DOCUMENT RELEASE AND CHANGE FORM

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: Aug 12,2019 HANFORD RELEASE

1. **Doc No:** RPP-40149-VOL2 **Rev.** 05

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
Clearance Review	Ayers, Lynn M	*Ayers, Lynn M*	08/12/2019
Document Control Approval	Hood, Evan	*Hood, Evan*	08/12/2019
Originator	Orme, Ronald M	*Orme, Ronald M*	08/05/2019
Responsible Manager	Wagnon, Todd J	*Wagnon, Todd J*	08/05/2019

8. **Description of Change and Justification**

Updated to bring into alignment with current long term and project planning for Direct Feed Low Activity Waste and reintroduce High Level Waste treatment elements.

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

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**

Name	Organization
Arm, Stuart T	FLOWSHEET INTEGRATION
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RPP-40149-VOL2
Revision 5

Integrated Waste Feed Delivery Plan: Volume 2 – Campaign Plan

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Date Published
August 2019

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
FY	fiscal year
HLW	high-level waste
ICD	interface control document
IHLW	immobilized high-level waste (canisters)
ILAW	immobilized low-activity waste (containers)
IWFDP	Integrated Waste Feed Delivery Plan
LAW	low-activity waste
LAWPS	Low-Activity Waste Pretreatment System
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
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

g	gram
gal	gallon
in.	inch
kg	kilogram
kgal	thousand gallons
L	liter
M	molar
MCi	megacurie
Mgal	million gallons
min	minute
mol	mole
MT	metric ton
Sv	sievert
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 TRU waste will be retrieved, treated and packaged for disposal at the Waste Isolation Pilot Plant (WIPP). The remainder and majority of the waste can 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 Supplemental Low Activity Waste (LAW) Treatment facility (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 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 Supplemental LAW Treatment facility. 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-50461, *2019 Flowsheet Integration Joint Scenarios*). 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 Mission Integration and Waste Feed Delivery organization, which leads and performs planning, analysis, and integration activities, develops and updates the IWFDP, as required, and has responsibility for maintaining the plan.

[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.

Waste feed delivery will support LAW vitrification in the direct-feed mode prior to commencement of HLW pretreatment in the WTP-PT. The DFLAW approach is implemented via two low activity waste pretreatment systems. Initially, stage one DFLAW involves processing tank farms supernate through the Tank Side Cesium Removal (TSCR) system. TSCR is a short term technology demonstration intended to provide pretreatment for the first five years of WTP-LAW operations. TSCR design has been completed and fabrication has commenced at the time of this writing (August 2019). Stage two DFLAW pretreatment commences approximately 2nd quarter fiscal year FY 2026 in a TBD[2] facility (possibly parallel TSCRs, or a higher capacity version of TSCR) that has throughput equivalent[3] to the shelved Low-Activity Waste Pretreatment System Project. Post-TSCR feed preparation is called Tank Farms Pretreatment (TFPT). Lessons learned from TSCR will be beneficial for designing TFPT.

DFLAW pretreatment of supernate removes solids and cesium via filtration and ion-exchange, respectively. Captured solids are returned to the tank farms. Spent ion exchange (IX) columns loaded with cesium are discharged to interim storage pending conversion to IHLW canisters.

Pre-treated DFLAW feed accumulates in AP-106[4] awaiting batch transfer to WTP LAW. Waste feed delivery infrastructure upgrades that provide DFLAW pumps at AP-106 and pipelines up to Interface Node 13 for ICD 30 are currently in design (Project T1P190). 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[5] (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.

All campaign planning information presented in the following discussion is derived from Case 9157 of the life-cycle planning tool. These results are subject to change as WFD planning continues to evolve.

Campaign 1 of 26 projected DFLAW campaigns is already prepared in AP-107 awaiting official qualification in 2020. During the DFLAW period, about 18.1 Mgal of supernate comes from either current DST waste or SST retrievals, with 6.9 Mgal of dilution and flush water added to reach the target sodium molarity of TSCR feed (RPP-RPT-60636, *Waste Acceptance Criteria for the Low Activity Waste Pretreatment Systems*). The TSCR Demonstration run commences in March 2021. About 24.5 Mgal from AP-107 are processed through TSCR/TFPT over the DFLAW phase, and about 23.5 Mgal of pretreated feed are processed at WTP-LAW.

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[2] The TBD nature of TFPT is not a detriment to campaign planning. Campaigns throughout stage one and stage two DFLAW are prepared in essentially the same way in the designated DFLAW tank system.

[3] Equivalent throughput is defined as averaging 185 kg Na per hour.

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

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

When DFLAW ends, a temporary outage ensues to implement new routings to Tank Waste Characterization and Staging (TWCS)[6] and WTP-PT, and eventually a rerouting to Supplemental LAW.

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 estimate for planning purposes is 0.4 Mgal over the DFLAW period. DFLAW processing activity results in 16.2 Mgal net volume reduction in the tank farms (Table 1-1).

Table 1-1. Direct Feed Low-Activity Waste and Process Returns Volumes

Source	Volume In (Mgal)	Volume Out (Mgal)
Waste to WTP-LAW	23.5	-
Dilution Water*		6.9
Process Returns		0.4
Net Tank Farm Volume Reduction	**16.2 Mgal**	

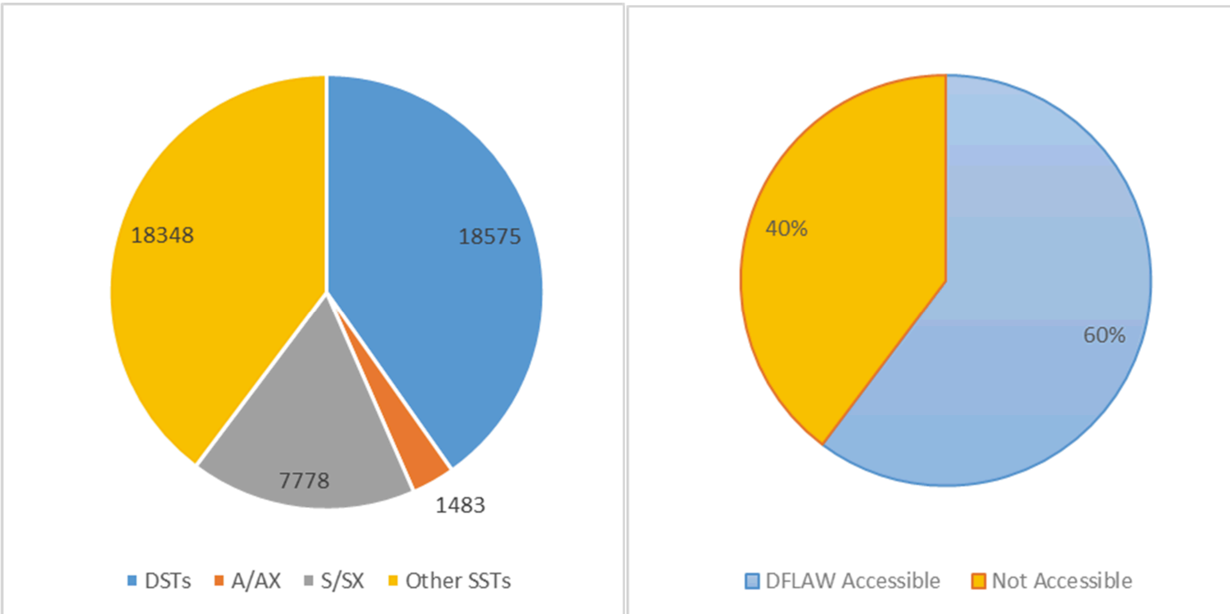
*Includes flush volumes after supernate is transferred to AP-105

The current tank farms waste inventory[7] contains approximately 46,200 metric tons (MT) sodium (Na) distributed among the DSTs and SSTs (Figure 1-1). Of this, 18,600 MT Na is held in the 27 sound DSTs. Access to some DST inventory is more difficult because special requirements are in effect for remediating Waste Group A tanks. Retrieval activities in A/AX Farms and S/SX Farms contribute to accessible sodium within the DFLAW timeframe. Sodium inventory of the DSTs, combined with A/AX Farms (1,480 MT Na) and S/SX Farms (7,780 MT Na), yields approximately 27,800 MT Na potentially accessible for treatment during the DFLAW phase. The life-cycle model estimates that 11,500 MT Na (25% of total sodium or 41% of potentially accessible) will be processed during the DFLAW phase. More emphasis on Waste Group A remediation could create considerable latitude for alternate feed delivery sequences during DFLAW.

[6] After transition to feeding TWCS and WTP-PT, TFPT provides BOM supernate pretreatment capacity only for Supplemental Treatment. A new routing from AP-106 to Supplemental LAW Treatment must be arranged for BOM. The direct feed routing from AP-106 to WTP-LAW will be discontinued.

[7] All metric tons mentioned in this paragraph are rounded numbers.

Figure 1-1. Metric Tons of Sodium Distribution and Fraction Accessible for Treatment During Direct Feed Low-Activity Waste Operations



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 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:

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[8] The IWFDP has to consider several WACs. There is the WAC for feed to TSCR and TFPT, the WAC for pretreated feed to WTP LAW in ICD-30, the WAC for feed to WTP PT in ICD-19, the WAC for feed to TWCS (not yet written), and the WAC for Supplemental Treatment (not yet written).

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).

Campaign planning does not address a number of facilitating tank farm preparations and projects that are assumed to be completed in advance of waste feed delivery. The Multi-Year Operating Plan (MYOP) shows the schedule for all of the facilitating projects. These prerequisite activities include:

- Repurposing of AP-106 to receive and maintain pretreated, WTP-compliant feed from TSCR.
- WFD Upgrades Project that provides pump pit upgrades at AP-106 and new transfer lines to Interface Nodes 14 for ICD 30/31 (the WTP project provides the continuation of the transfer lines to EMF and WTP-LAW).
- Outage of AP-02D to make upgrades for Interface 31 returns (EMF returns).
- Outage of AP-108 for upgrades in conjunction with the TSCR project.
- Outage of AP-107 for upgrades in conjunction with the TSCR project.

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

2.0 SUMMARY OF CAMPAIGNS

The WFD campaigns described in this IWFDP volume are informed by Case 9157 as modeled by the life-cycle modeling tool and is consistent 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. Technical challenges have delayed completion of the WTP-PT. In response, ORP has directed alternate mission strategies to treat 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[9] and TWCS and the full capabilities of the integrated WTP facilities become operational.

2.1 DIRECT-FEED LOW-ACTIVITY WASTE CAMPAIGNS

Campaigns for DFLAW operations are defined as 1 Mgal (nominally) of qualified supernatant waste staged into AP-107. Qualified waste campaigns in AP-107 are pretreated in TSCR/TFPT, the pretreated waste accumulating in AP-106. In practice, because of feed delivery and tank farm operating constraints, the campaigns average about 0.94 Mgal. Campaigns originate from:

a) supernatant waste currently in DSTs,

b) supernate derived from recently retrieved SST saltcake,

c) supernate derived from TSCR process returns, and

d) supernate derived from remediated Waste Group A DSTs.

Each campaign is adjusted (typically dilution with water), homogenized, and qualified in AP-105 prior to staging to AP-107.

Noting that Campaign 1 is already prepared in AP-107 awaiting qualification, Table 2-1 shows *proximate*[10] campaign sourcing (based on Case 9157) into AP-105 for preparing 26 DFLAW Campaigns. Campaign sourcing is simple only for the first three campaigns. Beyond Campaign 3, the original source of campaigns becomes complicated because ongoing tank farm operation may move supernate between tanks. Campaign original sourcing and delivery timing for AP-105 to AP-107 transfers and for AP-107 to TSCR/TFPT transfers is addressed later in Table 2-2. Supernate sources found to be out of compliance with the WAC for TSCR/TFPT (RPP-RPT-60636)[11] may necessitate blending with other sources in conjunction with campaign preparation in AP-105. Figure 2-1 shows the process flow during the DFLAW phase.

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

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

[11] 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.

