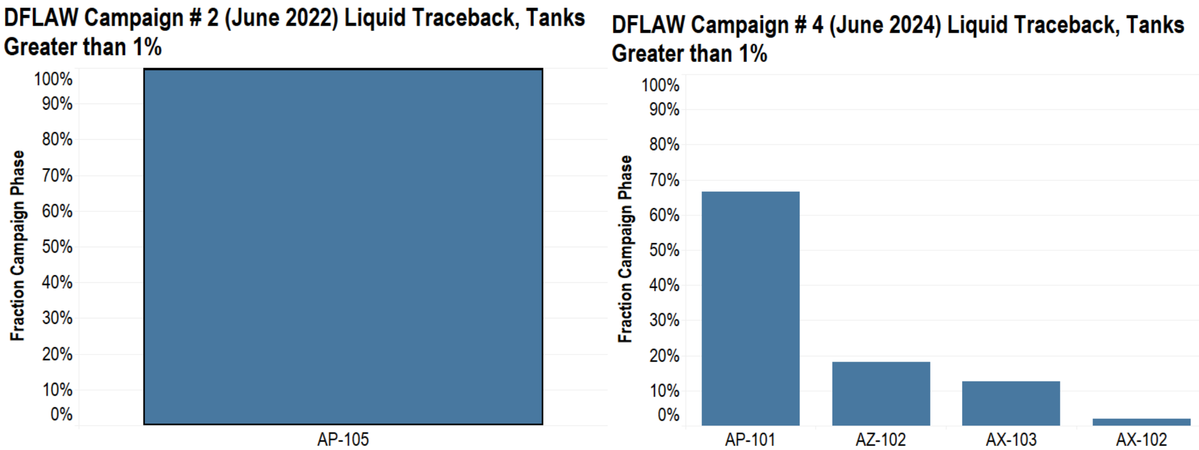
[13] Original sourcing refers to back-tracing campaigns to the point of origin in the reference BBI of the life-cycle model, and the prevalence of those original sources in each campaign.

[14] The WAC for TSCR/TFPT incorporates acceptance criteria that are specific to the design limitations of the TSCR/TFPT facilities as well as all of the WTP-LAW requirements from ICD-30.

Figure 3-2 Original Sourcing of DFLAW Campaigns – Two Examples



Noting that Campaign 1 is already prepared and qualified in AP-107, Table 3-1 shows tentative *proximate*[15] campaign sourcing into AP-105 for several early DFLAW Campaigns of Case 14517.

Campaign 1 to 11 are 'prescribed' campaigns, meaning that the proximate source tanks have been stipulated for their respective campaigns in the reference life-cycle model.

Being 'prescribed' does not, however, equate to certainty. Note that Campaigns 1 and 2 are the only campaigns with firm proximate sourcing at this point in time. Beyond Campaign 2 is less certain because other options are being considered for staging sources, and for the role that specific tanks will play in facilitating A Farm retrieval. For example, even at this writing there is consideration being given to blending early campaigns with the objective of minimizing water dilution.

Given the changing tank farm priorities and the variety of proximate sources that are available early in the DFLAW phase, other sequences are possible, in fact, likely as near-term tank farm plans evolve and take shape. Campaigns 4 to 11 are merely prospective pending further analysis by the Waste Feed Delivery and Operations Planning organization.

Campaign 12 and beyond are based entirely on the internal selection rules of the model. Campaign 14 is the first campaign where 200 West Area waste appears, and West Area waste is typically prevalent in campaigns thereafter. Because model-created DFLAW campaigns are completely speculative, they are not included in Table 3-1.

[15] Proximate sourcing refers to the tank immediately preceding AP-105, without consideration of previous transfers into the proximate tank. Proximate source tanks may, and in most cases have received supernate from other DSTs or SST retrieval, thus are not necessarily the original source of the supernate staged to AP-105.

Table 3-1 Qualification Campaign Proximate Sourcing to AP-105

Qualification Campaigns	Proximate Source Tank or Dilution Water	Start Date	Total Volume Transferred (gal)
1	Qualification Campaign 1 already qualified in AP-107		
2	AP-105 waste already in AP-105 for Qualification Campaign 2		
	WATER	10/26/2021	422,500
3	AP-101	7/2/2022	653,500
	WATER	7/7/2022	381,600
4	AP-101	10/26/2023	930,100
	WATER	11/2/2023	86,900
5	AP-104	6/17/2024	649,000
	WATER	6/22/2024	379,700
6	AP-108	1/12/2025	720,400
	WATER	1/18/2025	231,000
7	AP-103	8/25/2025	741,100
	WATER	8/31/2025	277,000
8	AY-101	2/23/2026	242,800
	AP-103	2/27/2026	442,800
	WATER	3/3/2026	241,800
9	AP-104	9/27/2026	666,300
	WATER	10/2/2026	352,700
10	AP-103	3/9/2027	238,800
	AP-104	3/12/2027	440,800
	WATER	3/16/2027	337,800
11*	AW-103	10/13/2027	575,500
	AP-102	10/18/2027	78,400
	WATER	10/20/2027	324,200

*Qualification Campaign 11 is the last prescribed campaign

Qualification Campaign 12 and beyond are omitted for the reasons discussed above.

A summary of the DFLAW feed campaigns, including the AP-105 to AP-107 feed staging and TSCR/TFPT feed delivery timing, is provided in Table 3-2, as well as the processed volume as determined by modeling. Again, campaigns become increasingly less certain the farther out the campaign planning.

Table 3-2 Direct Feed Low-Activity Waste Campaigns

Qualification Campaign	DFLAW Campaign	Feed Staging to AP-107 (Start Date)	Delivery to TSCR/TFPT (Start Date)	Volume Processed at TSCR/TFPT (gal)**
1	1	NA	11/12/2021	932,000
2	2	6/25/2022	7/3/2022	1,011,000
3	3	10/19/2023	10/27/2023	1,050,000
4	4	6/10/2024	6/18/2024	928,200
5	5	1/5/2025	1/16/2025	1,061,000
6	6	8/18/2025	8/26/2025	882,900
7	7	2/17/2026	2/25/2026	1,044,000
8	8	9/19/2026	9/27/2026	1,037,000
9	9	3/2/2027	3/10/2027	933,900
10	10	10/6/2027	10/14/2027	941,200
11	11	4/12/2028	4/20/2028	926,800

*Qualification Campaign 11 is the last prescribed campaign.

**Volume processed at TSCR and TFPT as determined by modeling.

All Case 14517 transfers to AP-105 amount to approximately 14.3 Mgal of concentrated tank waste with 5.9 Mgal of associated dilution water to adjust sodium molarity to the TSCR/TFPT target. The DFLAW phase continues until the startup of the WTP-PT; thereafter, only WTP-PT will perform pretreatment for feed to WTP-LAW.

The actual batch size and frequency[16] of DFLAW batches delivered from ILST (AP-106) to the WTP-LAW are at the discretion of WTP-LAW. Note that the model calculates about 2,915 *melter batches* (batches range from 5,830 gal to 8,830 gal per batch, averaging 6,960 gal) will be delivered to the WTP-LAW over the DFLAW phase, where further characterization is performed to support glass formulation.

Table 3-3 provides summary data for the campaigns to be delivered to the TSCR/TFPT, and subsequent discrete feed batches to be delivered to the WTP-LAW. The feed batches translate into melter batches, the corresponding statistics provided in parentheses.

[16] Any batch size and frequency that WTP-LAW could request is within the range that Waste Feed Delivery can support. Line flushing is usually not required unless WTP-LAW is going into an extended outage. Daily batch delivery is typical when WTP-LAW is operating, so the next batch transfer suffices in lieu of a flush.

Table 3-3 Direct Feed Low-Activity Waste Feed Delivery Summary

	Campaigns to TSCR/TFPT	Batches to WTP-LAW
Total number	24	3,156 (2,915)*
Nominal volume (gal)	902,000	6,430 (avg. 6,960 range 5,830 to 8,830)*
Total volume (Mgal)	21.6	20.3
Total sodium (MT)	-	9,753
ILAW containers	-	12,218

*AP-106 to WTP-LAW discrete transfers number 3,156 and average 6,430 gal. Statistics in parentheses are for the number of melter batches created in the WTP-LAW receipt tanks, and the range of waste volume in melter batches.

3.2 BALANCE OF MISSION WASTE FEED DELIVERY CAMPAIGNS

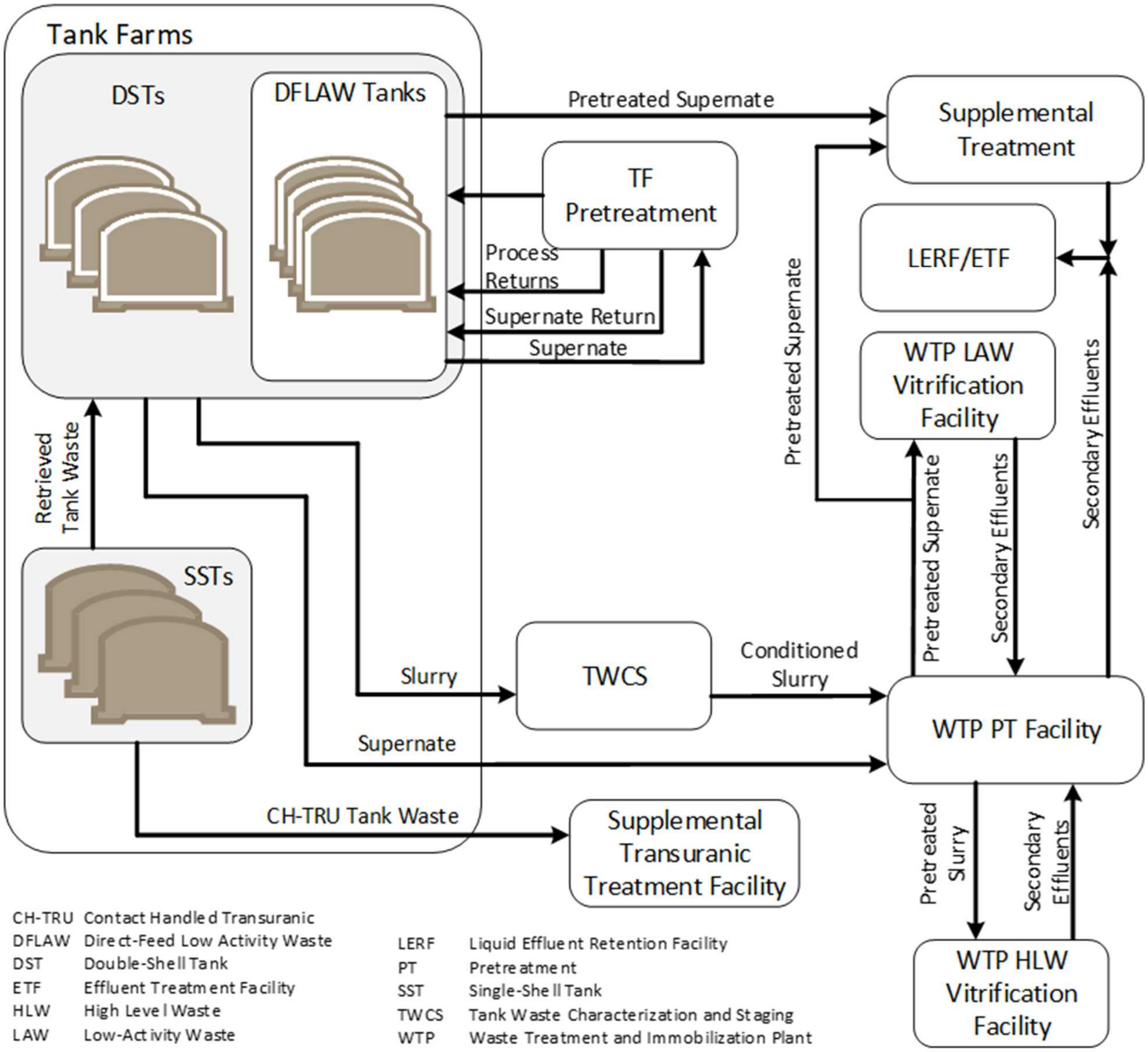
Following the DFLAW phase, full BOM operations will commence in 2034 and continue until tank waste treatment is complete. Figure 3-3 shows the BOM process flow configuration.