Table 2-1. DFLAW Campaign Proximate Sourcing to AP-105

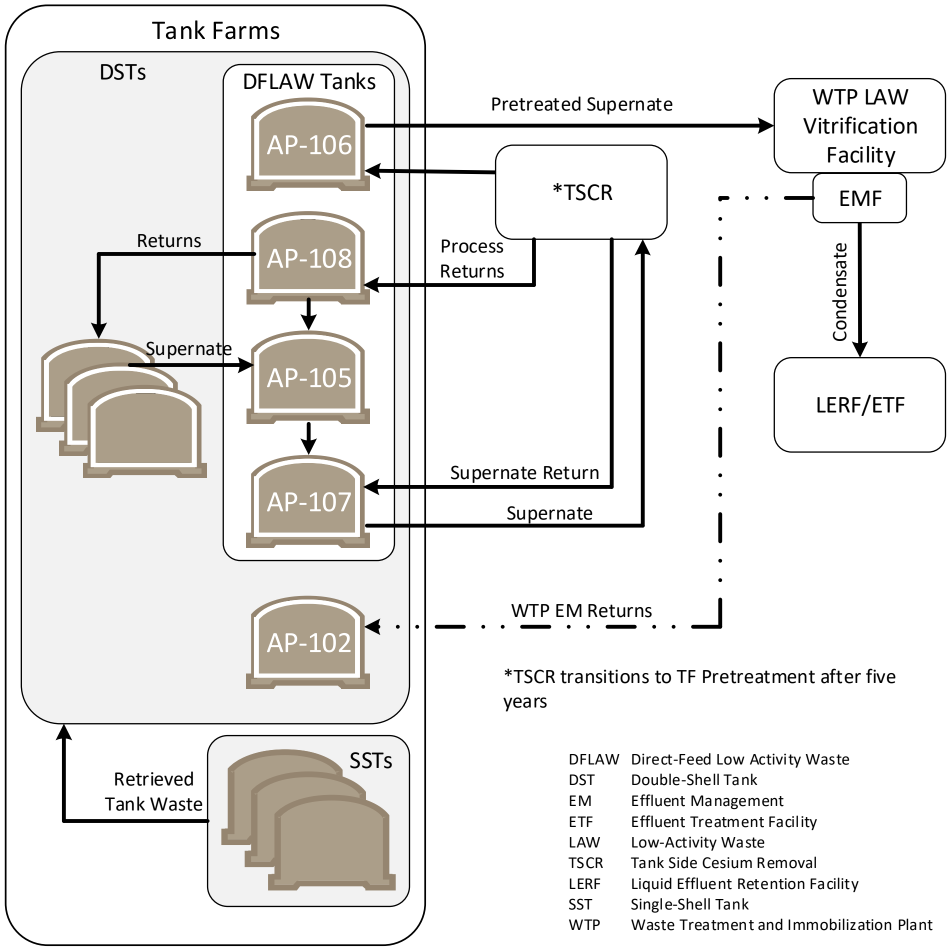
Proximate[a] Source Tank or Water	Supernate Volume (gal)	Start Date	Campaign #
Campaign 1 is already in AP-107			
Campaign 2 supernate is already in AP-105			
WATER	410,308	11/8/2020	2
AP-101	653,341	12/2/2021	3
WATER	378,638	12/11/2021	
AP-101	780,857	8/28/2022	4
WATER	209,262	9/5/2022	
AP-104	633,673	3/31/2023	5
WATER	392,423	4/8/2023	
AP-108	707,267	11/16/2023	6
WATER	314,724	11/25/2023	
AZ-102	738,066	5/24/2024	7
WATER	188,128	6/1/2024	
AY-101	762,309	11/22/2024	8
AW-105	593,023	6/28/2025	9
AP-104	212,416	7/5/2025	
WATER	204,025	7/12/2025	
AP-104	669,152	1/9/2026	10
WATER	342,898	1/17/2026	
AP-102	421,092	8/6/2026	11
AY-101	348,438	8/13/2026	
WATER	233,552	8/20/2026	
AZ-102	663,565	12/26/2026	12
WATER	327,291	1/3/2027	
AW-103	598,509	5/14/2027	13
WATER	328,574	5/22/2027	
AW-105	319,136	11/13/2027	14
AP-101	343,016	11/20/2027	
WATER	331,239	11/26/2027	
AW-105	206,722	4/21/2028	15
AN-105	476,890	4/27/2028	
WATER	311,571	5/4/2028	
AW-105	476,992	9/9/2028	16
AN-105	120,773	9/16/2028	
WATER	242,443	9/22/2028	
AN-105	215,004	2/26/2029	17
AP-101	457,656	3/4/2029	
WATER	315,041	3/11/2029	
AP-103	640,143	7/30/2029	18

WATER	345,577	8/8/2029	
AN-105	567,646	12/19/2029	19
WATER	290,611	12/27/2029	
AP-104	573,129	5/31/2030	20
AW-101	301,502	6/8/2030	
WATER	92,101	6/14/2030	
AW-101	733,205	11/15/2030	21
WATER	248,613	11/23/2030	
AP-103	463,407	4/25/2031	22
AW-106	247,190	5/2/2031	
WATER	249,712	5/8/2031	
AW-106	612,572	10/6/2031	23
WATER	338,323	10/14/2031	
AP-104	821,412	3/22/2032	24
WATER	116,822	4/1/2032	
AW-106	51,444	9/16/2032	25
AP-104	505,861	9/21/2032	
WATER	416,268	9/29/2032	
AW-106	419,184	2/7/2033	26
AP-104	228,906	2/14/2033	
WATER	296,228	2/20/2033	
AP-104	248,285	6/27/2033	27
AW-106	310,983	7/3/2033	
WATER	223,316	7/10/2033	
[a]See Table 2-2 for original sourcing of the campaigns.			
Transfers to AP-105 derived from Case 9157.			

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, upon implementation, will ensure 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 supernatant samples at different depths from a single riser in the designated double-shell tank (DST). The samples are analyzed to obtain feed acceptance data and processability data for qualifying a new campaign.

Figure 2-1. Process Flow Diagram for Direct Feed Low-Activity Waste Operations



Upon implementation, 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 treated feed to the WTP LAW Facility for immobilization into a glass waste form.

The initial feed campaign will consist of the supernatant waste currently maintained in AP-107. For this initial feed campaign only, all sampling, chemical adjustments, and feed qualification activities will be performed in AP-107 beginning in February 2020. The initial delivery of feed to TSCR is planned to occur in March 2021. Feed for all subsequent DFLAW campaigns will be staged in the DST system, with sampling, chemical adjustments, and feed qualification activities typically being performed in AP-105, or any DST capable of providing well-mixed supernate and having appropriate process controls in place. The DFLAW feed tank remains AP-107 throughout the DFLAW phase. The next qualified campaign will be transferred to AP-107 when the last ion exchange cycle of the previous campaign has completed. The new campaign will blend with AP-107 heel contents (nominally 24 in. of supernate above the solids level), and then be fed forward as the next DFLAW campaign.

A summary of the waste feed campaigns, including original source tanks, the TSCR/TFPT feed delivery timing, and process volume is provided in Table 2-2. Feed needs to be staged to AP-105 no less than 112 days before projected delivery to AP-107. As 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 as needed.

Table 2-2. Direct-Feed Low-Activity Waste Feed Delivery Campaigns

DFLAW Campaign	Original Source Tanks[c]	Feed Staging to AP-107 (start date)	Delivery to TSCR/TFPT (start date)	Volume delivered to TSCR/TFPT (gal)
1	AP-107	N/A	3/24/2021	938,927
2	AP-105	11/22/2021	11/27/2021	988,586
3	AP-101, AP-105	8/18/2022	8/23/2022	1,028,778
4	AP-101, AZ-102, AX-103, AX-102	3/21/2023	3/26/2023	1,059,501
5	AW-102, AP-105, AP-104, AP-101	11/6/2023	11/11/2023	887,409
6	AP-108, AW-102, AP-105, AP-106	5/14/2024	5/19/2024	865,227
7	A-101, AP-108, AP-101, AX-101, A-102…	11/13/2024	11/18/2024	1,065,002
8	AY-101, AP-108, AN-101, A-101…	6/18/2025	6/23/2025	908,368
9	AW-105, AX-101, AP-108, AW-102…	12/30/2025	1/14/2026	1,009,284
10[a]	AX-101, AN-104, AP-108, AW-102…	7/27/2026	8/1/2026	1,002,448
11	AN-104, A-103, AP-106, AW-105…	12/16/2026	12/21/2026	908,152
12	AN-103, A-103, SY-101, AN-104…	5/4/2027	5/9/2027	1,064,983
13	AP-103, AP-104, AN-103, AW-103	11/3/2027	11/8/2027	934,687
14	S-105, S-109, SY-103, AP-103, AN-104…	4/11/2028	4/26/2028	771,488
15	AN-105, S-109, S-105, SY-103	8/31/2028	9/4/2028	1,064,984
16	S-109, AN-105, S-105, S-102	2/16/2029	3/3/2029	917,412
17	S-109, AN-105, S-105, SY-103, AN-104	7/21/2029	7/26/2029	849,812
18	AP-103, AW-103, AY-101, AX-101…	12/10/2029	12/15/2029	967,779
19	S-103, AP-103, S-109, AW-103, AY-101…	5/21/2030	5/26/2030	992,323
20	SX-106, AW-101, S-106, AN-105, S-103…	11/5/2030	11/10/2030	948,484
21	AW-101, AN-105, SX-106, S-103, S-106…	4/15/2031	4/20/2031	950,762
22	AW-106, S-106, AN-105, AW-101, S-103…	9/26/2031	10/1/2031	971,187
23	AW-106, SX-102, S-108, S-106	3/13/2032	3/18/2032	1,036,712
24	S-108, SX-106, SX-102, S-103, AW-106…	9/6/2032	9/11/2032	841,358
25	AN-103, S-108, SX-106, AW-106…	1/28/2033	2/2/2033	770,290
26	AN-103, S-108, SX-105, AW-106…	6/18/2033	6/22/2033	804,492

27	AN-103, S-111, S-108, SX-105, SX-106	11/5/2033	11/9/2033	862,275
				Mgal
Total[b]		**–**	**–**	**24.5**

[a] Campaign 10 is initial feed to TFPT.
[b] Total is for Campaigns 1 to 26 only; BOM Campaigns 27 to 50 not included.
[c] Original source tanks more than 1% of campaign; … indicates additional minor source tanks

DFLAW = direct-feed low-activity waste.
TFPT = tank farms pretreatment.
TSCR = tank side cesium removal.

The DFLAW phase continues until the startup of the WTP-PT. Case 9157 estimates processing approximately 18.1 Mgal of concentrated tank waste with 6.9 Mgal of associated dilution water to adjust sodium molarity to the WAC for TSCR/TFPT target. The logic of the delivery sequence is explained in Sections 3.2 and 3.3. About 3,145 *batches* (batches range from 6,400 gal to 8,480 gal per batch, averaging 7,470 gal) will be delivered to the WTP-LAW, where further characterization is performed to support glass formulation. The actual batch size and frequency[12] of DFLAW batches delivered from AP-106 to the WTP-LAW are at the discretion of WTP-LAW.

WTP-LAW melters operating at full 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 2.3) and the average consumption of waste within the system. The assumption is limited, however, related to the instantaneous throughput of the system, which should be further assessed prior to DFLAW operations. TSCR supports 21 MTG/day *for the assumptions that are applied to Case 9157*. TFPT is going to be designed with the capability to feed the WTP-LAW at its maximum instantaneous throughput of 30 MT/day which more than supports the model rate.

Previous campaign plans saw little reduction in total tank farms activity until BOM started. A positive feature of the new TSCR-based DFLAW process is that significant radioactivity is captured on TSCR CST columns (as opposed to Cs eluates returning to the tank farms), permanently removing 15 MCi Cs-137 from the tanks farms during DFLAW.

Table 2-3 provides summary data for the campaigns to be delivered to the TSCR/TFPT and subsequent batches to be delivered to the WTP-LAW.

[12] Any batch size and frequency that WTP-LAW could request is within the range that Waste Feed Delivery can support. STD-26 will govern line flushing after DFLAW batch transfers. 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 2-3. Direct-Feed Low-Activity Waste Feed Delivery Summary Data

	Campaigns to TSCR/TFPT	Batches to WTP-LAW
Total number	26	3,145
Nominal volume (gal)	944,000	7,470 (6,400 to 8,480)
Total volume (Mgal)	24.5	23.5
Total sodium (MT)	-	11,500
ILAW containers	-	13,513

ILAW = immobilized low-activity waste.
MT = metric ton.
WTP-LAW = Hanford Tank Waste Treatment and Immobilization Plant Low-Activity Waste Vitrification Facility.

2.2 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 2-2 shows the BOM process flow configuration.

BOM WFD priorities are to (a) begin feed deliveries to TWCS/WTP-PT, and (b) continue operating TFPT for supernate that exceeds WTP-PT processing capacity.

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

The DFLAW staging system/TFPT is left intact during BOM but prepares feed only to the new Supplemental[13] Treatment. 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. BOM initiates new feed deliveries to TWCS/WTP-PT; WTP-PT in turn distributes pretreated supernate and pretreated slurry to the appropriate vitrification plants.

The scope of BOM WFD consists of the following campaigns:

- DFLAW campaigns 27 to 50, or 24 campaigns averaging 833,000 gal each, supernate pretreated at TFPT routed to Supplemental Treatment via a new routing.
- Feed delivered from various HLW DSTs to TWCS for conditioning[14] (211 slurry transfers becoming 184 campaigns of 500 kgal each in TWCS).
- Feed delivered to WTP-PT for pretreatment (conditioned slurry - 184 campaigns becoming 552 slurry transfers up to 143 kgal each (559 total including 7 cleanout transfers), and BOM supernate - 19 campaigns of nominally 1 Mgal each) followed by

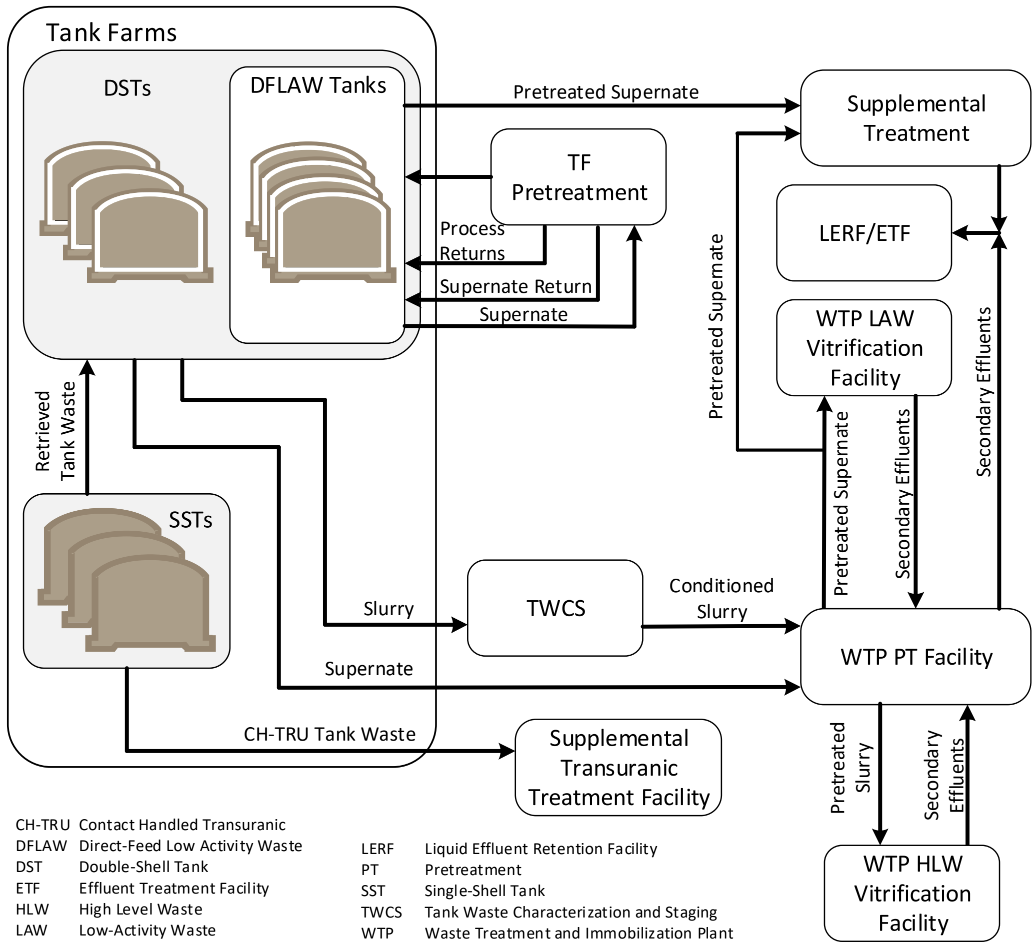
[13] The sodium remaining in tank farms after DFLAW (see Figure 1-1) plus sodium added pursuant to BOM pretreatment exceeds the WTP LAW treatment capacity. Supplemental LAW Treatment is TBD treatment capacity to handle the excess. Initiatives currently in progress, such as the effort to reclassify HLW, could result in some sludge bypassing pretreatment, less sodium added during pretreatment processing, and less need for supplemental treatment capacity.

[14] Conditioning is an open-ended concept encompassing any adjustments to HLW slurry within TWCS required to comply with waste acceptance criteria (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.

vitrification at the WTP-LAW and WTP-HLW. The 19 BOM LAW campaigns will be delivered in 57 transfers of up to 365 kgal each to the WTP-PT LAW receipt vessels.

- Feed of contact-handled transuranic (CH-TRU) waste delivered to supplemental transuranic (TRU) treatment.

Figure 2-2. Process Flow Diagram for Balance of Mission



The 19 BOM LAW campaigns are staged for modeling purposes from AP-104 to WTP-PT. In practice, the staging tank could be any tank that is operationally convenient at the time.

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 to ILAW as follows:

- Route pretreated supernate to keep WTP-LAW operating at near capacity (WTP-LAW ILAW containers 39,746).

- Route excess pretreated supernate to Supplemental Treatment to keep WTP-PT operating. Between excess pretreated supernate and BOM DFLAW there will be 33,905 SLAW ILAW containers.

WTP-PT and SLAW produce approximately equal numbers of containers. About one third of ILAW containers originating from WTP-PT pretreated supernate are processed at Supplemental Treatment, confirming that the volume of excess pretreated supernate from WTP-PT is not trivial.

Both WTP-PT and TFPT generate pretreated supernate for Supplemental Treatment. TFPT can store pretreated supernate for Supplemental Treatment in AP-106, and has the option of shutting down when AP-106 is full. WTP-PT has to shut down when excess WTP-PT pretreated supernate has no place to go, and thus is the preferential feed source for Supplemental Treatment over AP-106.

The HLW campaigns (nominally 500 kgal for planning purposes) are created in the tanks of the TWCS capability from tank waste slurry delivered from various DSTs. The HLW campaigns are conditioned and qualified against ICD-19 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 2-4 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 211 HLW transfers to TWCS become 184 HLW campaigns within TWCS. Note that 19 of 43 LAW campaigns into the WTP-PT receipt vessels are delivered in a series of 57 transfers (the other 24 LAW campaigns are pretreated at TFPT). Most of the conditioned slurry coming from TWCS to WTP-PT separates into a pretreated LAW fraction that is routed to either the WTP-LAW or LAW Supplemental Treatment. Therefore, the ILAW container count reflects LAW campaigns received directly 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.

Table 2-4. Balance of Mission Waste Feed Delivery Summary

	HLW	LAW
Total number of campaigns	184	43
Nominal campaign volume (Mgal)	0.5*	0.825 to 1
Total volume treated (Mgal)	79.7	37
Total activity (MCi)	54.9	1
Total production	7,626 canisters	77,073 containers

HLW = high-level waste.
LAW = low-activity waste.
MCi = megacurie.
Mgal = million gallons.
*Only 0.43 Mgal of each campaign is delivered to WTP-PT.

The following discussion shows a feed staging order to TWCS that is auto-selected by the life-cycle model to manage tank space. This is subject to change in the future after more consideration has been given to selecting the hot commissioning feed for WTP-HLW.

HLW slurry will be staged throughout the DST system to the appropriate solids content (nominally 105 g/L), and then sent to TWCS. The initial delivery of feed to TWCS will occur in 2032. Over the BOM, there are 211 DST-to-TWCS transfers, but on 25 occasions 2 or more transfers are combined to fill a TWCS tank. Therefore, TWCS tanks are completely filled 184 times (creating 184 HLW campaigns). Each full TWCS tank (or campaign) results in 3 TWCS-to-WTP-PT qualified feed transfers (143 kgal each). The qualified feed transfers leave a 70 kgal heel that incorporates into the next HLW campaign. At the end of mission, there are also 7 heel cleanout transfers for a total of 559 TWCS to WTP-PT transfers (3 X 184 + 7 = 559). Sampling, chemical adjustments, and feed qualification activities for each HLW campaign will be performed as part of the TWCS capabilities.

Table 2-5 lists the first 8 of 211 HLW transfers to TWCS including the proximate source of the slurry and transfer start dates. These transfers, constituting the initial fill of TWCS tanks, are started about once per week. HLW transfers for the initial fill of TWCS tanks are nominally 500 kgal, but on two occasions smaller transfers are combined to fill a TWCS tank. The initial fill of TWCS is followed by a long interval with no HLW transfers while the initial campaigns are qualified. After qualified feed transfers to WTP-PT begin in 2034, TWCS receives a HLW transfer(s) after every third qualified feed transfer. There is no set interval for HLW campaigns.

The proximate campaign sources listed in Table 2-5 are likewise the preponderant original source for the respective campaigns identified by the Case 9157 traceback matrix. Other >1 wt% original sources include AN Farm, AX Farm, and AW Farm with a smattering from other DSTs. This is consistent with SST retrievals and other DST operations planned and expected to be completed prior to 2032.

Table 2-5. Early High-Level Waste Slurry Transfers to TWCS

Campaign	Proximate Source	Volume kgal	Start Date	Other Original Source >1 wt%
1	AZ-102	500	7/5/2032	AX-101, AX-103
2	AZ-102	403	7/12/2032	AX-101, AX-103, AW-104
	AW-105	97	7/26/2032	
3	AW-105	500	7/31/2032	AW-104, AY-101
4	AW-105	287	8/8/2032	AW-104, AN-104, AY-101
	AZ-102	213	8/14/2032	
5	AZ-102	500	8/21/2032	AN-104, AN-105, AX-101, AX-103
6	AN-103	500	8/28/2032	AW-103, AN-106, MUSTS, AW-105

From each TWCS tank, the campaign is conveyed to WTP-PT in three qualified feed transfers (143 kgal each) leaving a 70 kgal heel. Consequently, after the initial fill of the TWCS tanks, subsequent HLW transfers (9 through 211) are nominally 430 kgal to top off the 70 kgal heel.

Table 2-6 lists the 18 qualified feed transfers to WTP-PT corresponding to the Table 2-5 early campaigns.

The first HLW campaign of a life-cycle model run is stipulated; thereafter, the model selects and composites the solids that will make up each campaign. TOPSim selects tanks containing either between 49 and 69 inches of settled solids or between 55 and 125 g/L of solids (concentration calculated as if the tank were full) for becoming HLW feed tanks. The model attempts to dissolve precipitated salts in group A tanks and tanks that have received evaporator bottoms before allowing any undissolved solids to become HLW feed. Certain problematic sludges, such as the high-CSL solids in AN-101 or the high-zirconium solids in AW-103 and AW-105 are intentionally blended across several tanks.

Case 9157 created some early campaigns that are exceptionally high in the fraction coming from high-zirconium sludge (Campaign 3 and 4 were 60 wt% and 50 wt% from AW-105, respectively). There are 17 campaigns (out of 184) in Case 9157 where high-zirconium sludge accounts for more than 10 wt% of the campaign. A potential area for future model improvement is to introduce selection rules that would prohibit HLW campaigns from exceeding 10 wt% high-zirconium sludge. This would entail a small increase in the total number of sludge transfers.

Table 2-6. Early High-Level Waste Feed Delivery Transfers From TWCS to WTP-PT

Campaign	Name	Volume kgal	Start Date
1	TWCSF to WTP-PT	143	12/31/2033
	TWCSF to WTP-PT	143	1/5/2034
	TWCSF to WTP-PT	143	2/8/2034
2	TWCSF to WTP-PT	143	3/4/2034
	TWCSF to WTP-PT	143	4/19/2034
	TWCSF to WTP-PT	143	6/2/2034
3	TWCSF to WTP-PT	143	7/18/2034
	TWCSF to WTP-PT	143	8/30/2034
	TWCSF to WTP-PT	143	10/6/2034
4	TWCSF to WTP-PT	143	11/12/2034
	TWCSF to WTP-PT	143	12/17/2034
	TWCSF to WTP-PT	143	1/15/2035
5	TWCSF to WTP-PT	143	2/23/2035
	TWCSF to WTP-PT	143	4/5/2035
	TWCSF to WTP-PT	143	5/11/2035
6	TWCSF to WTP-PT	143	6/16/2035
	TWCSF to WTP-PT	143	7/17/2035
	TWCSF to WTP-PT	143	8/21/2035

Following DFLAW operations, treatment of LAW feed at TFPT (24 campaigns) will continue for the remainder of the RPP mission and treatment at WTP-PT (19 campaigns) begins. The BOM LAW feed campaigns will consist of supernatant waste held within the DST system at the conclusion of DFLAW operations, generated from additional DST mitigation activities, and generated from retrieval of SSTs throughout the mission. Pretreated supernate generated by WTP-PT initially from 2034 is derived only from the HLW campaigns. Note the preparation and delivery of BOM LAW feed after WTP-PT startup is not until late 2036.The first four of 19 BOM LAW campaigns to WTP-PT are listed in Table 2-7. The Cs-137 and entrained solids are separated from the LAW feed in the WTP-PT and dispositioned as HLW. The supernates highest in Cs-137 have generally been treated before the end of DFLAW. A notable exception is AZ-101 supernate which is worked off neither as BOM DFLAW or BOM LAW, but as the carrier liquid in several HLW campaigns, thus it is introduced at WTP-PT via the TWCS. Consequently, the BOM LAW campaigns contribute only 1.5 MCi to the total activity processed at WTP-PT. As startup of the full capabilities of the integrated WTP facilities approaches, these campaigns will be further refined and optimized to support the overall RPP mission.

Table 2-7. Balance of Mission Early Low-Activity Waste Feed Delivery Campaigns

LAW Campaign[a]	Source tanks[b]	Pretreatment system	First delivery to pretreatment	Volume delivered (kgal)	MCi
1	SX-103, SX-101, SX-109…	WTP-PT	10/27/2036	0.978	0.17
2	S-101, SX-101, SX-104…	WTP-PT	5/20/2038	0.916	0.37
3	TX-116, BY-101, BY-110…	WTP-PT	8/7/2041	0.973	0.14
4	TX-116, TX-102, BY-112…	WTP-PT	10/1/2042	0.934	0.04

[a]Four of 19 BOM LAW campaigns.
[b] Original source tanks more than 1% of campaign; … indicates additional minor source tanks

LAW = low-activity waste.
WTP-PT = Hanford Tank Waste Treatment and Immobilization Plant Pretreatment Facility.

Treated LAW feed will be immobilized in one of two facilities, either the WTP-LAW or LAW Supplemental Treatment. ILAW production rate increases with the startup of LAW Supplemental Treatment in 2035 (see Figure 2-5). The waste form to be produced by LAW Supplemental Treatment has not been selected. However, ILAW container production rates are based on a vitrified waste form being produced by LAW Supplemental Treatment. The enabling assumption for mission planning is that LAW Supplemental Treatment will be sized appropriately to ensure that the removal of waste sodium, the primary metric for LAW feed treatment, does not constrain RPP mission completion.

2.3 GLASS PRODUCTION SUPPORTED BY DFLAW AND BOM FEED DELIVERY

The ultimate objective of Waste Feed Delivery is immobilizing tank waste in glass waste forms. As noted below (Table 2-8), a canister of IHLW is approximately 300 gal and contains approximately 3.0 MT of HLW glass, on average. A container of ILAW is approximately 500 gal and contains approximately 5.5 MT of LAW glass, on average. The size and geometry of an IHLW canister and an ILAW container are visualized in

Figure 2-3.

Progress in treating 76 MCi of tank farm activity[15] is charted in Figure 2-4. The cumulative production of ILAW containers and IHLW canisters is charted in Figure 2-5. The ILAW container count includes DFLAW, WTP-LAW and Supplemental LAW production.

By the end of the mission, about 1 MCi (1.3%) is in treated LAW (90,586 ILAW containers, 13,513 having been generated during the DFLAW phase), and about 55 MCi (72.4%) is in treated HLW (7,626 IHLW canisters). An additional 20 MCi (26.3%) is captured on 115 TSCR CST columns and 185 TFPT CST columns that will eventually be processed into IHLW canisters.

Table 2-8 (see also Figure 2-3) shows canister and container characteristics.

Table 2-8. 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.