BOM facility designs and flowsheets are far from settled this far in advance. Most decisions about BOM processing are yet to be made. Virtually everything about BOM is an assumption. Therefore, the following discussion of BOM campaigns, which is derived from Case 14517, is intended to give only a sense of the BOM feed delivery scope, not to be taken literally. No BOM campaign tabulations are provided because it is too speculative.

BOM WFD priorities are to (a) begin feed deliveries to TWCS/WTP-PT, and (b) resume operating TFPT after a six-year hiatus. The combined WTP-PT and TFPT supernate processing capacity facilitates a shorter BOM duration[17]. Note that after the DFLAW phase is over, TFPT is processing feed only for LAWST, but WTP-PT prepares feed for both WTP-LAW and LAWST. The hiatus in TFPT operations is due to delay of the LAWST start date which is specific to Case 14517.

[17] The waste sodium processed through WTP-PT plus sodium added pursuant to BOM pretreatment also exceeds the WTP LAW treatment capacity. The excess is treated at LAWST.

Figure 3-3. Process Flow Diagram for Balance of Mission



Supernate processing at WTP-PT is preferable to TFPT during BOM because the WTP-PT IX process incorporates separated Cs-137 eluates directly into the pretreated HLW slurry rather than generating expensive spent CST columns that then have to be processed into IHLW.

BOM TFPT provides both supplemental supernate pretreatment capacity as well as backup capacity to ensure continuity of ILAW production independent of issues that may arise at WTP-PT/LAW. BOM initiates new feed deliveries to TWCS/WTP-PT; WTP-PT in turn distributes pretreated supernate and pretreated slurry to the appropriate vitrification plants.

Based on Case 14517, the scope of BOM WFD consists of the following campaigns:

- Nominally another 27 campaigns averaging 921,000 gal each pretreated at TFPT and routed to LAWST via a new routing. A total of 24.9 Mgal is pre-treated through TFPT.
- HLW slurry delivered from various DSTs to TWCS for conditioning[18] (nominally 221 slurry transfers becoming 178 campaigns of 500 kgal each in TWCS).
- Feed delivered to WTP-PT for slurry pretreatment (conditioned slurry - 178 TWCS campaigns becoming nominally 5,349 slurry transfers up to 20,000 gal each (nominal volume being 15,500 gal after the initial fill), and BOM supernate (4 campaigns of nominally 750,000 each) followed by vitrification at the WTP-LAW and WTP-HLW.
- Feed of contact-handled transuranic (CH-TRU) waste delivered to supplemental transuranic (TRU) treatment.

Note that HLW receipt at WTP-PT is predicated on a new conceptual flowsheet (integrated into Case 14517) that entails four small (20,000 gal) receipt vessels, three of which are filled by one continuous transfer. This may or may not end up being the final interface between TWCS and WTP-PT.

The LAW campaigns of the BOM (i.e., the supernate transfers to WTP-PT) are staged for modeling purposes from AP-104 to WTP-PT. BOM LAW transfers occur at irregularly spaced intervals over the duration of the BOM. The total volume of BOM LAW transferred to WTP-PT is 3 Mgal, relatively small compared to BOM HLW transferred from TWCS to WTP-PT at 83 Mgal.

Conveying HLW solids to TWCS (and then to WTP-PT) by slurry requires large carrier liquid volume that subsequently becomes pretreated supernate. Supernate delivered directly to WTP-PT and sodium added at WTP-PT to pretreat the solids account for the remainder of pretreated supernate. WTP-PT will generate more pretreated supernate than WTP-LAW can process.

WTP-PT pretreated supernate is routed for processing into ILAW as follows:

- Route pretreated supernate to keep WTP-LAW operating at near capacity (WTP-LAW ILAW containers 41,110). There are 53,328 ILAW containers total, 12,218 during DFLAW.
- Route excess pretreated supernate to LAWST. The excess pretreated supernate routing allows WTP-PT to keep operating when there is more pretreated supernate than WTP-LAW can handle. Between excess pretreated supernate and BOM DFLAW there will be 36,457 LAWST ILAW containers.

[18] Conditioning is an open-ended concept encompassing any adjustments to HLW slurry within TWCS required to comply with WTP waste acceptance criteria listed in 24590-WTP-ICD-MG-01-019, *ICD 19 – Interface Control Document for Waste Feed* (ICD-19). Typical adjustments to facilitate transferability and acceptance at WTP-PT could include particle size reduction, blending to optimize solids composition for HLW glass making, and decanting to manage suspended solids content. The current model *does not* change the solids content across TWCS.

WTP-LAW and LAWST produce approximately equal numbers of containers. About one third of ILAW containers originating from WTP-PT pretreated supernate are processed at the LAWST.

Both WTP-PT and TFPT generate pretreated supernate for the LAWST operation. The LAWST preferentially takes WTP-PT pretreated supernate because if the WTP-PT LAW effluent has no place to go then WTP-PT would have to shut down. TFPT pretreated supernate for the LAWST can be stored in ILST (AP-106), and TFPT has the option of shutting down when AP-106 is full.

The HLW campaigns (nominally 500 kgal for planning purposes) are created in the tanks of the TWCS from tank waste slurry delivered from various DSTs. The HLW campaigns are conditioned and qualified against ICD-19 requirements in TWCS. The conditioned HLW campaigns will then be delivered to the WTP-PT and eventually to the WTP-HLW. Currently, the total slurry volume entering TWCS equals the total conditioned slurry volume feeding WTP-PT.

Table 3-4 summarizes the HLW campaigns to be delivered from TWCS to WTP-PT, and LAW campaigns to be delivered to the WTP-PT and TFPT from the DST system. Note that 221 HLW transfers to TWCS become 178 HLW campaigns within TWCS. Note that 4 of 31 LAW campaigns (3 Mgal) go into the WTP-PT receipt vessels while the other 27 LAW campaigns (24.9 Mgal) are pretreated at TFPT. Most of the conditioned slurry volume coming from TWCS to WTP-PT separates into a pretreated LAW fraction that is routed to either the WTP-LAW or LAWST. Therefore, the ILAW container count reflects LAW campaigns received from the tank farms as well as the LAW fraction that is separated from HLW campaigns in the WTP-PT. The IHLW canister count only includes the waste that is processed through the WTP-HLW.

BOM operations are too speculative for proximate sourcing projections to have any credibility. Specifics about BOM campaign proximate sourcing are not being provided at this point in time, except to mention that AP-102 sludge is the designated source for the first of ~178 HLW campaigns. The initial delivery of HLW slurry to TWCS will occur circa 2032.

Table 3-4 Balance of Mission Waste Feed Delivery and Production Summary

	HLW	LAW
Total number of campaigns*	178	31
Nominal campaign volume (Mgal)	0.5**	0.75 to 1
Total volume treated (Mgal)	83	27.9
Total activity (MCi)	48	2.9
Total production	9,896 canisters	77,567 containers

*HLW campaigns are created in TWCS; LAW campaigns in tank farm.
**Only 0.4695 Mgal of each HLW campaign is delivered to WTP-PT.

Each full TWCS tank (or campaign) results in numerous TWCS-to-WTP-PT qualified feed transfers of nominally 15,500 gal (previously each TWCS campaign was conveyed in three 143 kgal transfers). The above change is due to re-design of HLW receipt at WTP-PT. Around 5,500 of these small slurry transfers to WTP-PT are expected. The HLW feed transfers to WTP-PT leave a 34,100 gal heel that incorporates into the next qualified HLW campaign.

Following DFLAW operations, treatment of LAW feed at WTP-PT (12 campaigns) begins and resumption of treatment at TFPT (27 campaigns) will continue for the remainder of the RPP mission. LAW campaigns constitute a relatively small part of the waste processed through WTP-PT. Pretreated supernate generated from 2034 forward by WTP-PT is derived mostly from the carrier liquid of HLW campaigns. Consequently, the BOM LAW campaigns contribute relatively little to the total activity processed at WTP-PT. As startup of the full capabilities of the integrated WTP facilities approaches, these BOM campaigns will be further refined and optimized to support the overall RPP mission. As with BOM HLW campaigns, BOM LAW campaigns are too speculative to proximate source.

Treated BOM LAW feed will be immobilized in one of two facilities, either the WTP-LAW or LAWST. ILAW production rate increases with the startup of LAWST in 2040 (see Figure 3-6). The waste form to be produced by LAWST has not been selected, but is assumed to be ILAW containers for planning purposes.

3.3 PRODUCTION SUPPORTED BY DFLAW AND BOM FEED DELIVERY: GLASS AND SPENT MEDIA

The ultimate objective of Waste Feed Delivery is immobilizing tank waste in glass waste forms. The characteristics of a canister of IHLW and a container of ILAW are as noted below (Table 3-5). The size and geometry of an IHLW canister and an ILAW container are visualized in Figure 3-4.

Table 3-5 Vitrified Package Characteristics

	IHLW canister	ILAW container
Nominal volume (gal)	300	500
MT glass	3	5.5

IHLW = immobilized high-level waste.
ILAW = immobilized low-activity waste.
MT = metric ton.

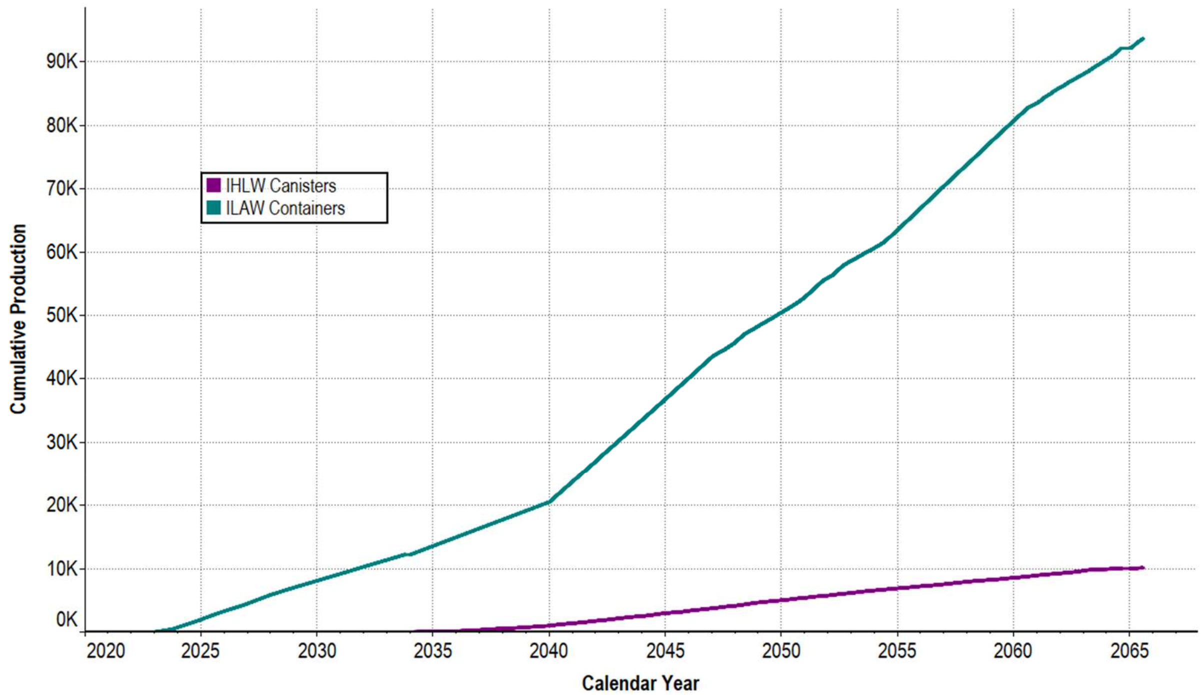
Figure 3-4. High-Level Waste Canister (left) and Low-Activity Waste Container (right)

The cumulative production of ILAW containers and IHLW canisters is charted in Figure 3-5. The ILAW container count includes WTP-LAW and LAWST production.