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

Figure 2-3. High-Level Waste Canister (left) and Low-Activity Waste Container (right)

Figure 2-4. Curies Treated

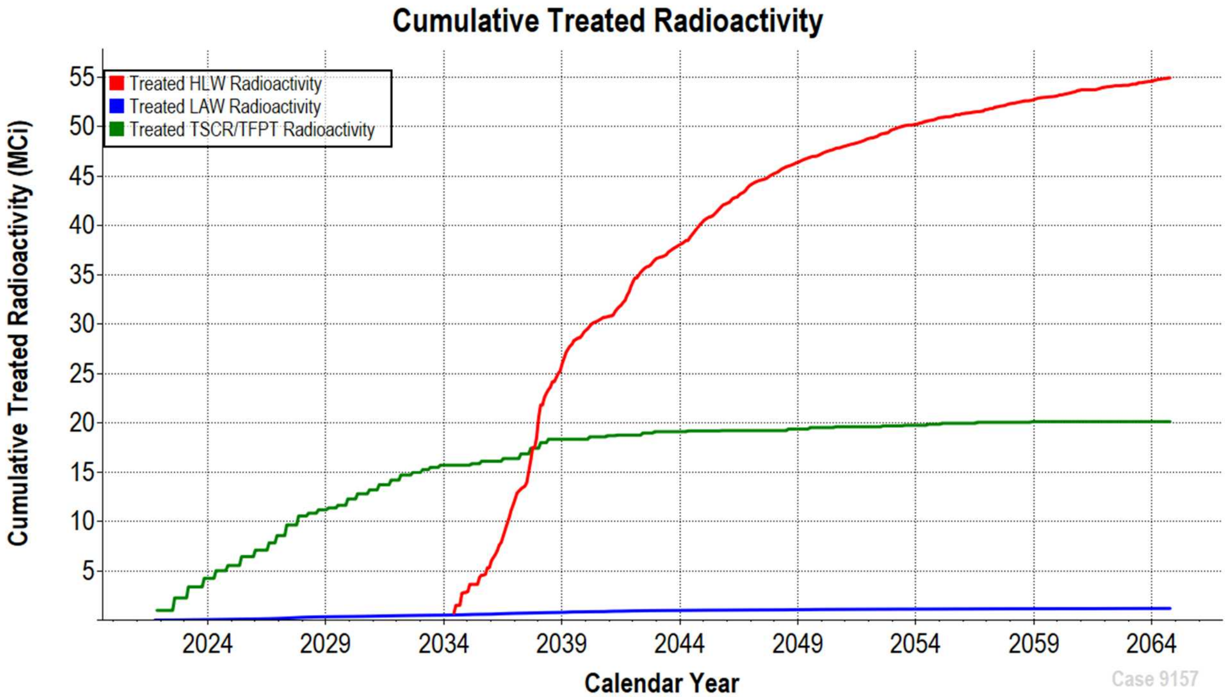
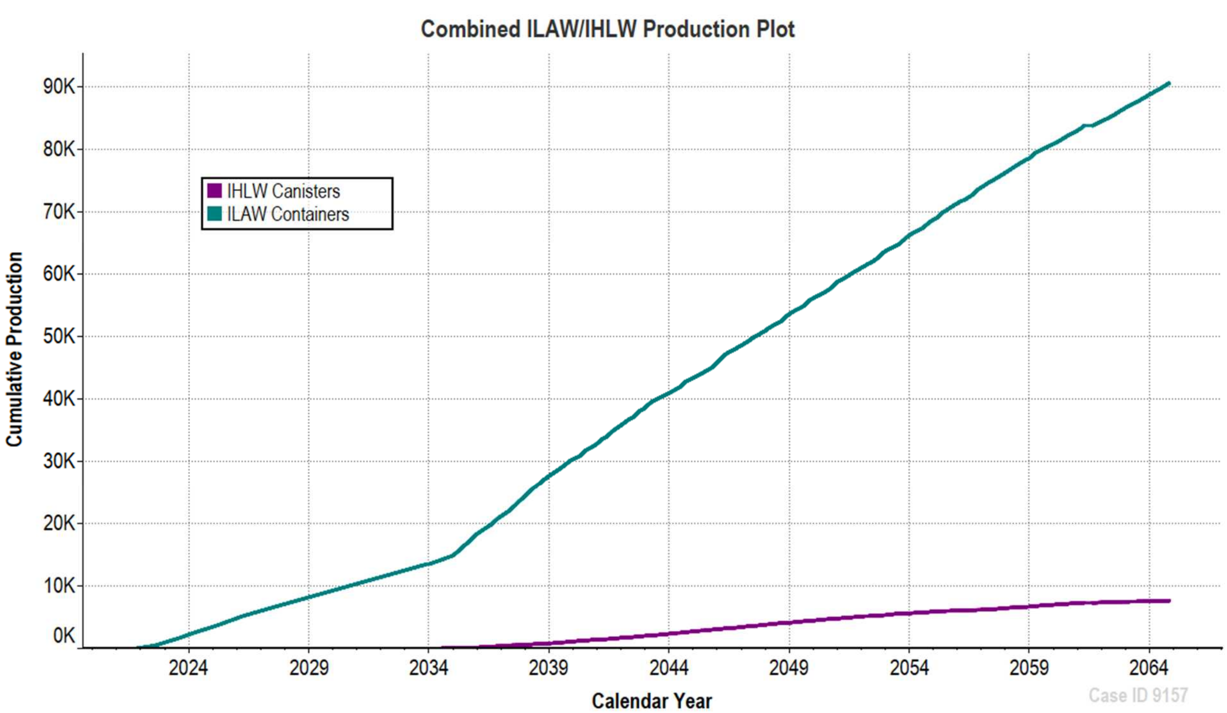


Figure 2-5. Cumulative Production



3.0 CAMPAIGN PLANNING

Waste feed campaigns will be prepared in the DST system and delivered to the respective feed 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.

Treatment of LAW feed in a direct-feed mode at TSCR is scheduled to begin in March 2021. Preparation of the waste in AP-107 for Campaign 1 has been in progress for several years. The waste has been staged, recirculated, sampled, and preliminarily qualified to be feed for TSCR and WTP-LAW. After removal of entrained solids via filtration and cesium capture via ion-exchange at TSCR, the pre-treated Campaign 1 will be stored in 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 LAW feed and HLW feed within the DST system. LAW campaigns will be staged, prepared, sampled, and qualified within the DST system prior to delivery to either the WTP-PT or TFPT. 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.

Direct Feed High Level Waste (DFHLW) is a conceptual, non-baseline feed configuration that necessitates a TWCS-DF with additional capability to leach/wash slurry and facilitate small volume (3,000 gal), short distance slurry batch transfers direct to WTP HLW. DFHLW is outside the scope of the IWFDP Campaign Plan.

3.1 NEAR-TERM PLANNING/MULTI-YEAR OPERATING PLAN

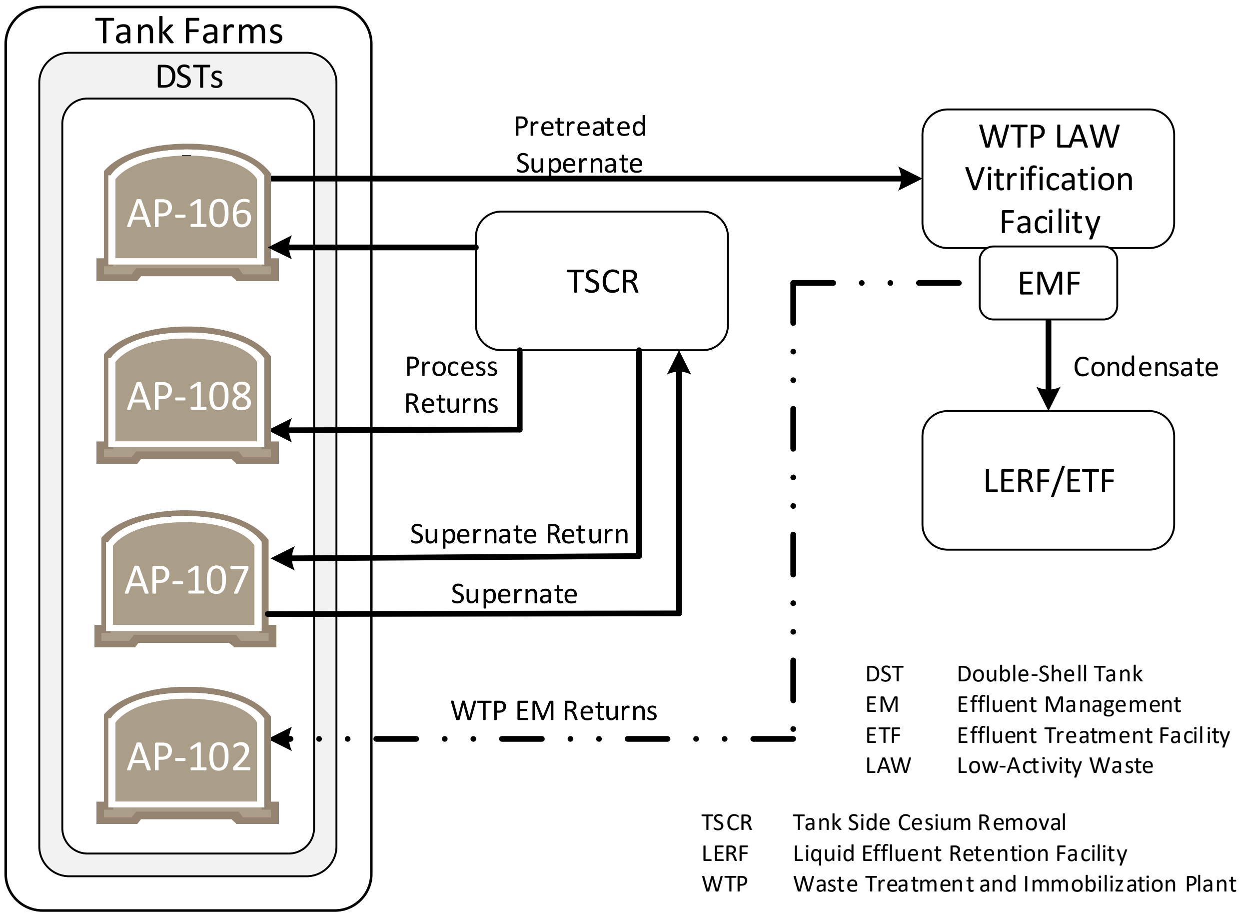
The Washington River Protection Solutions, LLC (WRPS) Multi-Year Operating Plan (MYOP), currently in Revision 8, helps link mission objectives to near-term operational plans and day-to-day field activities through FY 2026, which covers the time frame through DFLAW Campaign 10. It establishes a near-term schedule consistent with the process strategy and project plan in RPP-40149-VOL1 and RPP-40149-VOL3, *Integrated Waste Feed Delivery Plan* and provides the basis for the scope and schedule of the infrastructure upgrades necessary to execute the RPP mission. This document is also the tool used to monitor and plan the operational DST space. The MYOP is integrated with the IWFDP and the RPP Integrated Flowsheet (RPP-RPT-57991) and is scheduled for revision along with the IWFDP and RPP-RPT-57991.

3.2 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 3-1 illustrates the process flow for Campaign 1, which is unique in that the waste is already staged and prepared in AP-107.

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

Figure 3-1. Process Flow Diagram for the First DFLAW Campaign



3.2.1 Source of Waste

The current supernate in AP-107 is the initial DFLAW feed campaign. The early selection of the first DFLAW feed supports the development of a campaign-specific flowsheet and early feed qualification activities.

The current inventory of AP-107 is documented in RPP-RPT-48103, *Derivation of Best-Basis Inventory for Tank 241-AP-107 as of Jan 01, 2019*. This composition is expected to meet the WAC for TSCR (RPP-RPT-60636). The current contents of AP-107 are also predicted to have an acceptable waste oxide loading, which is a quantitative measure of the amount of pretreated waste that can be incorporated into a unit mass of glass.

3.2.2 Sampling

The diluted, prepared feed in AP-107 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 preliminary qualification of AP-107. There are 14 days allocated for mixing and sampling the waste in AP-107.

3.2.3 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-107 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). The qualification exercise for the first campaign will be completed conservatively several months in advance of the TSCR feed date.

Projected Campaign 1 constituent concentrations have been screened previously against ICD-30 and Specification 7 of Section C of the WTP Contract (DE-AC27-01RV14136, *Design, Construction, and Commissioning of the Hanford Tank Waste Treatment and Immobilization Plant*). For Campaign 1, no constituents are anticipated to be outside the limits defined in the ICD-30 WAC. The screening results are summarized in RPP-RPT-57991.

3.2.4 Delivery to Tank Side Cesium Removal

The initial transfer of DFLAW from AP-107 to TSCR is planned for March 2021, as reflected in the MYOP. The initial DFLAW campaign includes a TSCR Demonstration period. The TSCR Demonstration, processing about 174 kgal of Campaign 1, is the final task of the TSCR Project. For Campaign 1 only, after pretreating the balance of the campaign, the accumulated Campaign 1 in AP-106 will be sampled for WAC compliance before WTP-LAW starts. This is a precaution to ensure that the heel in AP-106 has not re-contaminated the initial pretreated campaign. For subsequent campaigns, 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. The number of TSCR loading cycles is not fixed, although 4 or 5 loading cycles is typical of a TSCR campaign.

3.2.5 Tank Side Cesium Removal Returns to Tank Farms

TSCR produces two streams that return to tank farms: feed returns and process returns. TSCR receives feed from AP-107 in excess of the instantaneous TSCR processing rate. At TSCR, feed in excess of 5 gpm recycles to AP-107. 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 0.4 Mgal based on Case 9157.

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

Pretreated DFLAW supernatant is ready for transfer from AP-106 to the concentrate receipt vessels at the WTP-LAW (LCP-VSL-00001/-00002) in approximately 6,500- to 8,500-gal increments via the rerouted feed transfer line (AP-106 to WTP-EMF to WTP-LAW) starting in October 2021. The WTF-EMF also recycles concentrates via the same line to the concentrate receipt vessels as needed. The DFLAW transfer to WTP-LAW is a daily occurrence so the line is not flushed unless an extended outage at WTP-LAW is planned. WFD has flexibility to deliver whatever batch size WTP requests. WTP is responsible for requesting the volume of DFLAW that makes an acceptable melter feed batch taking the recycled EMF concentrates into consideration.

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

As returns to Tank Farms from WTP EMF are considered an off-normal event, TOPSim does not model EMF effluent returns (i.e., there is not a 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 DFLAW operations, any WTP EMF effluent that cannot be internally recycled will be sent to the tank farms or off-load tanker trucks for disposal.

3.3 SUBSEQUENT DIRECT-FEED LOW-ACTIVITY WASTE CAMPAIGNS

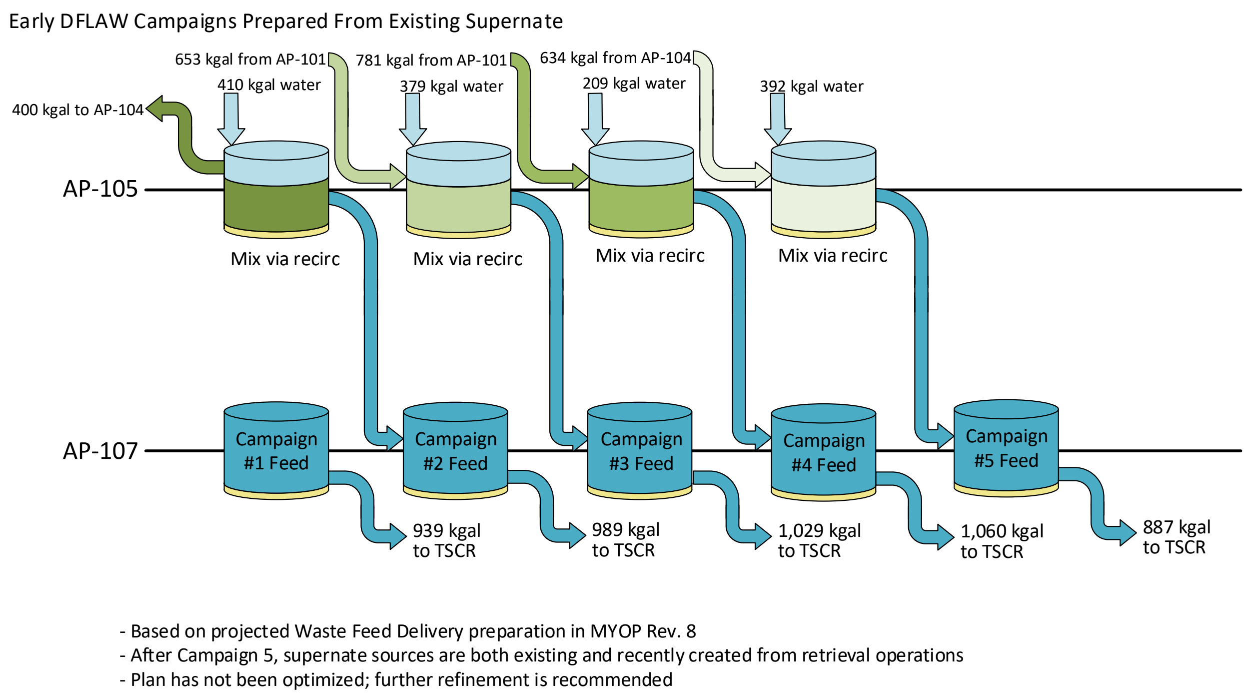
LAW will be treated in direct-feed mode until the WTP-PT startup. With current assumptions, the life-cycle modeling tool estimates 28 DFLAW campaigns processed through TSCR/TFPT prior to startup of the WTP-PT/HLW, and 25 more campaigns during BOM. However, the exact number of campaigns during the DFLAW 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 *maximum* depends on glass formulation assumptions. TSCR is capable of supporting up to 16 MTG/day[16] before the inventory in AP-106 begins to draw down. TFPT, on the other hand, can be designed for uninterrupted feed to WTP-LAW operating at 21 MTG/day.

[16] 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.

Until startup of the WTP-PT, LAW feed will be processed according to the process flow diagram shown in Figure 2-1 (Section 2.1). 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 3-2 depicts the transfers and dilutions that occur to prepare the first five 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 410 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 (if necessary), and completing the mix, sample, and qualify routine.

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



Beyond Campaign 5, campaign sourcing becomes more complicated to track. Table 2-1 is a tabulation of *proximate* source tanks at the time of DFLAW campaign creation. Table 2-2 shows the original sources of each campaign. For example, AP-101 is the proximate source for Campaign 4, but by that date AP-101 has previously received supernate from AZ-102 and from SST retrieval. Original source tracking through the first 26 DFLAW campaigns is discussed below.

Figure 3-3 shows the aggregate original sourcing of 26 DFLAW campaigns on a dry wt% basis. DFLAW is 68.5 wt% *original-sourced from DSTs*, AP Farm, AN Farm and AW Farm contributing the largest portions (28.2 wt%, 16.6 wt% and 16.5 wt%, respectively). Smaller portions come from AY/AZ Farms (5.3 wt%), and SY Farm (1.9 wt%). DFLAW feed is *31.5* *wt% original-sourced from SST retrievals*, S/SX Farms and A/AX Farms (23.2 wt% and 8.3 wt%, respectively).

Figure 3-4 shows about 21.4 wt% of DFLAW is from Waste Group A mitigations.

Figure 3-3. Feed Sources for DFLAW Campaigns by Farm

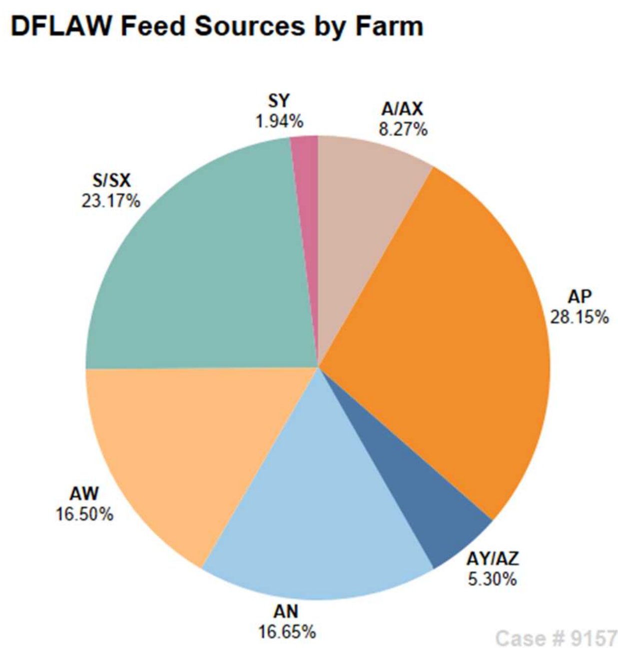
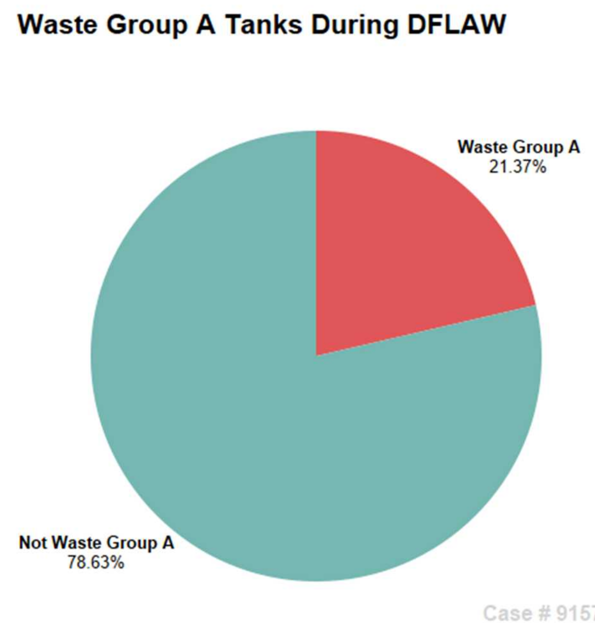
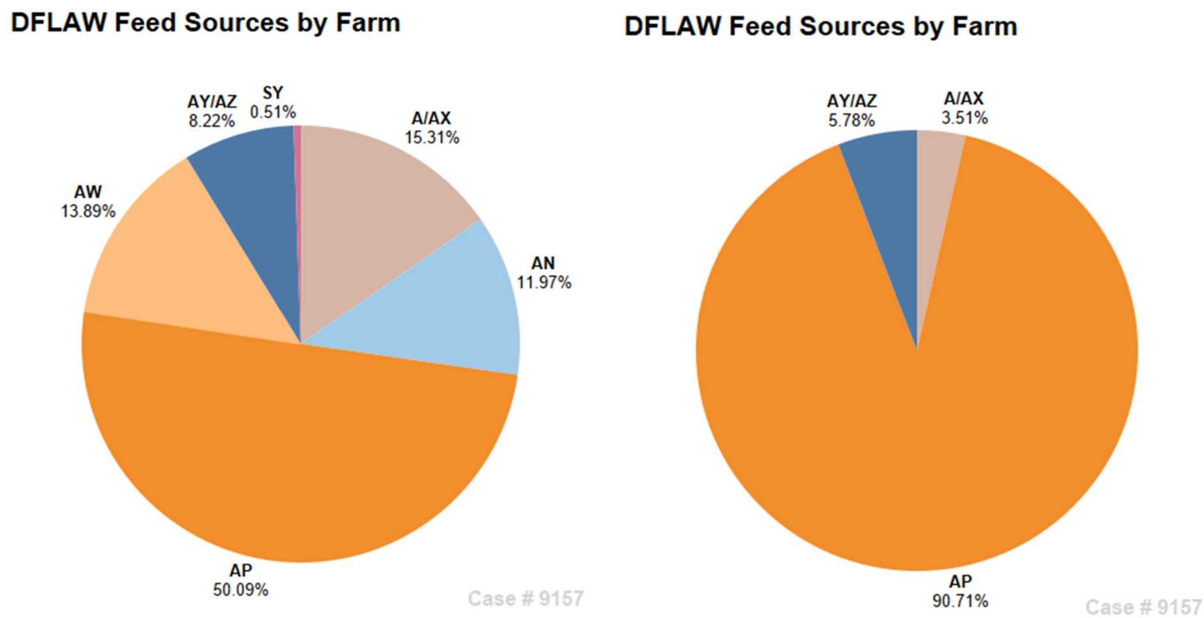


Figure 3-4. Waste Group A in DFLAW Campaigns



As shown in Figure 3-2, the first five campaigns are proximate-sourced from AP-101, AP-104, AP-105, and AP-107. Figure 3-5, however, clarifies that DFLAW is original-sourced from outside of AP- Farm for the first time in Campaign 4, with 5.8 wt% coming from AY/AZ Farm and 3.5 wt% from A/AX Farm. Comparing charts in Figure 3-5 illustrates that after Campaign 5, original sourcing becomes increasingly more complicated. Figure 3-5 also shows the first supernate from 200 West Area (SY Farm) appearing in DFLAW Campaign 12, and becoming more prevalent thereafter.

Figure 3-5. Feed Sources for DFLAW Campaigns 1 thru 12 and Campaigns 1 thru 4



3.3.1 Feed Preparation

Following the first campaign, DFLAW campaigns will typically be prepared in the staging and characterization tank (AP-105). The majority of supernatant 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. This dilution will occur prior to recirculation and 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.

Figure 3-2 shows a simplification of the transfers and dilutions that need to occur to prepare the first five campaigns of DFLAW feed. The second and subsequent feed campaigns are discussed in this subsection. This waste will be transferred to a staging and characterization tank, diluted, transferred to AP-107, and then to the TSCR/TFPT. Figure 3-2 shows that approximately 1,500 kgal of water must be added to the DST system to meet the WAC for TSCR/TFPT for DFLAW Campaigns 2 to 5. Feed preparation through the DFLAW tank system provides incidental blending of campaigns in several ways. First, many campaigns are prepared from more than one proximate source tank. Second, supernates staged into AP-105 are blended with any residual heel from the previous campaign. Third, qualified campaigns transferred to AP-107 are blended into the residual heel from the previous campaign. Fourth, pretreated LAW feed entering AP-106 at 5 gpm blends continuously into the large volume of interim-stored LAW feed. AP-106 operating in semi-continuous mode moderates changes in concentration that would be more abrupt in a batch process.

3.3.2 Sampling

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.

3.3.3 Feed Qualification

As previously discussed (in Section 3.2.3), 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 constrain WFD. Designating a second qualification tank so campaigns can be qualifying in parallel is a simple solution if qualification ever becomes constraining.

The 222-S Laboratory has been chosen as the feed qualification laboratory for DFLAW operations.

3.3.4 Delivery to the TSCR/TFPT

Campaign 2 from AP-107 to the TSCR will begin in November 2021. DFLAW campaign size as modeled varies from minimum 0.77 Mgal to maximum 1.06 Mgal, the average over 26 DFLAW campaigns being 0.94 Mgal. DFLAW campaigns will continue to be delivered to the TSCR/TFPT (TSCR for five years and then TFPT) until the integrated WTP facilities come online. Case 9157 life-cycle model has the DFLAW phase continuing until approximately December 2033. After the DFLAW phase ends, TFPT continues to prepare feed for Supplemental Treatment in Campaigns 27 through 50.

3.3.5 TSCR/TFPT Process Returns to Tank Farms

Section 3.2.5 describes the return streams from the TSCR/TFPT to tank farms.

AP-108 is dedicated to receiving TSCR/TFPT process returns. During DFLAW operations, AP-108 receives about 0.4 Mgal of TSCR/TFPT process returns. Returns are generated at the end of the IX column loading cycle when the system is flushed, and by the daily backflush of the TSCR/TFPT filter.

The TSCR/TFPT DFLAW approach generates spent CST columns but no cesium eluate returns, eliminating the issues of managing cesium eluate in the DSTs, and having to process the same cesium a second time by ion exchange at a later date. When BOM begins, WTP-PT operates an elutable ion exchange process but the cesium eluate blends off into the pretreated sludge going to WTP-HLW.

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

Section 3.2.6 describes the delivery of waste from AP-106 to WTP-LAW.

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

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

As discussed in Section 3.2.7, 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 flowsheet.

3.4 BALANCE OF MISSION

During the BOM phase of the RPP mission, HLW feed and LAW feed are handled at the same time but follow different pathways through differing facilities with different processing capabilities. Section 2.2 and the RPP Integrated Flowsheet (RPP-RPT-57991) provide additional detail on the BOM phase.

Treatment of HLW can begin following startup of the WTP-PT and WTP-HLW. When operational, slurry from the DST system will be 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 prior to startup of the WTP-PT.

LAW continues to be treated, with two available pathways during integrated WTP facility operations. At the completion of DFLAW operations, the TFPT will be temporarily shut down to switch from direct feeding WTP-LAW to direct feeding LAW Supplemental Treatment, when available. 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 large volume of LAW feed generated as part of the HLW preparation and treatment. The supernate pretreatment capacity of WTP-PT is about three times the capacity of WTP-LAW, the excess pretreated supernate being treated at SLAW.