WTP-LAW melters operating at nameplate capacity can generate 30 MT glass per day. Total estimated operational efficiency of 70 percent is applied to account for planned and unplanned outages for equipment maintenance and failures. Therefore, the life-cycle model is based on an average throughput of 21 MT of glass per day (70 percent of the 30 MT glass per day of full production capacity). This basis provides an upper limit for the life-cycle model production rate of ILAW containers (see Section 3.3) and the average rate of waste consumption. TSCR supports[19] 21 MTG/day *for the assumptions that are applied to Case 14517*. TFPT is assumed to be designed for 185 kg Na per hr for modeling purposes (vs. TSCR 100 kg Na per hour), so TFPT has more than enough capability to feed the WTP-LAW without interruption even at its maximum instantaneous throughput of 30 MT/day which is 43% more than the modelled rate. However, the modeling assumptions stated above related to the instantaneous throughput of the glass system may come out somewhat short of where the glass plant actually operates, and the impact of potentially higher glass production rates on waste feed delivery should be further assessed (in a future campaign plan) prior to DFLAW operations.

[19] 'TSCR supports' means that the ILST (AP-106) feed inventory is not depleted (TSCR never bottlenecks glass production).

Figure 3-5. Cumulative ILAW/IHLW Production



Prior to the implementation of the DFLAW operating mode, processing scenarios saw little reduction in total tank farm activity until BOM started. A positive feature of the TSCR-based DFLAW process is that significant radioactivity is captured on TSCR/TFPT CST columns, permanently removing ~9 MCi Cs-137 from the tank farms during DFLAW.

Progress in treating tank farm radioactivity[20] is charted in Figure 3-6. By the end of the mission, about 3.36 MCi (1.3%) is in treated LAW (93,638 ILAW containers, 12,218 having been generated during the DFLAW phase), and about 48.4 MCi (72.4%) is in treated HLW (10,116 IHLW canisters). An additional 9.09 MCi (26.3%) is captured on 254 CST columns (100 TSCR CST columns and 154 TFPT CST columns, bringing the total to 57.5 MCi that will eventually be processed into IHLW canisters.

IHLW canisters are the final disposition for radioactivity captured on TSCR/TFPT IXCs shown in Figure 3-6. Note that the canister count shown in Figure 3-5 omits IHLW canisters that come from the conversion of spent IXCs to glass. A plan for working off spent IXCs into glass has yet to be developed. After that plan is formulated, it will undoubtedly consume some of the excess HLW glass plant capacity that is present for most of the lifetime model.

[20] The tank farm activity stated here does not include the daughter products of Sr-90 and Cs-137.

Figure 3-6. Cumulative Treated Radioactivity

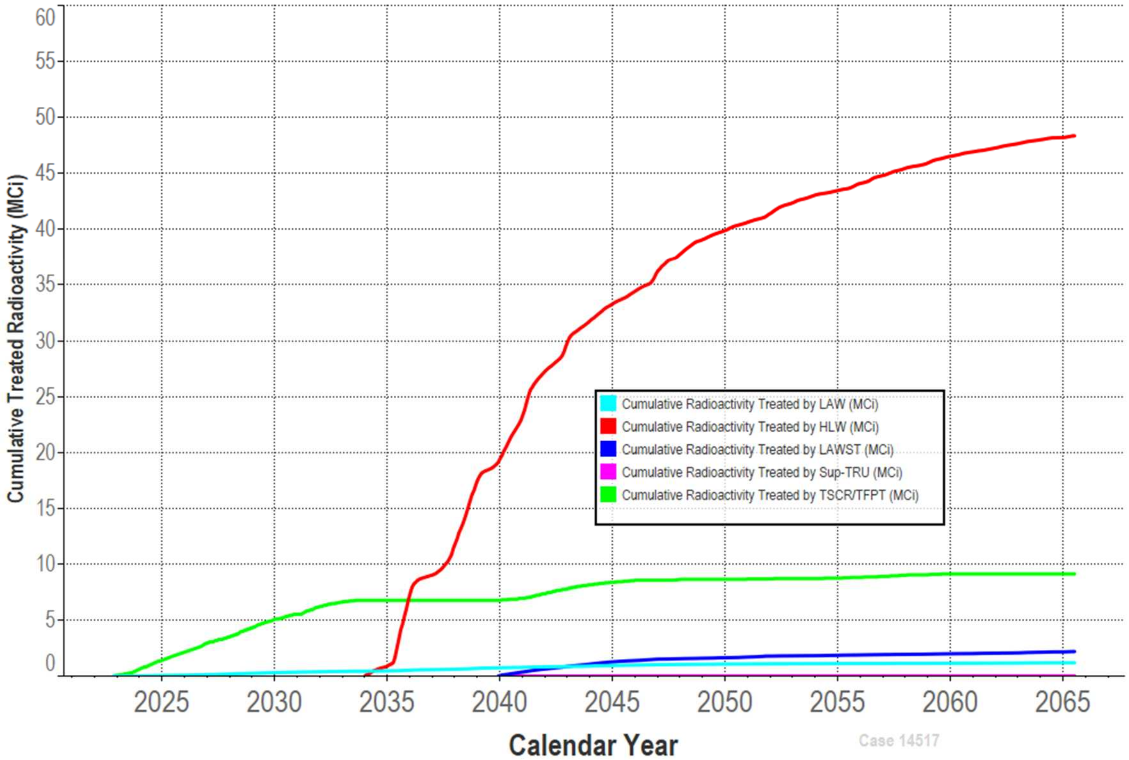


Table 3-6 shows spent IXCs broken out by DFLAW feed campaign. This table only goes through Campaign 8 to establish what is typical for the TSCR phase. TSCR campaigns typically discharge 14 spent IXCs. Two spent IXCs are discharged each loading cycle. The number of TSCR loading cycles per campaign is not fixed, although seven loading cycles is typical of a TSCR campaign.

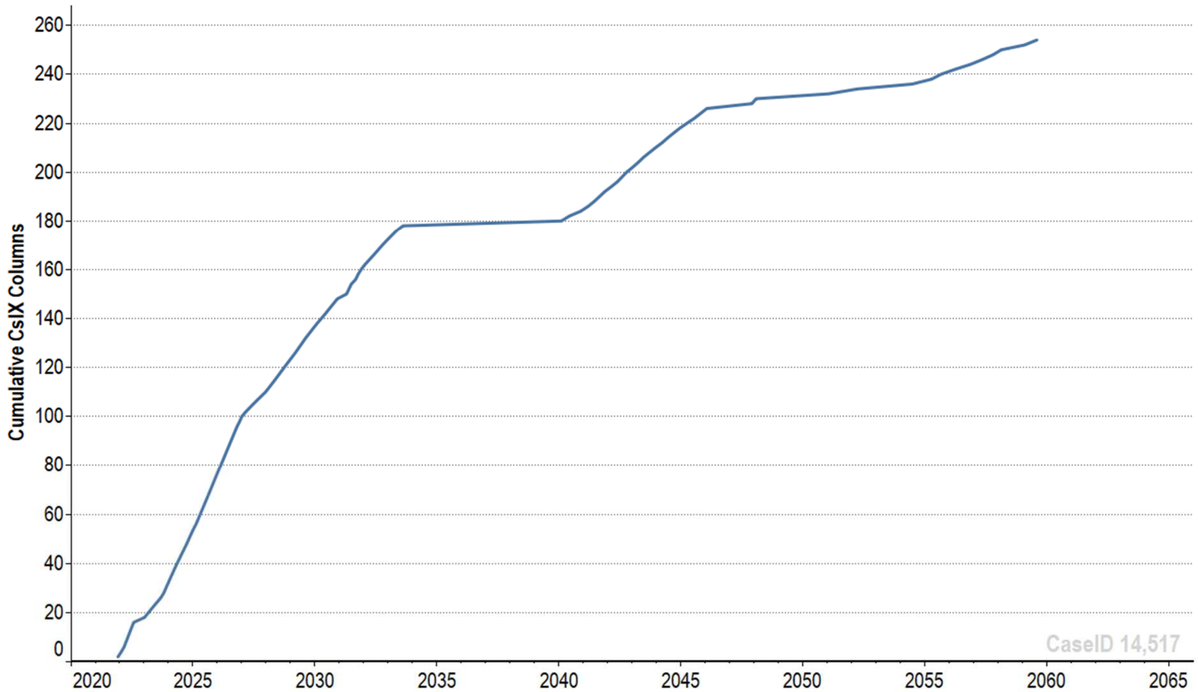
Table 3-6 Spent Ion Exchange Columns by TSCR Campaigns

DFLAW Campaign	Campaign Start	Campaign End	Columns per Campaign
DFLAW Campaign # 1	11/12/2021	6/24/2022	14
DFLAW Campaign # 2	7/3/2022	10/18/2023	14
DFLAW Campaign # 3	10/27/2023	6/9/2024	14
DFLAW Campaign # 4	6/18/2024	1/4/2025	12
DFLAW Campaign # 5	1/16/2025	8/17/2025	14
DFLAW Campaign # 6	8/26/2025	2/15/2026	12
DFLAW Campaign # 7	2/25/2026	9/18/2026	14
DFLAW Campaign # 8	9/27/2026	2/28/2027	4

Based on Case 14517. Transition to TFPT occurs during Campaign 8, which accounts for the untypical number of TSCR columns. Only the TSCR column design is known for certain, so column projections beyond the transition to TFPT are not included in this table.

Figure 3-7 shows the spent IXC accumulation, keeping in mind that the IXC design beyond the TSCR phase is speculative at this point in time; a larger TFPT column design is assumed for modeling purposes. After the transition to TFPT in 2027, 6 columns per campaign is typical, but that is representative only of the TFPT column design assumed in Case 14517.

Figure 3-7. Cumulative Spent Ion Exchange Columns



4.0 TANK USAGE AND DFLAW AVAILABILITY

Supernates from the DST system will be staged through AP-105 to AP-107, then delivered to the TSCR/TFPT, where the waste will undergo treatment to remove solids and cesium. The DFLAW supernates will be derived from three primary sources, specifically:

1. Supernates already accumulated in the 200 East Area DSTs at the start of DFLAW operations.
2. Supernates generated from the retrieval of SSTs in A, AX, S, and SX Farms that occurs during DFLAW operations.
3. Supernates generated from Waste Group A DST mitigations.

Treated DFLAW supernate accumulates in ILST (AP-106) to be delivered to the WTP during DFLAW operations.

Waste Group A DSTs are tanks that, due to waste composition and quantities, have the potential for a spontaneous buoyant displacement gas release event. These tanks are conservatively estimated to contain enough flammable gas in the waste that if all of the gas was released into the tank headspace instantaneously, the concentration of flammable gas in the headspace would be a flammable mixture. Waste Group A tanks are not a preferred early DFLAW source because the tank space to do Waste Group A mitigation is not available during the TSCR phase. However, before the end of the DFLAW phase, waste from the mitigation of all five Waste Group A tanks appears in the campaigns of Case 14517 (see Figure A-1).

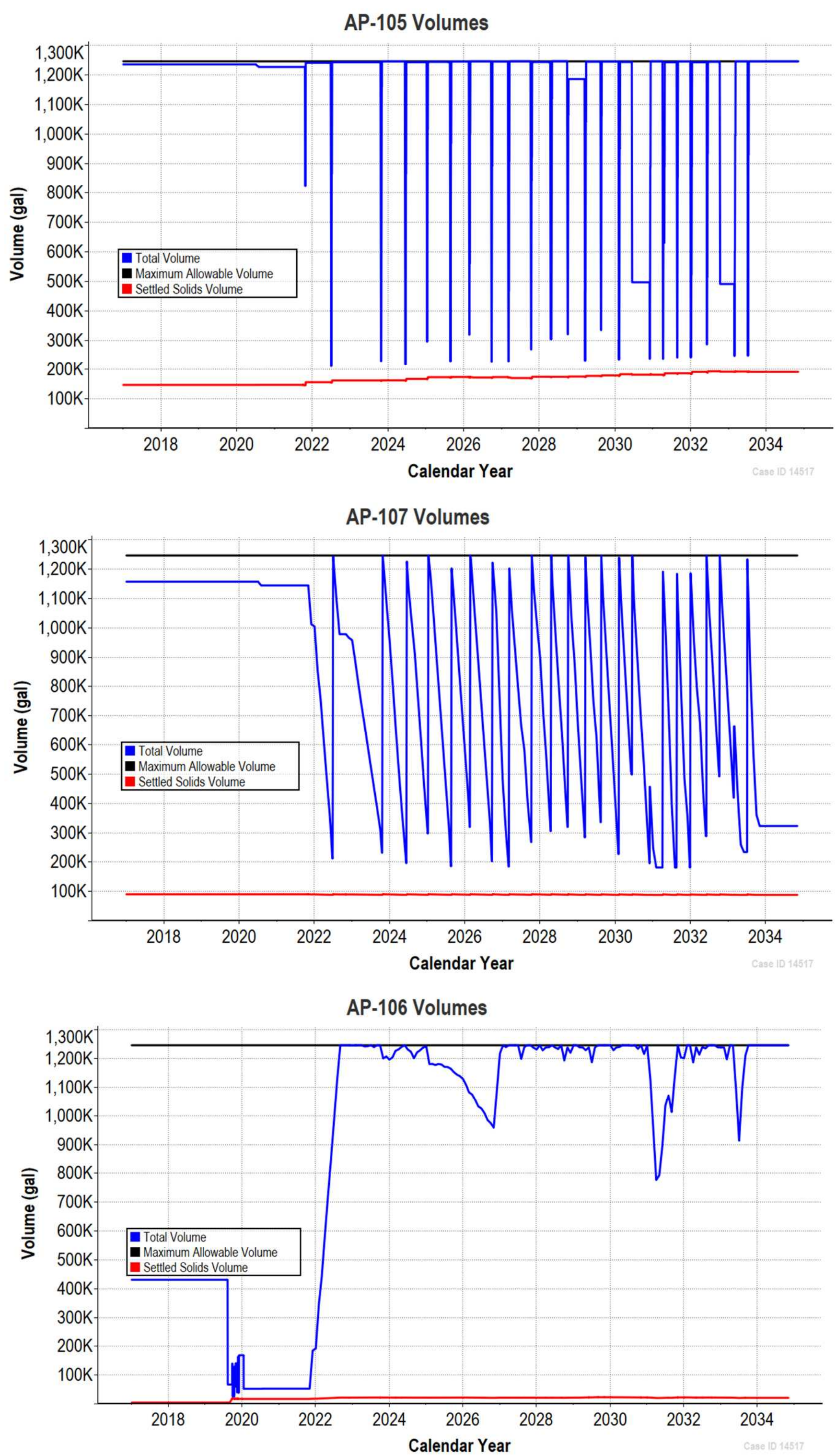
4.1 DOUBLE-SHELL TANK USAGE

DST transfer activities during DFLAW operations (2021 through 2033) will support SST retrievals, 242-A Evaporator campaigns, Waste Group A DST mitigations, waste staging, and feed deliveries to TSCR/TFPT, and the receipt of process returns from the TSCR/TFPT. DFLAW operations represent a significant increase in tank farms transfer activity compared to recent history. Transfer activities for the DSTs that support DFLAW operations are shown in **Figure** 4-1. This figure shows the DSTs of the DFLAW system that will be used to accumulate, transfer, prepare, and deliver feed during the DFLAW phase. The DST system activities and space usage during DFLAW operations are discussed further in Section 4.2.

Figure 4-1 shows the cycles of feed preparation in AP-105 and AP-107, and the running inventory of DFLAW feed in ILST (AP-106). AP-105 receives both an incoming waste transfer from the DST system and a water addition to dilute concentrated supernate to meet the feed specifications. Except for the campaign transfer to AP-107, AP-105 is typically full. The depiction of AP-107 shows the drawdown of each campaign to feed the TSCR/TFPT. Refilling is triggered when there is insufficient residual supernate to complete another IX column loading cycle.

The solubility model used within life-cycle model predicts the gradual buildup of settled solids in AP-105 and ILST (AP-106). The buildup of solids is related to waste chemistry when diluting some supernates and mixing unlike supernates. This behavior is consistent with RPP-RPT-59586, *Evaluation of Risks to the DFLAW Mission from Solids in East Area Double-Shell Tanks*. Note that campaigns transferred from AP-105 during DFLAW never encroach on the settled solids. If entrainment of solids to AP-107 becomes an issue post-DFLAW, suggested corrective actions include a) recover the solids, b) raise the transfer pump elevation and adjust to smaller campaign sizes, and c) select an alternate qualification tank.

Figure 4-1. Double-Shell Tank Transfer Activity Plots for DFLAW

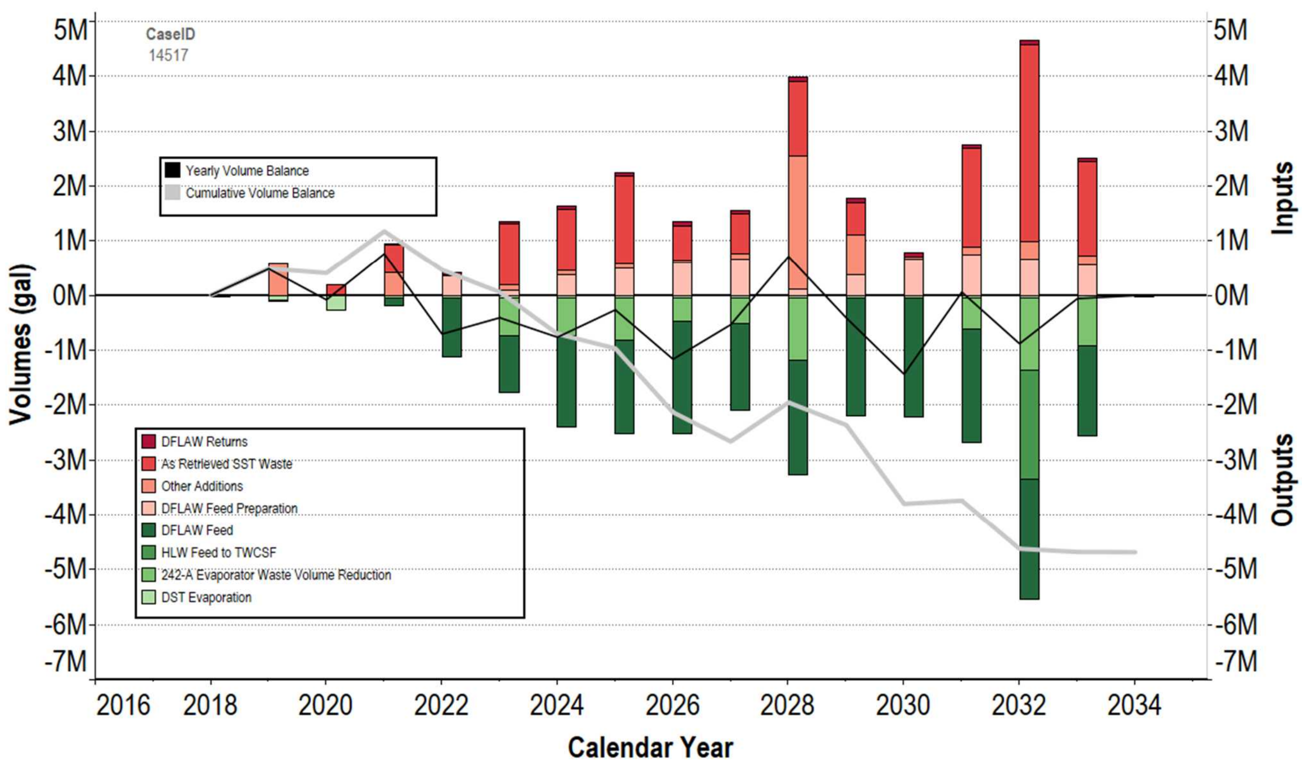


4.2 WASTE VOLUME MANAGEMENT

Approximately 1.2 Mgal of operational DST emergency space must be maintained as a minimum at all times; Tank Farms attempts to maintain no less than 2.2 Mgal free space in order to facilitate transfers. The available space is distributed among several tanks and is not always directly accessible without a series of waste transfers. As the DST system nears capacity, transfers supporting SST retrievals, evaporator campaigns, and DFLAW feed staging operations become increasingly complex.

Feeding DFLAW to WTP-LAW and the 242-A Evaporator are the primary means of DST space management throughout the DFLAW phase. The life-cycle model assumes that the 242-A Evaporator is available, as needed, to support the space management of SST retrievals, Waste Group A DST mitigations, and waste staging throughout the mission. The 242-A Evaporator campaigns will occur frequently, with a total of 19 campaigns (EC-11 to EC-29) projected from 2023 to 2033. These 242-A Evaporator campaigns are merely life-cycle model projections, so each specific evaporator campaign will be refined and managed by the Process Engineering organization prior to execution. Much depends on the actual water used during SST retrieval and Waste Group A mitigations. Figure 4-2 demonstrates an ~5 Mgal net volume reduction from DST inputs and outputs over the DFLAW phase.

Figure 4-2. Double-Shell Tank System Inputs and Outputs



5.0 FEED VARIABILITY

5.1 DIRECT-FEED LOW-ACTIVITY WASTE VARIABILITY

The initial DFLAW waste feed campaigns will consist of supernate waste derived primarily from the 200 East Area DSTs. Existing DST supernate has typically been characterized as well as it can be through a thorough analysis of all available analytical and process knowledge as documented in the (BBI) and supporting tank-specific characterization reports. Supernate that is earmarked for DFLAW is also placed on a schedule in the Sampling Projection Annual Update to ensure that there will be timely preliminary sampling and analysis to head off problems in advance of formal qualification sampling. Due to the unique history of the waste in each tank, campaign to campaign variation is normal, but early campaigns typically will have no problem meeting the WAC for TSCR/TFPT (RPP-RPT-60636).

The supernate usually requires dilution to the acceptable DFLAW sodium concentration range. This dilution step will typically occur in the staging and characterization tank (AP-105) requiring the addition of approximately 5.9 Mgal of water to the concentrated supernate to make up the DFLAW campaigns. While dilution water sacrifices DST space, the effect is not cumulative because the added water leaves the DST system when ILST (AP-106) feeds the WTP-LAW.

5.1.1 Feed Variability and TSCR/TFPT Acceptance

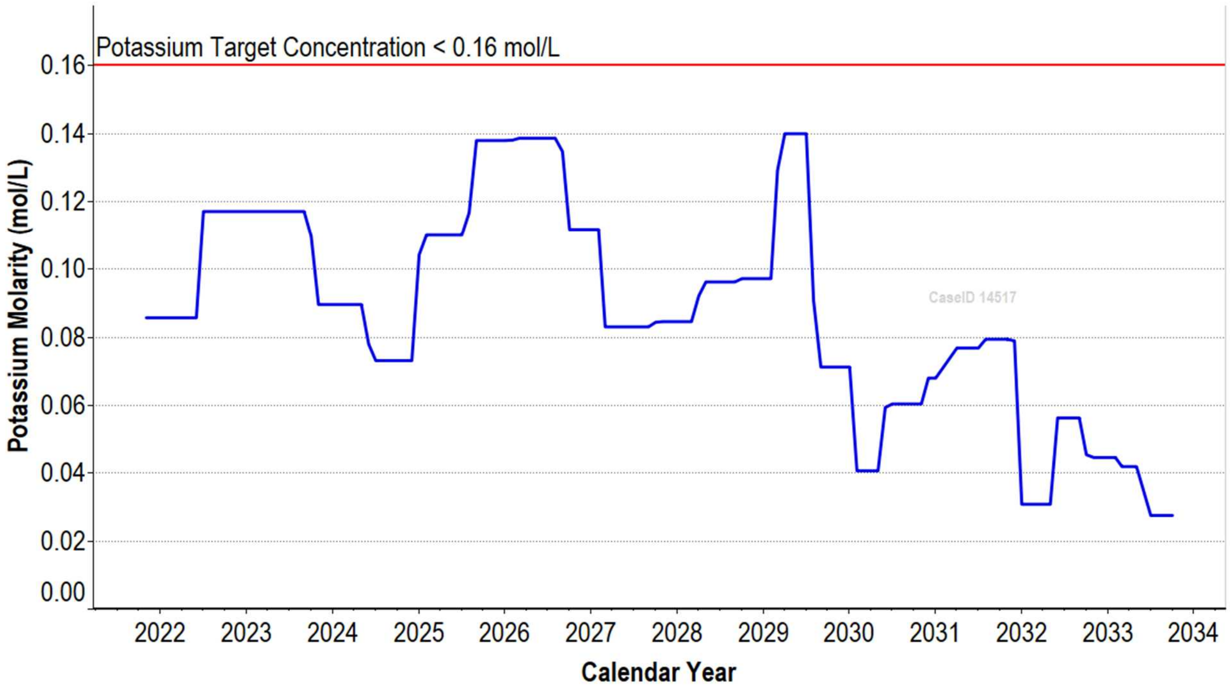
TSCR/TFPT feed acceptance is evaluated in detail in the RPP Integrated Flowsheet (RPP-RPT-57991). It is sufficient for current purposes to state that TSCR/TFPT feed variability of the WAC limited properties listed below is acceptable across the DFLAW phase:

- Density (1.35 g/mL)
- Viscosity (8 cP)
- Sodium Molarity (5 M to 6 M)
- Phosphate Molarity (0.1 M)
- Cesium Ratio (0.24 g Cs-137 per g Cs)
- Cs-137 Concentration (0.3 Ci/L)
- Potassium Molarity (0.16 target, see Figure 5-1)

However, one of the above limited properties have been singled out for comment: potassium.