3.4.1 Source of Waste

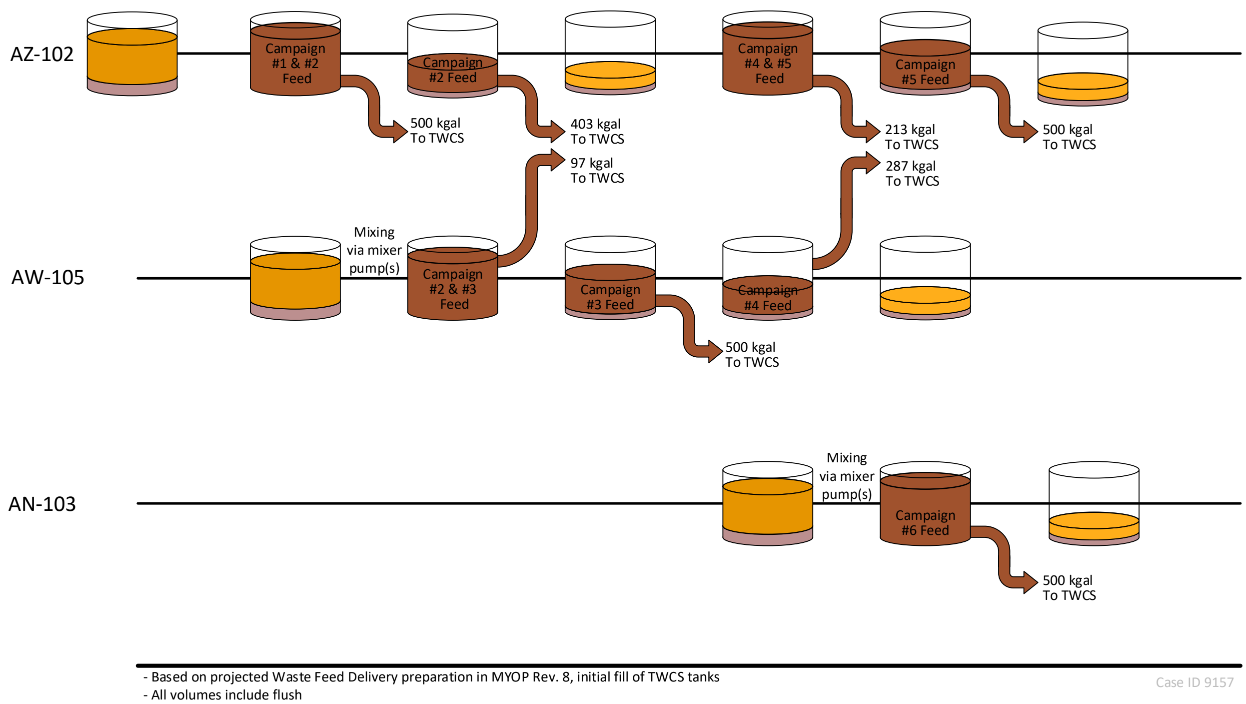
The HLW hot commissioning feed has not yet been determined. As discussed in Section 2.2, early waste for the BOM phase comes from the tank farms specified in Case 9157 of the life-cycle model. As planning progresses, feed will be chosen that satisfies the target concentrations and acceptance criteria for TWCS, WTP-PT, and WTP-HLW. Figure 3-6 provides an example of the potential early HLW campaigns that will involve transfers from the tank farms to TWCS, and then to the WTP-PT.

3.4.2 Feed Preparation

The HLW slurry (that includes sludge solids, cesium-laden liquids, and high-heat waste) will be mobilized in the DST system, mixed with existing tank supernate as necessary, and sent to TWCS for further preparation prior to delivery to the WTP-PT. No additional conditioning or intentional blending is currently planned in the DST system for HLW.

Similar to DFLAW operations, LAW feed will continue to be prepared in DSTs prior to transfer to AP-107, then TFPT, before immobilization in LAW Supplemental Treatment. For the BOM, LAW feed can also be prepared, sampled, and characterized in any capable DST and transferred directly from the DST system to the WTP-PT through existing lines from Project W-211.

Figure 3-6. Preparation of Early High-Level Waste Campaigns



3.4.3 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 functional requirements are still under development for TWCS but will include the necessary functionality to blend, mix, sample, and condition sludge solids. There are no current plans for any return streams from TWCS to the tank farms.

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 2.2 and the IWFDP Volume 3 – Project Plan.

Representative sampling will be performed in each TWCS tank. 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. Any conditioning of HLW required to ensure that the WAC are satisfied is planned to occur in TWCS.

Following qualification of the feed in a TWCS tank, the tank will be mixed to mobilize any solids and the feed will then be transferred to the WTP-PT. The HLW campaigns will be transferred from a TWCS tank to the 145-kgal HLW receipt vessel in the WTP-PT in three approximately 143-kgal batches. The contents of the tank will be mixed prior to each delivery to the WTP-PT. Depending on the solids concentration, presence of fast settling solids, and time between deliveries of batches, mixing may not be required between batches. Further study is recommended and will be necessary during design of the TWCS capability.

Figure 3-6 provides details of the initial projected HLW campaigns based on the current life-cycle model, while acknowledging the campaigns will likely change as the mission evolves. Figure 3-6 shows the tank farms inventory that will initially fill TWCS. As most DSTs are 1.2 Mgal and a TWCS tank is projected to be 500 kgal, a single DST can provide enough waste for multiple HLW campaigns.

3.4.4 Waste Treatment and Immobilization Plant Pretreatment Facility

Within the WTP-PT, waste 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 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 LAW Supplemental Treatment.

3.4.5 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 production rates are shown in Figure 2-5 (Section 2.2). The projected amount of curies treated as HLW (75 MCi) vs. LAW (1.5 MCi) is shown in Figure 2-4 (Section 2.0). As illustrated in these figures and tables, the WTP-HLW produces far fewer canisters of IHLW than the ILAW containers produced by the WTP-LAW and LAW Supplemental Treatment.

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

The WTP-LAW will vitrify the LAW fraction from the WTP-PT. In combination with the output of LAW Supplemental Treatment, the anticipated throughput is provided in Figure 2-4 and Figure 2-5.

3.4.7 Tank Farms Pretreatment

Sampling, qualification, and delivery of feed to the TFPT is currently predicted to be the same as during DFLAW operations, as described in Sections 3.2 and 3.3. However, during the BOM, the TFPT will transfer pretreated supernate only to the Supplemental LAW Treatment.

3.4.8 Low-Activity Waste Supplemental Treatment

LAW Supplemental Treatment is an additional LAW feed immobilization facility sized to ensure that LAW feed treatment and immobilization does not constrain 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 throughput of LAW Supplemental Treatment is provided in Figure 2-4 and Figure 2-5 based on the facility producing a vitrified waste form.

3.4.9 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 designated TRU tanks are processed via this path.

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 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 DFLAW source during the TSCR phase because there are additional safety requirements for accessing the waste in these tanks. 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 9157 (see Table 2-2).

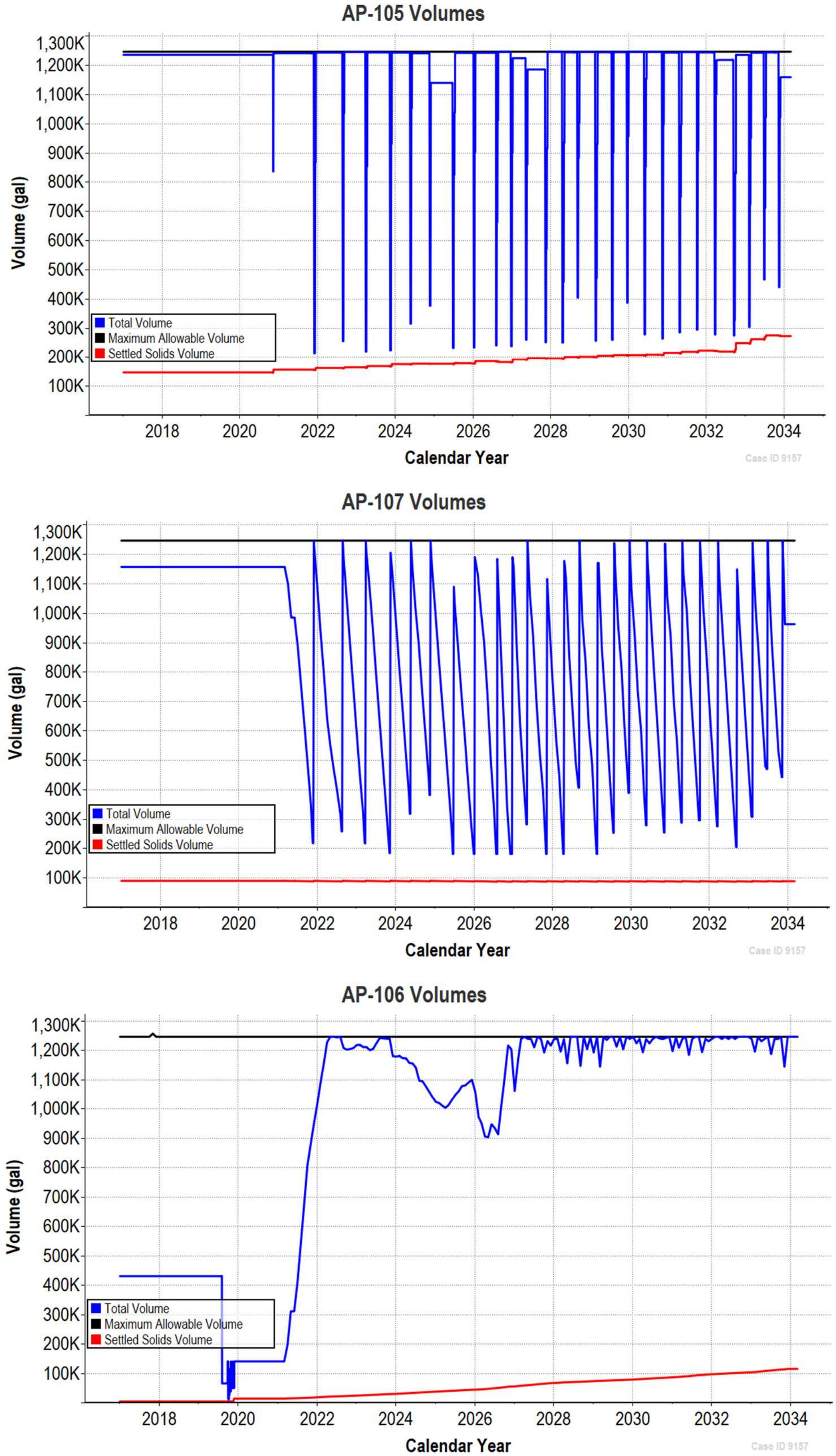
4.1 DOUBLE-SHELL TANK USAGE

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 activity compared to ongoing status quo operations. 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 inventory of DFLAW in 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 AP-106 (the model is conservative). 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

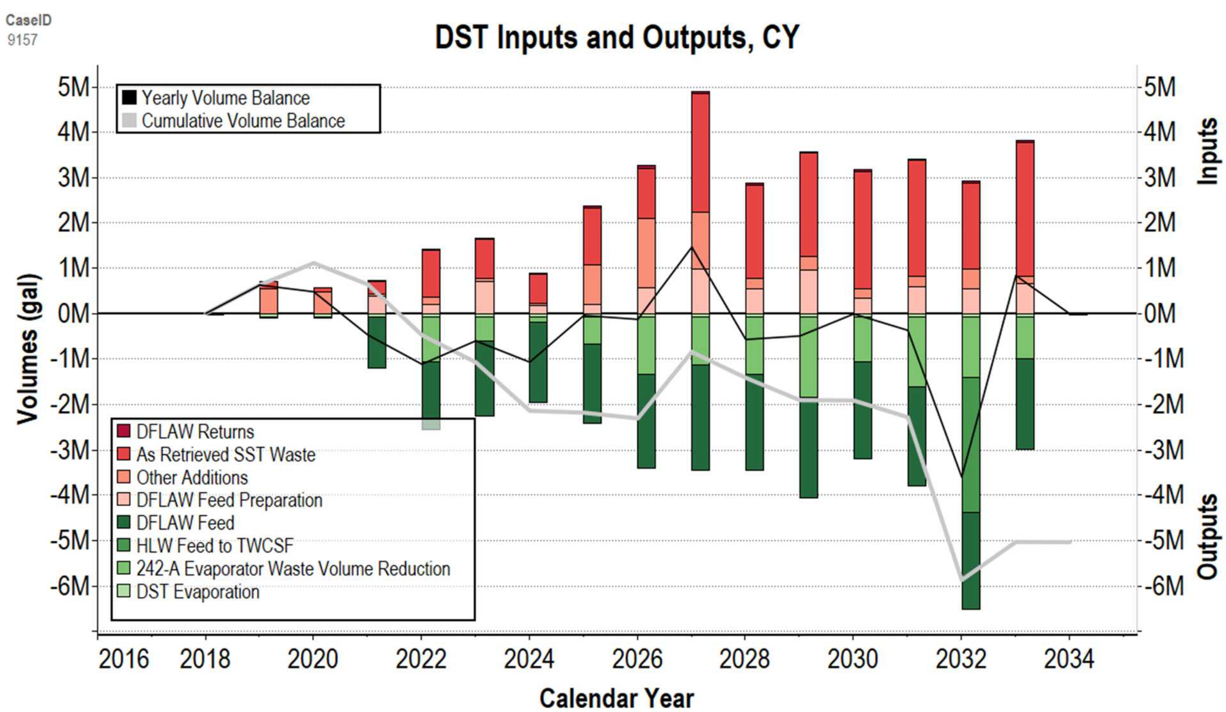


4.2 WASTE VOLUME MANAGEMENT

Approximately 3 Mgal of operational DST space is available from 2017 to 2022, although that space may not be readily usable. The available space will be 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 will become increasingly complex.

The 242-A Evaporator supports management of DST space throughout the RPP mission. 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 34 campaigns (EC-12 to EC-45) planned from 2021 to 2033. As can be determined from Figure 4-2, the evaporator campaigns will result in ~10-Mgal reduction of the total waste volume stored in the DSTs. While these 242-A Evaporator campaigns are projected by the life-cycle model, each specific evaporator campaign will be refined and managed by the Process Engineering organization prior to execution.

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 supernatant waste derived from the 200 East Area DSTs. Existing supernate is usually concentrated to conserve space for other tank farms operations (such as supporting SST retrievals). The supernate will require chemical adjustment (i.e., dilution to a consistent sodium concentration) to meet the WAC for TSCR/TFPT (RPP-RPT-60636). This dilution step will typically occur in the staging and characterization tank (AP-105) requiring the addition of approximately 6.9 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 AP-106 feeds the glass plant.

5.1.1 Feed Variability and TSCR/TFPT Acceptance

TSCR/TFPT acceptance is addressed in detail in the RPP Integrated Flowsheet (RPP-RPT-57991). It is sufficient for current purposes to state that TSCR/TFPT feed variability across the WFD mission is acceptable relative to the WAC for TSCR/TFPT (RPP-RPT-60636, Rev. 1) limited properties listed below:

- Density (1.35 g/mL)
- Viscosity (8 cP)
- Sodium Molarity (5 M to 6 M)
- Phosphate Molarity (Figure 5-1)
- Cesium Ratio (0.24 g Cs-137 per g Cs)
- Cs-137 Concentration (0.3 Ci/L)
- Potassium Molarity (Figure 5-2)

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

The latest revision of the WAC for TSCR/TFPT imposes a new phosphate molarity limit to preclude gelling during DFLAW feed preparation. Per the Waste Transfer Compatibility Program, phosphate gelling is unlikely when phosphate is below 0.1 M. Figure 5-1 shows that phosphate variability trends up over time but never exceeds the gelling threshold.

Potassium molarity does not have an acceptance limit per se, but Figure 5-2 shows potassium spikes relative to the preferred target concentration. Potassium spikes 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 and lower cesium loading on spent columns are potential adverse impacts. If further study shows that the impacts are consequential, there may be merit to developing alternate source sequencing that blends out the potassium spikes.

Figure 5-1. Phosphate Molarity vs. TSCR/TFPT Acceptance Limit

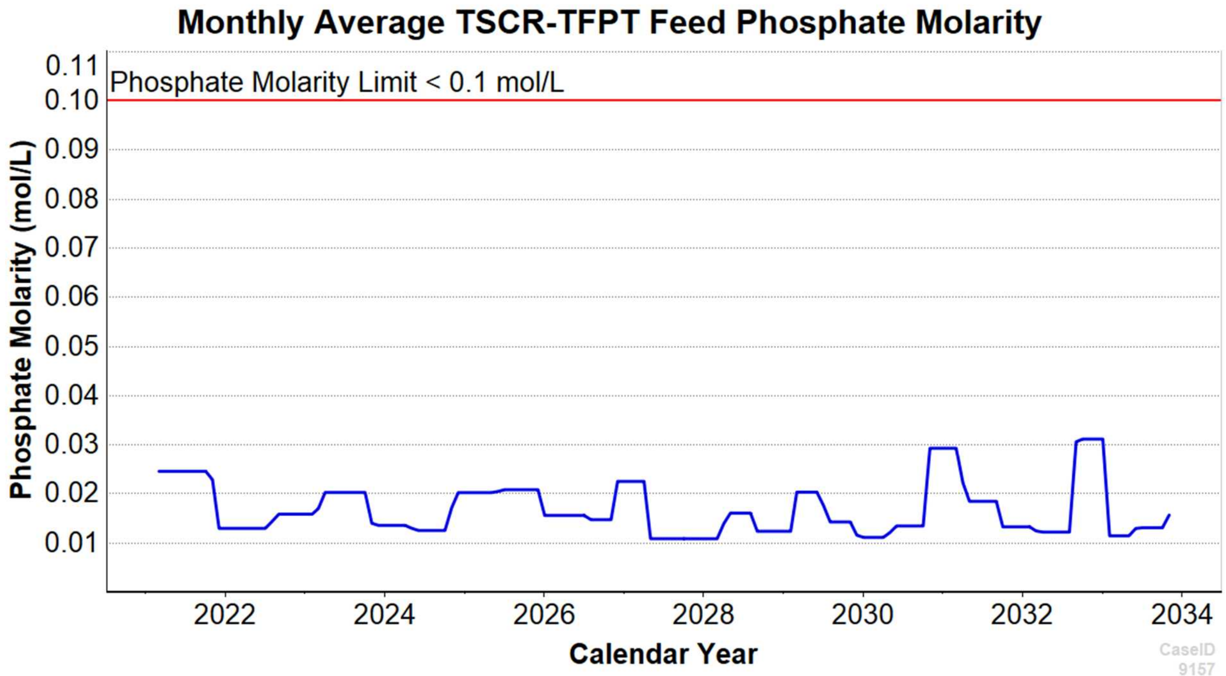
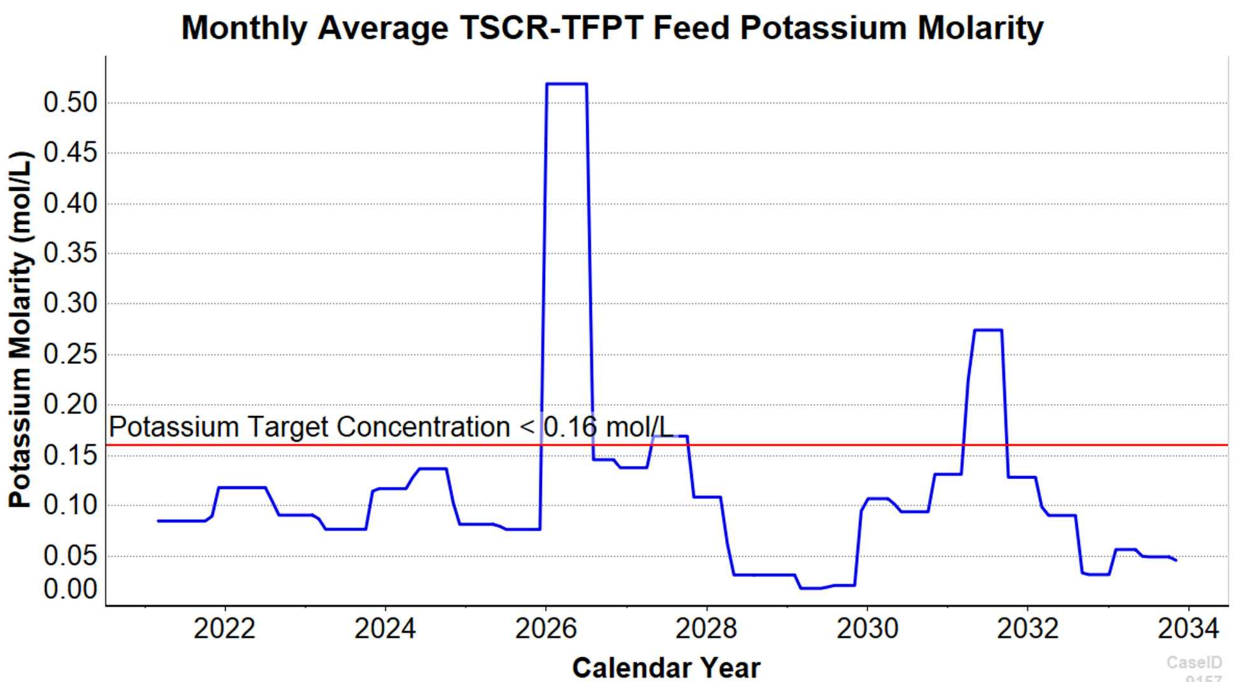


Figure 5-2. Potassium Molarity vs TSCR/TFPT Acceptance Target



5.1.2 Feed Variability and WTP-LAW Acceptance

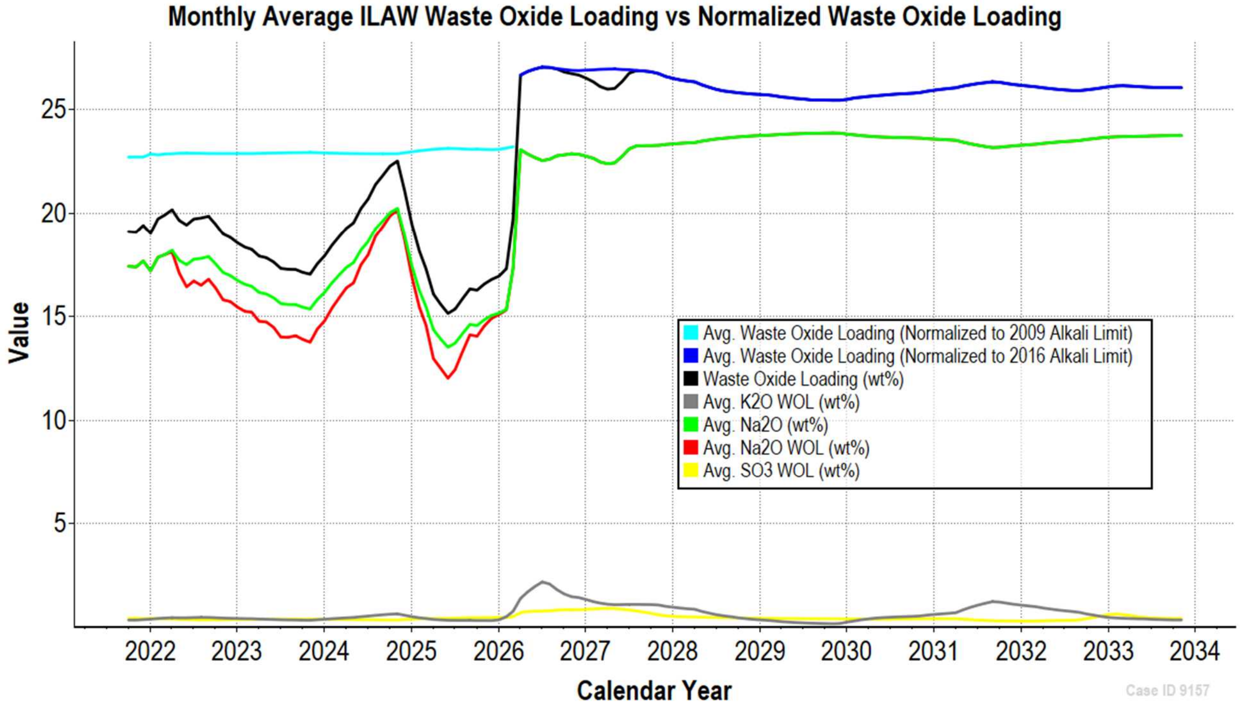
DFLAW acceptance at WTP-LAW is addressed in detail in the RPP Integrated Flowsheet (RPP-RPT-57991). It is sufficient to state for current purposes that WTP-LAW feed variability tracked across the WFD mission is well within the WAC limits in ICD-30. This is not surprising because the future contents of AP-106 will be a blend of campaigns that were themselves previously qualified as WTP-LAW compliant. DFLAW feed that is interim stored in 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 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 the loading rules that control glass formulation. 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 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 utilizes the improved 2016 LAW glass model from PNNL-25835. Figure 5-3 plots a normalized WOL (light blue and dark blue) which derives from *ignoring all glass formulation rules except each model's alkali rule*. Also, each model's actual WOL is plotted (in black) wherever it is different from the alkali-normalized WOL. Normalization illustrates that the alkali loading rule does not control WOL during the first five years, but the alkali rule is close to controlling the remainder of DFLAW (see below for further discussion of which rule is controlling). In Figure 5-3, a step change to nearly flat (around 26 wt%) WOL is obvious when the improved glass model goes into effect.

Figure 5-3. DFLAW Waste Oxide Loading and Na_2O Loading in ILAW



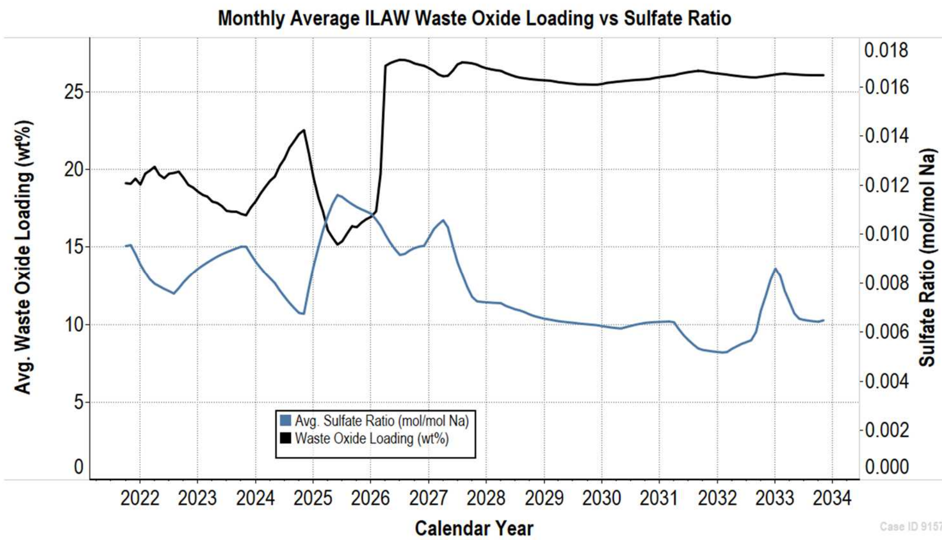
Na_2O content over the DFLAW period ranges from 16 wt% to nearly 24 wt%. Note that maximum Na_2O content allowed by the respective glass models is 21 wt% and 24 wt%.

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 5-4 composites a group of charts that simultaneously plot waste oxide loading and the variability of component molar ratio.