Potassium molarity does not have an acceptance limit per se, but Figure 5-1 shows potassium spikes relative to the preferred target concentration. Potassium spikes above the target are of interest for potential adverse impacts on ion exchange performance. Potassium competes with cesium for uptake on the CST ion exchange media. Shorter ion exchange loading cycles, lowered TSCR throughput, higher operating costs, and lower cesium loading on spent columns are potential adverse impacts. Figure 5-1 confirms that a new supernate selection rule for Case 14517 has resolved potassium spikes that were observed in the previous Campaign Plan. If further study shows that the potassium variability is still consequential, there may be merit to source sequencing to optimize potassium.

Figure 5-1. Potassium Molarity vs. TSCR/TFPT Acceptance Target



5.1.2 Feed Variability and WTP-LAW Acceptance

DFLAW acceptance at WTP-LAW is addressed in detail in the RPP Integrated Flowsheet (RPP-RPT-57991). It is sufficient to state for current purposes that WTP-LAW feed variability tracked across the WFD mission is well within the WAC limits in ICD-30. This is not surprising because the future contents of ILST (AP-106) will be a blend of campaigns that were themselves previously qualified as WTP-LAW compliant. DFLAW feed that is interim stored in ILST (AP-106) varies continuously because AP-106 is operated on a semi-continuous basis rather than a batch basis.

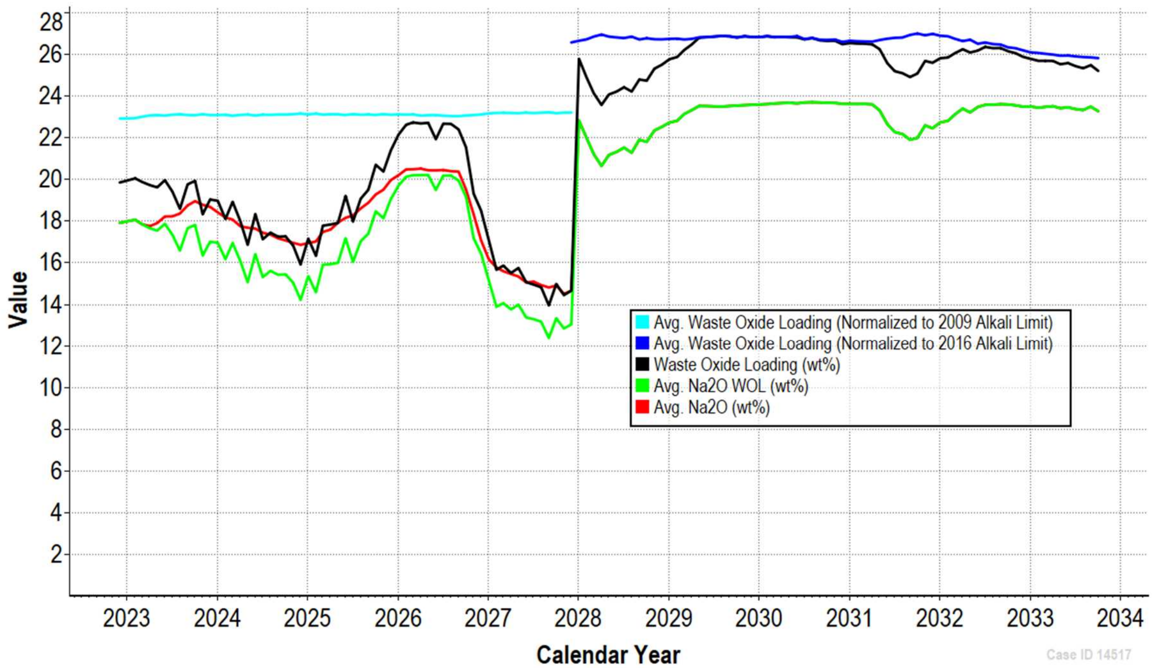
5.1.3 Feed Variability and Glass Formulation Impacts

Each qualified DFLAW campaign has a fixed composition. However, the pretreated, DFLAW inventory in ILST (AP-106) is a continuously changing blend of campaigns. While AP-106 is always in compliance with WTP-LAW acceptance criteria, waste acceptance is a separate matter from glass formulation and the associated loading rules . This section discusses which loading rules are glass-formulation-controlling over the duration of the DFLAW period. The following discussion will demonstrate that feed variability does impact waste oxide loading (WOL) of DFLAW glass, but not so much as the glass model selected.

WOL for the first 5 years of glass production during the DFLAW period is based on the 2009 LAW glass model from 24590-WTP-RPT-PT-02-005, *Flowsheet Bases, Assumptions, and Requirements* (BARD); the remainder of the DFLAW period (and beyond) utilizes the enhanced

2016 LAW glass model from PNNL-25835, *2016 Update of Hanford Glass Property Models and Constraints for Use in Estimating the Glass Mass to be Produced at Hanford by Implementing Current Enhanced Glass Formulation Efforts*. In Figure 5-2, a step change to flatter (around 26 wt%) WOL is obvious when the enhanced glass model goes into effect in 12/2027. Figure 5-2 also plots a normalized WOL (light blue and dark blue) which derives from *ignoring all glass formulation rules except each model's alkali rule*. Each model's actual WOL is plotted (in black) wherever it is different from the alkali-normalized WOL. Normalization helps visualize where feed composition is detracting from better WOL, and where WOL is already as good as it can be, (see below for further discussion of which formulation rule is controlling). Especially in the early years of vitrification based on the 2009 glass model, the DFLAW feed components that drive lower WOL are ubiquitous, so fine tuning feed selection is not likely to yield dramatic improvements to WOL.

Figure 5-2. Waste Oxide Loading and Na_2O Loading in ILAW During DFLAW



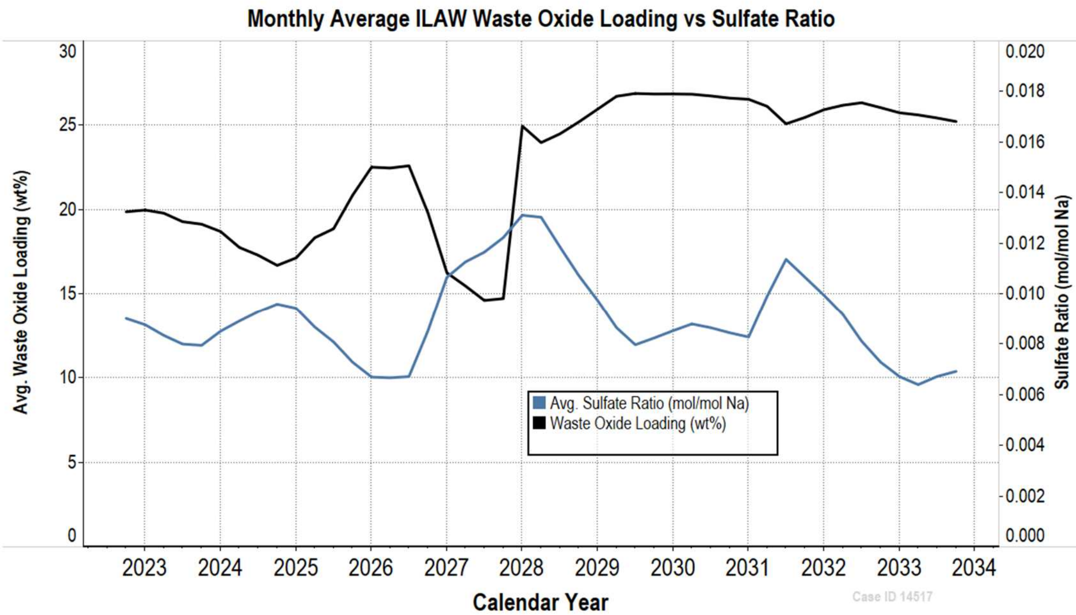
Total Na_2O content of glass over the DFLAW period ranges from ~15 wt% (red line to the end of 2027) to nearly 24 wt% (green line after 2028). Note that maximum Na_2O content allowed by the respective glass models is 21 wt% and 24 wt%.

The DFLAW components considered in the LAW waste loading rules, as identified in 24590-LAW-RPT-RT-04-0003, *Preliminary ILAW Formulation Algorithm Description*, include:

- Sodium (Na^+)
- Potassium (K^+)
- Sulfate (SO_4^{2-})
- Chloride (Cl^-)
- Fluoride (F^-)
- Phosphate (PO_4^{3-})
- Chromate (CrO_4^{2-}).

Figure 5-3 composites a group of charts to visually examine any obvious correlation between waste oxide loading and the variability of component molar ratio.

Figure 5-3. Charts of Waste Oxide Loading vs Molar Ratio of Selected Components



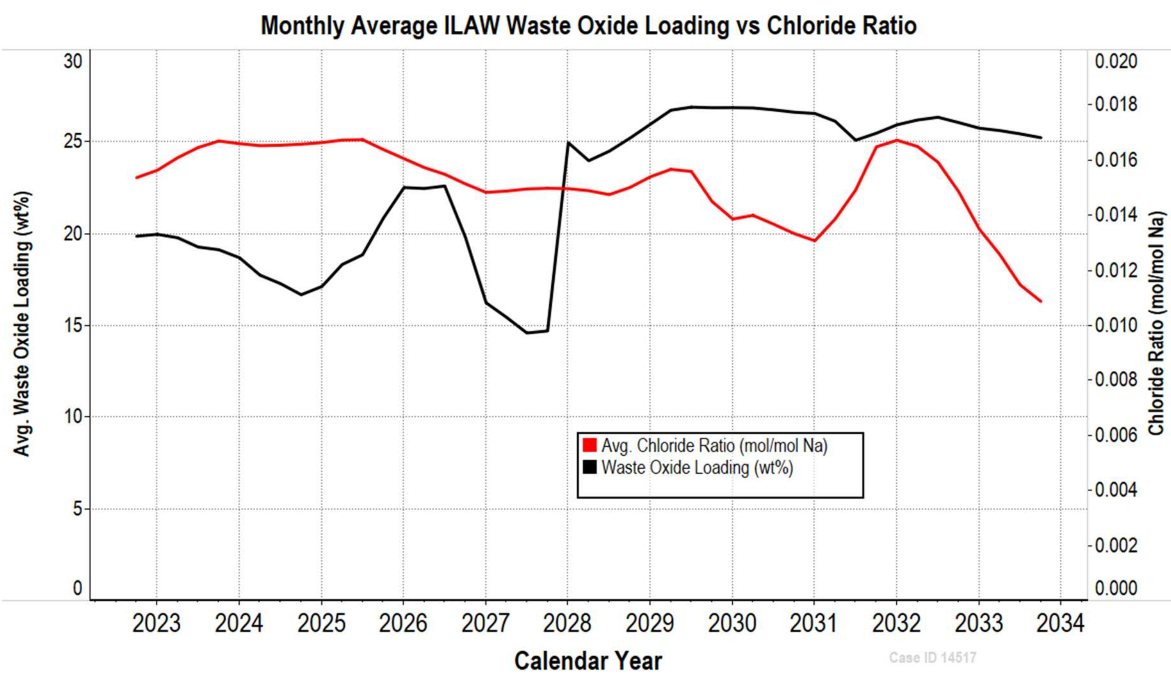
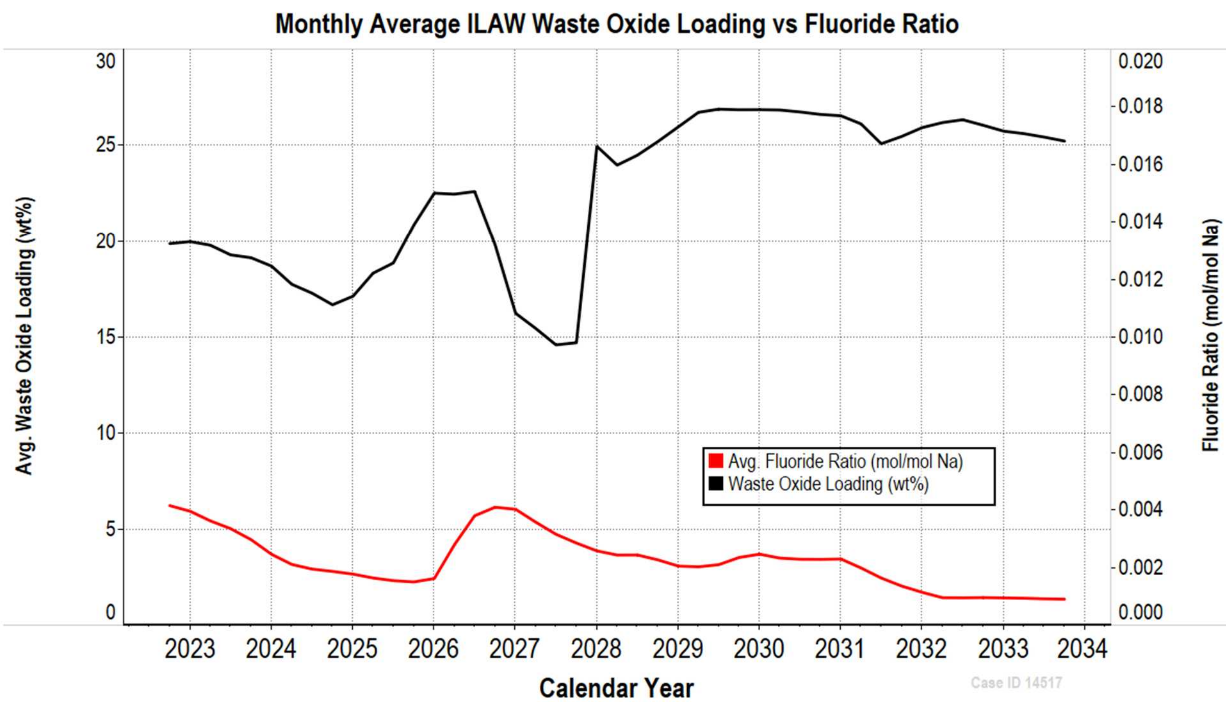


Figure 5-3 (cont) Charts of Waste Oxide Loading vs Molar Ratio of Selected Components



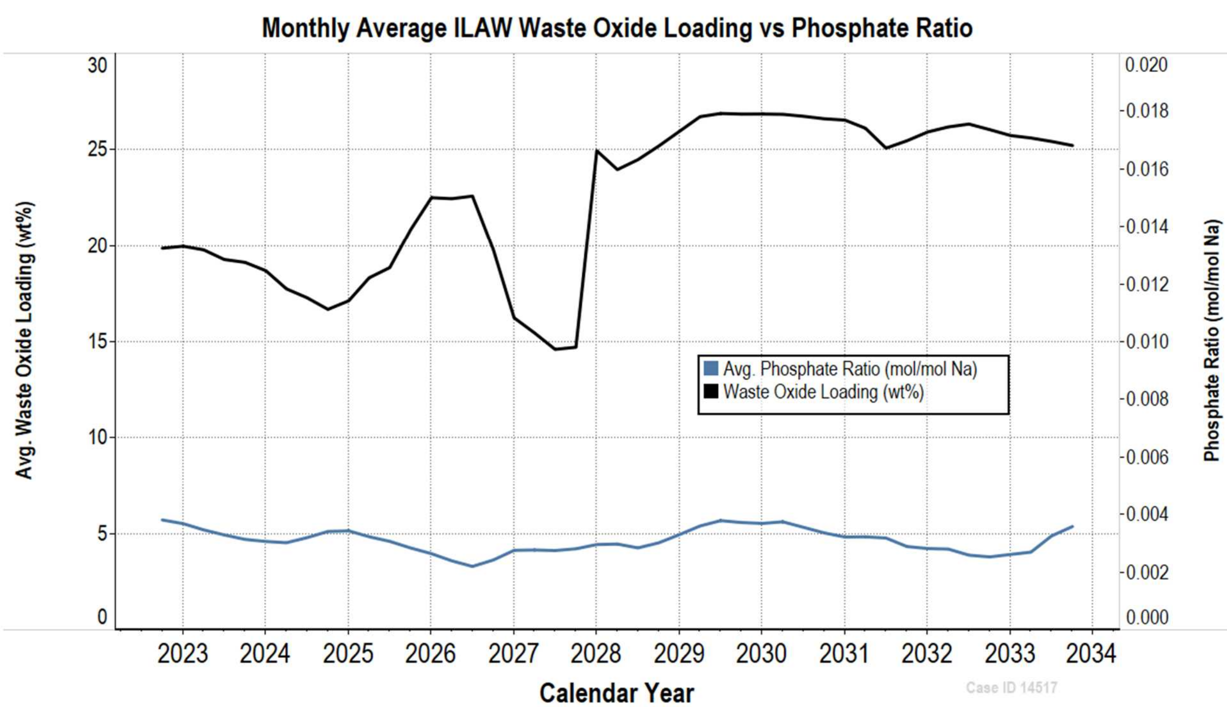
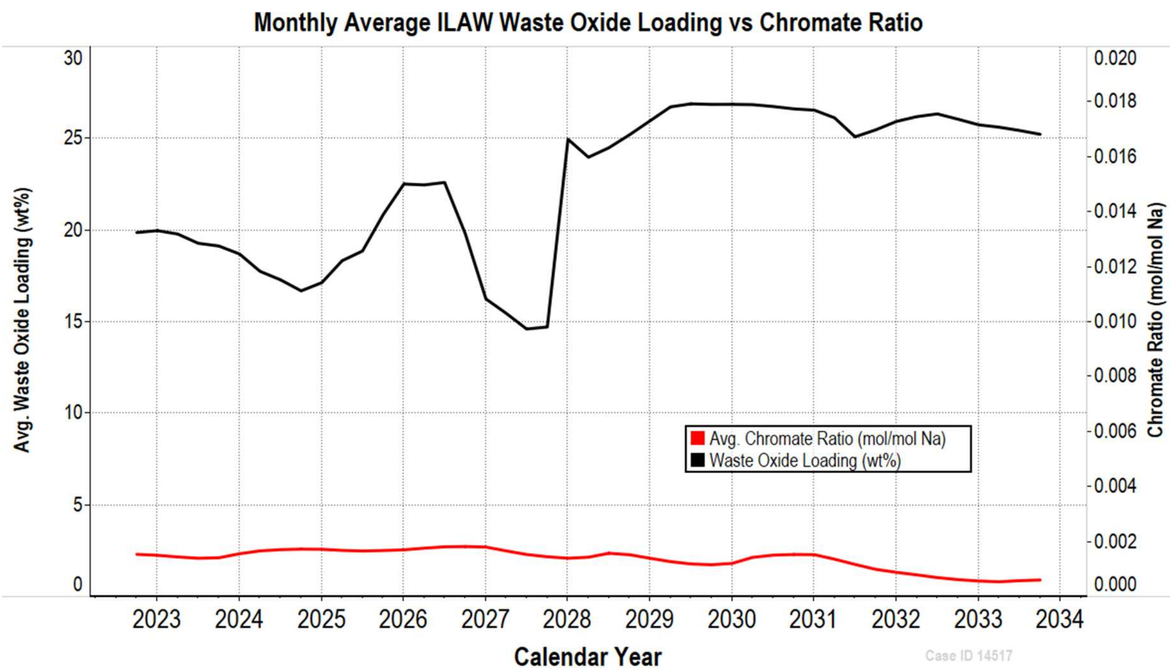


Figure 5-3 (cont) Charts of Waste Oxide Loading vs Molar Ratio of Selected Components

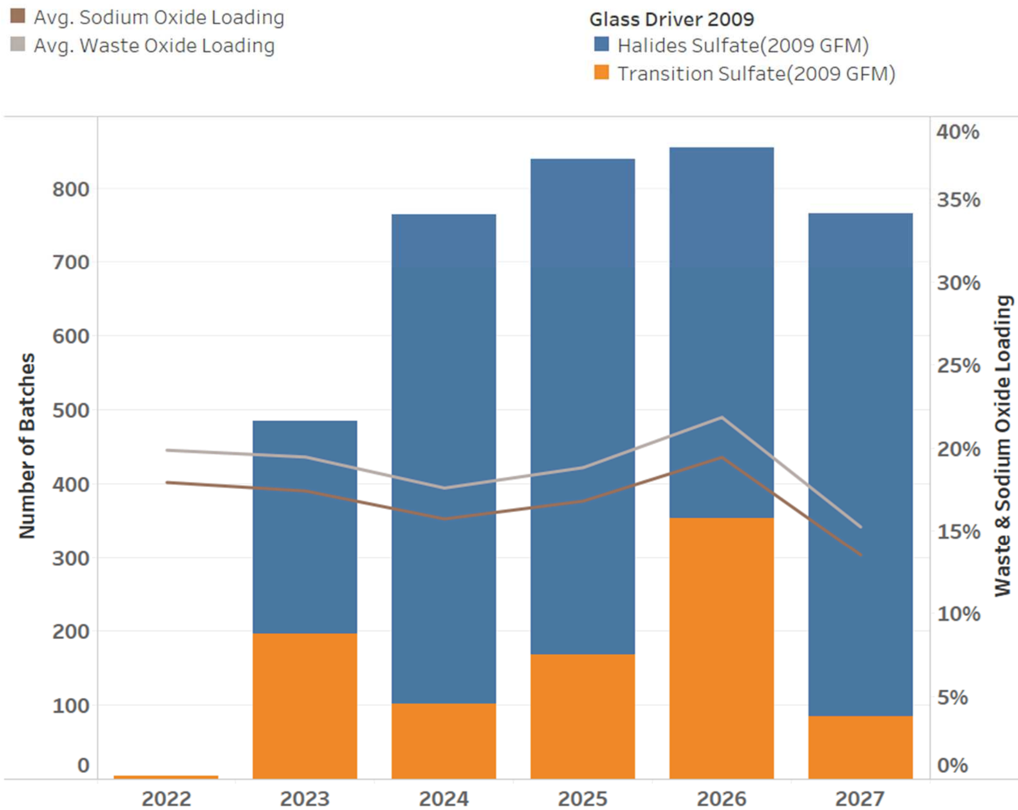


Sodium is always the most concentrated cationic species in supernate, and sodium salts dominate LAW feed chemistry. Sodium salts convert to sodium oxide in the melter, which is a principal determinant of melt viscosity, conductivity, and glass durability. As sodium is the dominant oxide former in DFLAW, feed variability is plotted as the relative concentration of the other components to sodium, or the molar ratio. DFLAW components that potentially control immobilized waste loading are all highly soluble.

Waste loading rules in the glass models are more complex than can be conveyed in the above charts. Therefore, caution is advised in the interpretation of these charts to draw firm conclusions. That having been said, there appears to be an inverse relationship between WOL and sulfate ratio during the first five years of glass production when the 2009 LAW glass model is in effect, inferring that the glass formulation is driven by one of the sulfate related loading rules during this period. Even though large variation in some molar ratios is present, there is little or no obvious corresponding WOL sensitivity to the other five components. When none of these components is controlling, then by default, the glass is formulated based on an alkali rule.