Figure 5-4. Charts of Waste Oxide Loading vs Molar Ratio of Selected Components



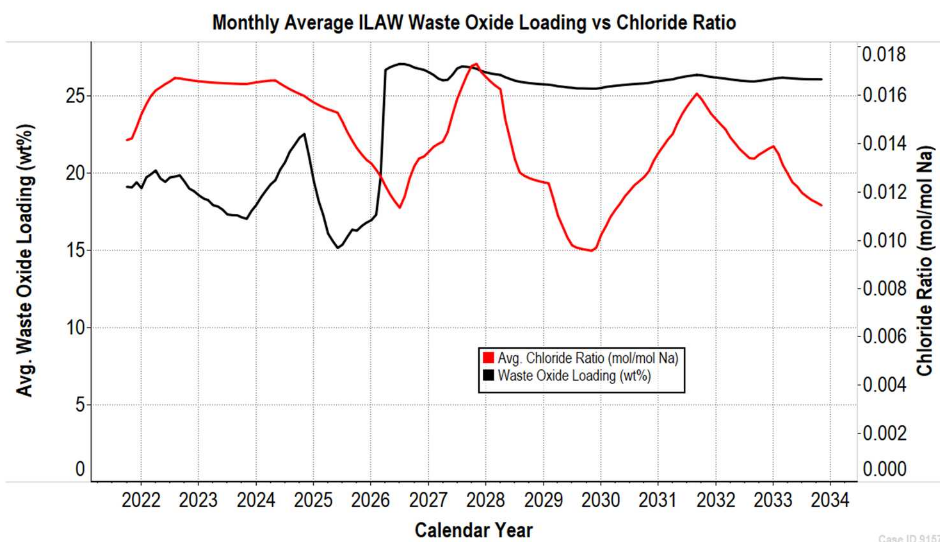
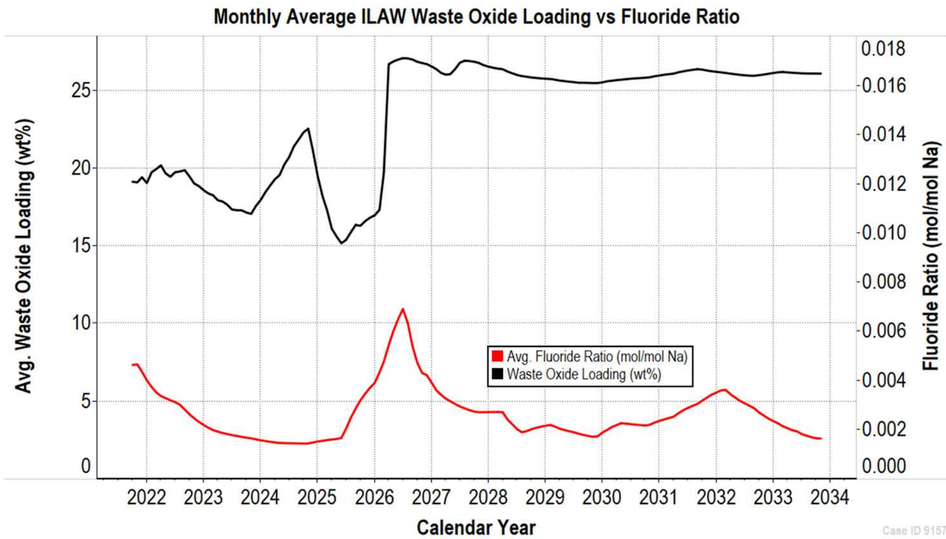


Figure 5-5 (cont) Charts of Waste Oxide Loading vs Molar Ratio of Selected Components



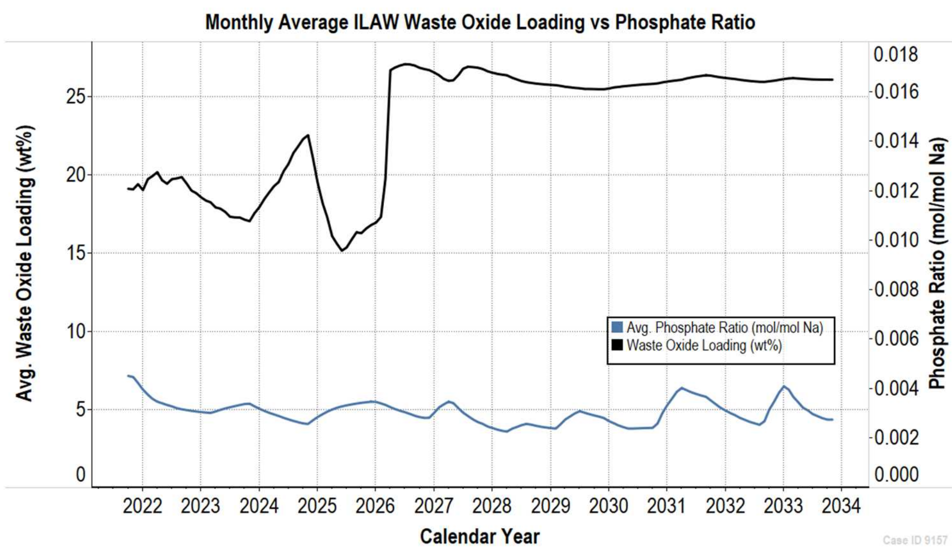
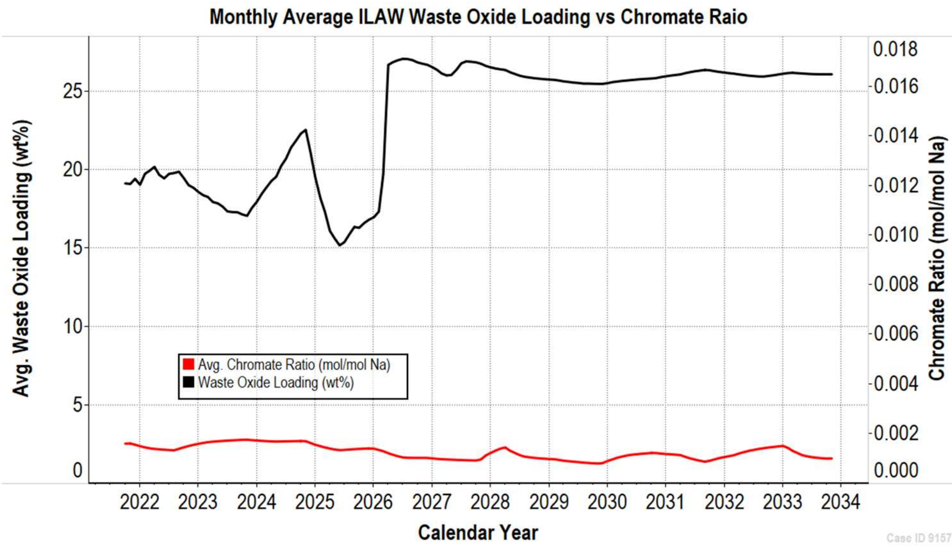


Figure 5-6 (cont) Charts of Waste Oxide Loading vs Molar Ratio of Selected Components



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 drawing firm conclusions from visual interpretation of these charts. There appears to be an inverse relationship between WOL and sulfate ratio during the first five years 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 after 2026, there is little or no obvious WOL sensitivity to these five components. When none of these components is controlling, then by default, the glass is formulated based on an alkali rule.

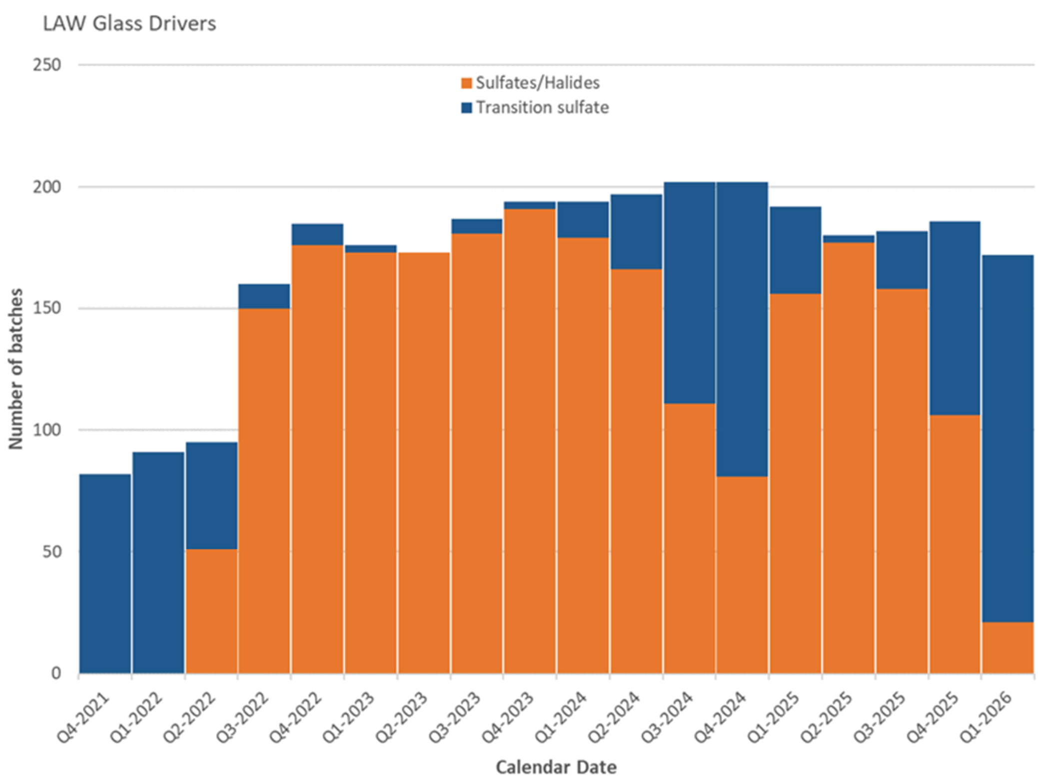
Figure 5-5 shows the number of DFLAW batches and summarizes more specifically which waste loading rule or property constraint is controlling. Figure 5-5 confirms that all DFLAW batches during the first five years are either sulfate limited or sulfate/halide limited, which is consistent with Figure 5-3 that shows no batches are alkali limited.

Figure 5-5 further confirms that DFLAW glass after 2026 and before 2035 is controlled on the alkali/sulfur rule or the alkali rule. During the first three years of TFPT, many batches are formulated on the alkali/sulfur rule. However, Figure 5-3 shows actual WOL departure from alkali WOL is fairly minimal. Therefore, when the alkali/sulfur rule is controlling, it is just barely controlling. The 2016 glass model has a higher tolerance for sulfur than the 2009 model.

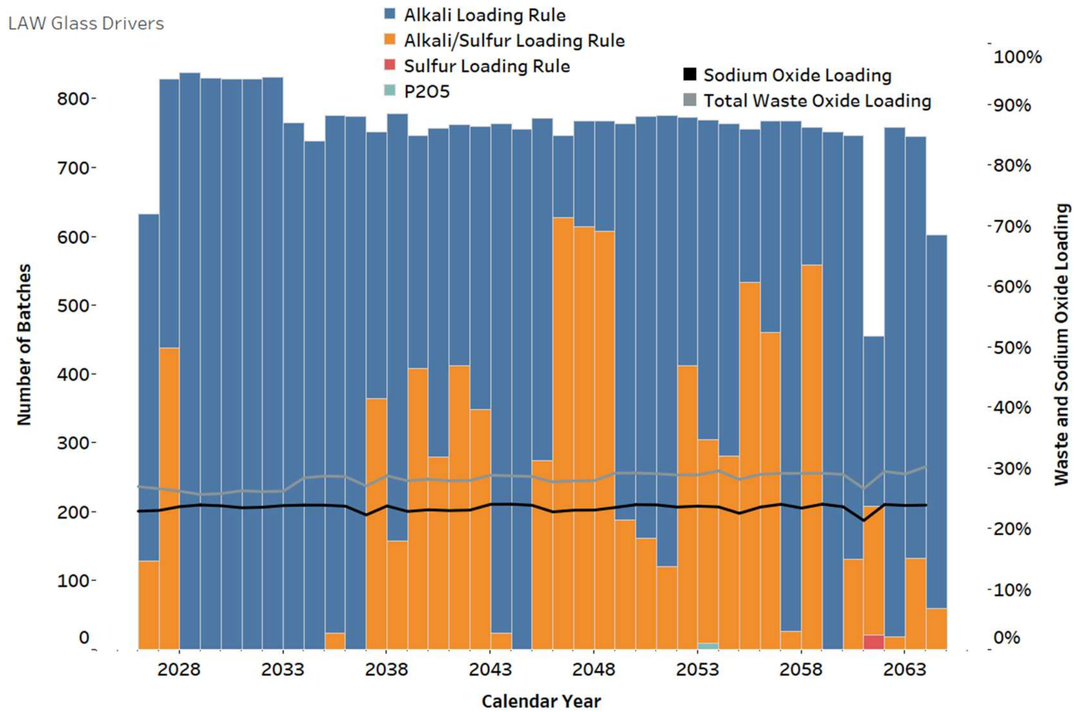
Sulfate is problematical by virtue of forming an alkali sulfate salt phase on the melt surface. Per 24590-WTP-RPT-PT-02-005, *Flowsheet Bases, Assumptions, and Requirements*, the sulfate salt phase promotes bubbler and refractory corrosion, is more electrically conductive than the melt, and is significantly less viscous. The sulfate salt phase could penetrate melter refractory joints causing damage to the melter. Therefore, the sulfate concentration in the melter is regulated to mitigate these deleterious effects.

Future refinements to the DFLAW campaigns and selection of feed sources should focus on the sulfate-to-sodium concentration as the dominant factor in the ability of the WTP-LAW to effectively and efficiently immobilize LAW.

Figure 5-7. LAW Glass Drivers Pre-2027 (2009 model) and Post-2026 (2016 model)



B



5.2 GLANCE OF MISSION WASTE FEED VARIABILITY

For BOM activities, the feed campaigns are projected based on the life-cycle model. The employed model logic aims 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 compared against the WAC for the various facilities. For this scenario of the life-cycle model, several criteria were exceeded in the early HLW treatment mission. Modeled early campaigns exceed the solids concentration limits (200 g/L), the slurry bulk density (1.5 kg/L), and fissile-to-total-uranium ratio (8.4 g/kg). In each case, the limit was exceeded for a period of less than a single campaign and was exceeded by less than 0.5 percent. These do not represent a concern as both the solids concentration and the slurry bulk density can be adjusted as part of campaign-specific preparations for TWCS.

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 March 2021 and WTP-LAW in October 2021) 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. Future refinements to the DFLAW campaigns and selection of feed sources should focus on the sulfate-to-sodium concentration as the dominant factor in the ability of the WTP-LAW to effectively and efficiently immobilize LAW.	FY 2020	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.
Evaluate suitability of as-retrieved SST waste from AX and A Farms and Waste Group A DSTs for DFLAW feed.		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.	FY 2020	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 2020	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 canisters.	FY 2021	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 2022	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) with updated baseline dates and additional information	FY 2022	Current ICD requirements are based on contract language and design requirements and are scheduled for limited-scope revision in FY 2018.
Develop detailed information supporting the potential early treatment of HLW in direct feed mode.	FY 2020	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.
Evaluate DFLAW supernates for OH molarity drift up to the time of staging to AP-105.	FY-2020	OH depletion is a natural process that moves supernates closer to the gibbsite phase boundary. Understanding where OH molarity will be in the future could impact how DFLAW feeds are prepared.

[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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