Of the above glass formulation-impacting components, sulfate and halides are typically the ones that the 2009 LAW glass model has to work around. Figure 5-4 shows the number of DFLAW batches and summarizes more specifically which waste loading rule or property constraint is controlling. Figure 5-4 confirms that all DFLAW glass batches during the first five years are either sulfate limited or sulfate/halide limited, which is consistent with Figure 5-3.

Figure 5-4. LAW Glass Drivers Pre-2028 (2009 model) and Post-2027 (2016 model)



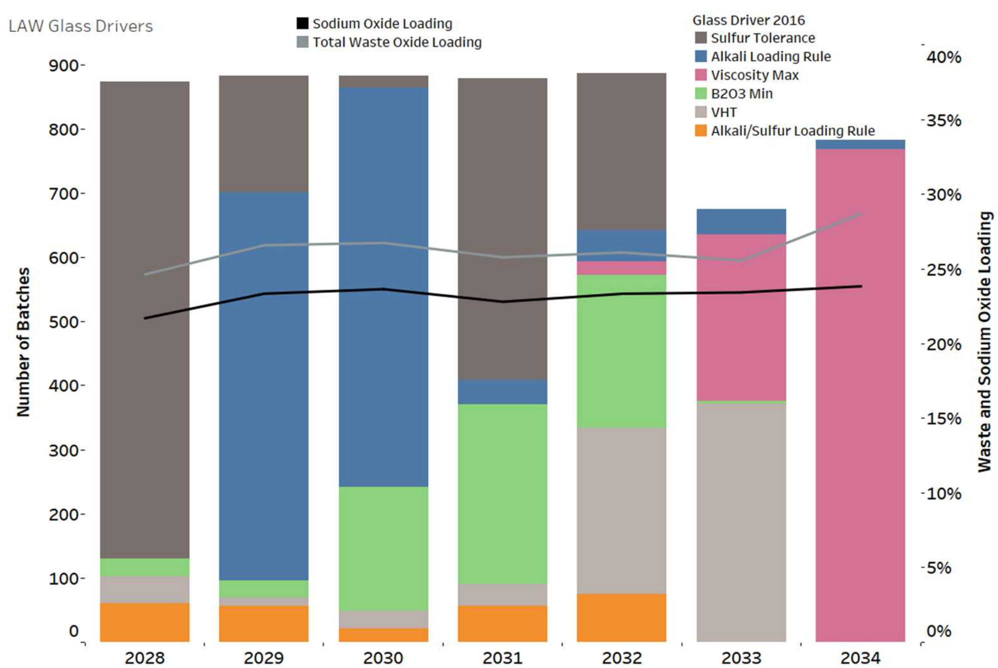


Figure 5-4 further confirms that DFLAW glass post-2027 formulated to the 2016 enhanced glass model exhibits much more diversity in the formulation controlling rule. The controlling rule is often determined by very subtle composition differences, so the post-2027 charts does not necessarily equate to great variation in composition.

Sulfate is problematic by virtue of forming an alkali sulfate salt phase on the melt surface. Per 24590-WTP-RPT-PT-02-005, the sulfate salt phase promotes bubbler and refractory corrosion, is more electrically conductive than the melt, and is significantly less viscous. The sulfate salt phase could penetrate melter refractory joints causing damage to the melter. The 2016 glass model has a higher tolerance for sulfur than the 2009 model, and there are relatively fewer sulfate controlled batches when the 2016 glass model is in effect.

Future refinements to the selection of feed sources for DFLAW campaigns should focus on leveling the sulfate-to-sodium concentration as a means to more uniform WOL during the first five years of glass production.

5.2 BALANCE OF MISSION WASTE FEED VARIABILITY

For BOM activities, the feed campaigns are projected based entirely on the life-cycle model. The model employs logic aimed at optimization and minimization of the number of HLW canisters produced. The availability and location of feed for the balance of the mission is heavily dependent on the feed used during the DFLAW phase and the progress of SST retrieval activities. Within the RPP Integrated Flowsheet (RPP-RPT-57991), future feed campaigns are evaluated at length against the WAC for the various facilities. For current purposes, this Campaign Plan revision is opting to forgo detailed discussion of the BOM feeds because it is speculative. These feeds do not represent an immediate concern as non-compliances can be adjusted as part of campaign-specific preparations for TFPT and TWCS that will happen beyond the foreseeable horizon.

6.0 PATH FORWARD: FUTURE REFINEMENTS

This document describes the sequential WFD campaigns and associated tank farms operations supporting the DFLAW phase of the mission. DFLAW hot operations are scheduled to commence (TSCR in November 2021 and WTP-LAW in December 2022 or January 2023) and continue until the startup of WTP-HLW operations in 2034. The campaign sequence was developed using the life-cycle model and is consistent with the IWFDP Volume 1– Process Approach.

Future revisions of the IWFDP will include updates to the planning assumptions and life-cycle modeling of WFD for DFLAW operations, tasks completed to resolve existing issues and uncertainties, and emerging issues that arise during ongoing WFD planning activities. Long-term planning for the RPP mission will also be refined in future revisions, including updates to the planning assumptions and process modeling for HLW WFD. Refinements will include changes to the HLW WFD strategy and waste selection.

Table 6-1 presents opportunities for improvement to the campaign planning elements of the IWFDP. Some work on these activities has been initiated and are tracked here for completeness as the activities relate to future feed planning scope. These actions are also integrated with RPP-PLAN-58003, *One System River Protection Project Integrated Flowsheet Maturation Plan*, as appropriate.

Table 6-1 Opportunities for Improvement

Action	Target	Description of benefit
Develop feed selection strategy for DFLAW campaigns. This IWFDP revision implemented changes that prevent the creation of high potassium feeds that hurt TSCR performance. Future refinements to the DFLAW campaigns and selection of feed sources should focus on minimizing swings in the sulfate-to-sodium concentration as the dominant factor in the ability of the WTP-LAW to effectively and efficiently immobilize LAW. Formalize in a Feed Selection & Sequence Strategy and develop a desktop tool to implement.	FY 2022	Identify key drivers for ILAW production and develop a strategy to allow for future feed selection and optimization. Enables implementation of an intentional or incidental blending strategy prior to feed preparation. This action is ongoing
DST space optimization strategy	FY 2022	This is an additional aspect of feed selection strategy aimed at maximizing DST free space in the near-term and recovering SST retrieval schedule

Table 6-1 Opportunities for Improvement

Action	Target	Description of benefit
Evaluate suitability of as-retrieved SST waste from AX and A Farms and Waste Group A DSTs for DFLAW feed.	FY 2022	Possible opportunistic use of waste to avoid additional processing steps in the DST system. Based on current modeling projections, several campaigns will undergo a series of multiple evaporator campaigns before delivery to a TSCR staging and characterization tank for dilution. This results in additional waste processing without added benefit.
Layered waste retrieval feasibility. Preliminary studies of layered waste retrieval have been completed. Implementation of principles learned to campaign planning and modeling is the next step.	FY 2022	Improve assumptions and planning basis for Waste Group A mitigations, SST retrievals, and sludge mobilization.
Develop feed selection strategy for HLW campaign creation. Objectives include limiting the high-zirconium sludge content of campaigns to 10 wt%, and other modeling rules to optimize IHLW production.	FY 2023	The life-cycle model currently does a reasonable job of metering high zirconium sludge over multiple campaigns. However, there don't appear to be controls in place that prevent creation of campaigns that are exceptionally high in zirconium sludge. Campaigns that are too high in zirconium sludge can result in unnecessary canister production.
Develop modeling rules for the conversion of CST to IHLW canisters.	FY 2023	BOM modeling does not currently account for how many additional canisters result from processing spent CST which is the assumed disposition of CST. Converting CST to canisters[a] would utilize some of the model's excess IHLW capacity.
Evaluate in-tank treatment of strontium/TRU waste in AN-102 and AN-107. Reference process RPP-24809 (2005) as implemented in TOPSim from 8/2036 to 6/2037.	FY 2023	If viable, additional LAW feed may be available in the 200 East Area for DFLAW feed, if needed. Treatment of these tanks would remove restrictions for use of these DSTs and further improve the availability of DST space during DFLAW operations.
Revise ICD-19[b] (waste feed to the WTP-PT) with updated baseline dates and additional information	FY 2023	Current ICD requirements are based on contract language and design requirements and are scheduled for limited-scope revision in FY 2018.

Table 6-1 Opportunities for Improvement

Action	Target	Description of benefit
Develop detailed information supporting the potential early treatment of HLW in direct feed mode. Preliminary DFHLW acceptance criteria and DFHLW washing studies have been completed. Continue supporting DFHLW scenario development as needed.	FY 2023	Several scenarios modeled in the System Plan (ORP-11242[c]), and ongoing discussions, involve the potential initiation of early HLW treatment at the WTP-HLW that bypasses the WTP-PT (i.e., Direct Feed HLW).

[a]ORP-61830, *Final Report: Vitrification of Inorganic Ion-Exchange Media, VSL-16R3710-1*, Rev. 0, suggests that formulating 12.5 wt% TiO_2 glass directly from CST is possible without generating excessive numbers of additional canisters.

[b]24590-WTP ICD-MG-01-019, 2015, *ICD 19 – Interface Control Document for Waste Feed*, Rev. 7, Bechtel National, Inc., Richland, Washington.

[c]ORP-11242, 2017, River Protection Project System Plan, Rev. 8, U.S. Department of Energy, Office of River Protection, Richland, Washington.

CD = critical decision.
DFLAW = direct-feed low-activity waste.
DST = double-shell tank.
EMF = Effluent Management Facility.
FY = fiscal year.
HLW = high-level waste.
ICD = interface control document.
ILAW = immobilized low-activity waste.
TSCR = Tank Side Cesium Removal.
SST = single-shell tank.
TRU = transuranic.
WAC = waste acceptance criteria.
WTP = Hanford Tank Waste Treatment and Immobilization Plant.
WTP-HLW = Hanford Tank Waste Treatment and Immobilization Plant High-Level Waste Vitrification Facility
WTP-PT = Hanford Tank Waste Treatment and Immobilization Plant Pretreatment Facility

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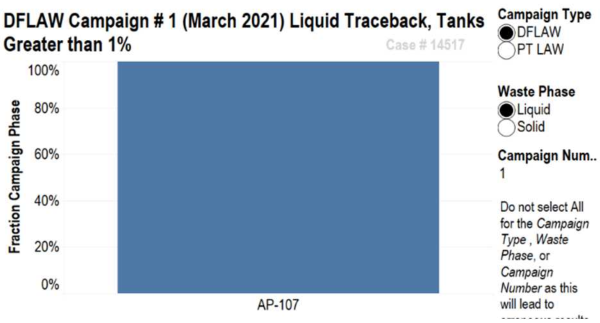
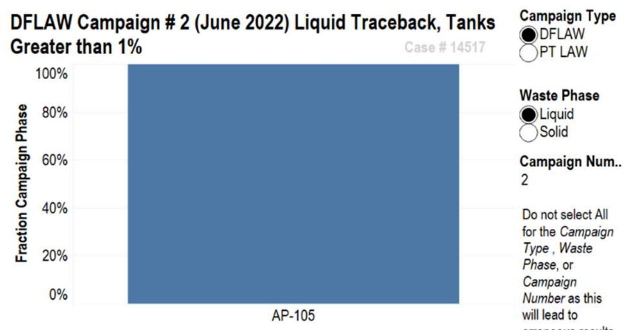
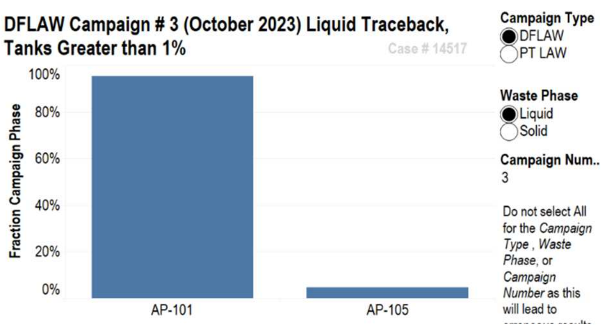
Appendix A

Original Source Charts for DFLAW Campaigns 1 to 11

Recognize that original sourcing is strictly a result of life-cycle modeling. The farther out the campaign is, the more likely it is that modeled transfers will be different from what actually happens in the tank farm.


DFLAW Campaign # 1 (March 2021) Liquid Traceback, Tanks Greater than 1%
Case # 14517
Fraction Campaign Phase
100%
80%
60%
40%
20%
0%
AP-107
Campaign Type
DFLAW
PT LAW
Waste Phase
Liquid
Solid
Campaign Num..
1
Do not select All for the Campaign Type , Waste Phase, or Campaign Number as this will lead to


DFLAW Campaign # 2 (June 2022) Liquid Traceback, Tanks Greater than 1%
Case # 14517
Fraction Campaign Phase
100%
80%
60%
40%
20%
0%
AP-105
Campaign Type
DFLAW
PT LAW
Waste Phase
Liquid
Solid
Campaign Num..
2
Do not select All for the Campaign Type , Waste Phase, or Campaign Number as this will lead to


DFLAW Campaign # 3 (October 2023) Liquid Traceback, Tanks Greater than 1%
Case # 14517
Fraction Campaign Phase
100%
80%
60%
40%
20%
0%
AP-101
AP-105
Campaign Type
DFLAW
PT LAW
Waste Phase
Liquid
Solid
Campaign Num..
3
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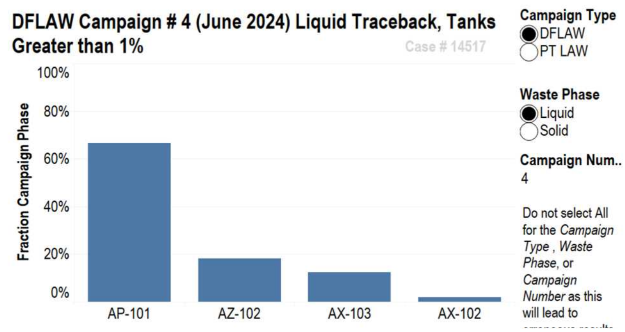
DFLAW Campaign # 4 (June 2024) Liquid Traceback, Tanks Greater than 1%
Case # 14517
Fraction Campaign Phase
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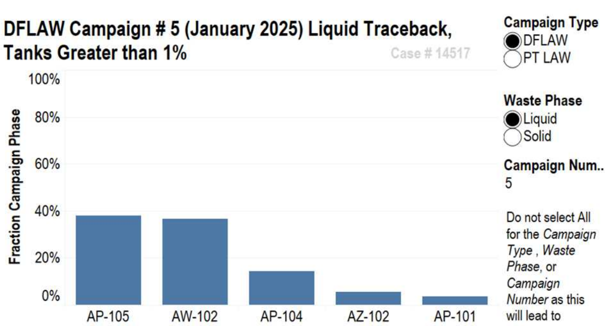
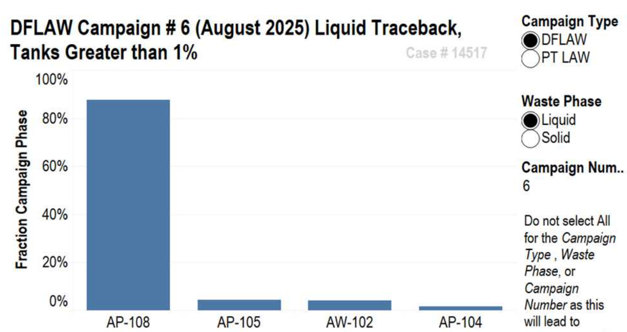
60%
40%
20%
0%
AP-101
AZ-102
AX-103
AX-102
Campaign Type
DFLAW
PT LAW
Waste Phase
Liquid
Solid
Campaign Num..
4
Do not select All for the Campaign Type , Waste Phase, or Campaign Number as this will lead to


DFLAW Campaign # 5 (January 2025) Liquid Traceback, Tanks Greater than 1%
Case # 14517
Fraction Campaign Phase
100%
80%
60%
40%
20%
0%
AP-105
AW-102
AP-104
AZ-102
AP-101
Campaign Type
DFLAW
PT LAW
Waste Phase
Liquid
Solid
Campaign Num..
5
Do not select All for the Campaign Type , Waste Phase, or Campaign Number as this will lead to


DFLAW Campaign # 6 (August 2025) Liquid Traceback, Tanks Greater than 1%
Case # 14517
Fraction Campaign Phase
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60%
40%
20%
0%
AP-108
AP-105
AW-102
AP-104
Campaign Type
DFLAW
PT LAW
Waste Phase
Liquid
Solid
Campaign Num..
6
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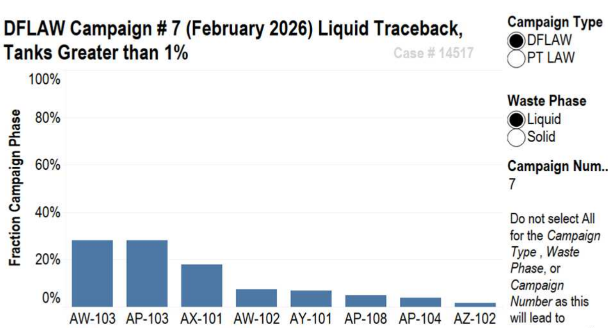
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Case # 14517
Fraction Campaign Phase
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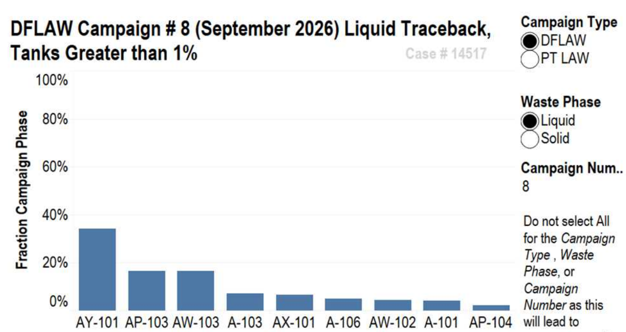
80%
60%
40%
20%
0%
AW-103
AP-103
AX-101
AW-102
AY-101
AP-108
AP-104
AZ-102
Campaign Type
DFLAW
PT LAW
Waste Phase
Liquid
Solid
Campaign Num..
7
Do not select All for the Campaign Type , Waste Phase, or Campaign Number as this will lead to


DFLAW Campaign # 8 (September 2026) Liquid Traceback, Tanks Greater than 1%
Case # 14517
Fraction Campaign Phase
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60%
40%
20%
0%
AY-101
AP-103
AW-103
A-103
AX-101
A-106
AW-102
A-101
AP-104
Campaign Type
DFLAW
PT LAW
Waste Phase
Liquid
Solid
Campaign Num..
8
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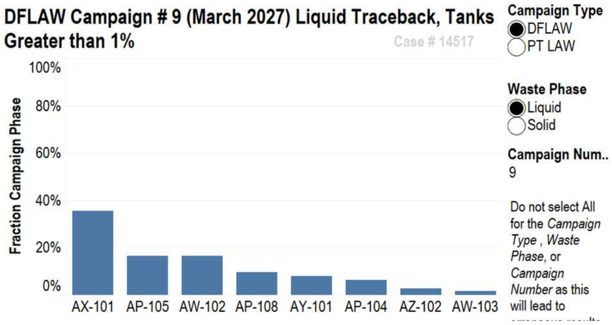
DFLAW Campaign # 9 (March 2027) Liquid Traceback, Tanks Greater than 1%
Case # 14517
Fraction Campaign Phase
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80%
60%
40%
20%
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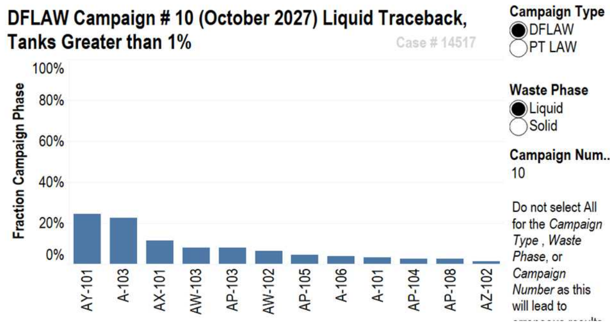
AX-101
AP-105
AW-102
AP-108
AY-101
AP-104
AZ-102
AW-103
Campaign Type
DFLAW
PT LAW
Waste Phase
Liquid
Solid
Campaign Num..
9
Do not select All for the Campaign Type , Waste Phase, or Campaign Number as this will lead to


DFLAW Campaign # 10 (October 2027) Liquid Traceback, Tanks Greater than 1%
Case # 14517
Fraction Campaign Phase
100%
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60%
40%
20%
0%
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AX-101
AW-103
AP-103
AW-102
AP-105
A-106
A-101
AP-104
AP-108
AZ-102
Campaign Type
DFLAW
PT LAW
Waste Phase
Liquid
Solid
Campaign Num..
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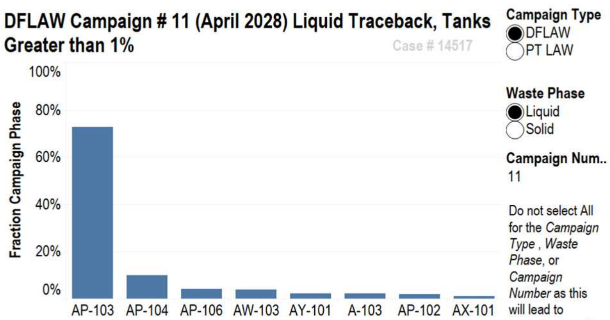
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AW-103
AY-101
A-103
AP-102
AX-101
Campaign Type
DFLAW
PT LAW
Waste Phase
Liquid
Solid
Campaign Num..
11
Do not select All for the Campaign Type , Waste Phase, or Campaign Number as this will lead to

Figure 1. Technical Report Checklist.

Report Number: RPP-40149-VOL2 Revision: 6

Report Title: Integrated Waste Feed Delivery Plan: Volume 2- Campaign Plan

The following checklist is used by checkers to ensure technical reports are complete and in compliance with engineering procedures (i.e., TFC-ENG-DESIGN-C-25). This checklist is also applicable to ECNs that revise these types of documents.

Item No.	Yes	No	N/A	Item
				Version/Format
1	☑	☐	☐	If revising an existing report, are the changes being made against the current revision in SPF?
2	☑	☐	☐	Is the Document Release and Change Form (DRCF) properly filled out?
3	☑	☐	☐	Are all of the pages properly labeled with Report Number, Revision Number, and Sequential Page Number?
4	☑	☐	☐	Are the Subject and Purpose clearly stated and do they meet the end users' needs?
				References
5	☑	☐	☐	Are all References properly documented within the report and can they be easily verified within Document Control, online, or within the library, etc.? If reference documents are not readily available, are they attached?
6	☑	☐	☐	Have the correct design bases documents been identified (e.g., codes, standards, DOE Orders, TOC standards, regulatory requirements, etc.)?
				Open Items/Input
7	☑	☐	☐	Is there a reference/source for each input?
8	☑	☐	☐	Do the identified references/sources fully support the inputs?
9	☑	☐	☐	Are all assumptions used to support the report individually listed and numbered?
10	☑	☐	☐	Is there a justification written for each assumption that includes a technical basis?
11	☑	☐	☐	Do the justifications adequately support the assumptions?
12	☐	☐	☑	If the report has open items, TBDs, and/or HOLDs, is there a method identified to track them?
				Results/Conclusion
13	☑	☐	☐	Are the results of the report consistent with the input and assumptions?
14	☑	☐	☐	Do the results of the report affect any other technical documents?
15	☑	☐	☐	Do the results substantiate the conclusion?
				Approvals
16	☑	☐	☐	Does the DRCF identify the method of verification and checking and does it have a signature block for the verifier/checker?
17	☑	☐	☐	Does the DRCF identify the appropriate approvers required by TFC-ENG-DESIGN-C-52?

Item No.	Comments

Checker: Nguyen, Vinh C — Digitally signed by Nguyen, Vinh C Date: 2021.10.13 11:38:08 -07'00'

Print Name **Signature** **Date**