The Integrated Waste Feed Delivery Plan for the Direct Feed Low-Activity Waste Mission - 17160

Todd J. Wagnon, Jacob G. Reynolds, Ben M. Tardiff

Washington River Protection Solutions, LLC

ABSTRACT

In order to begin tank waste treatment and reduce the risk to the liquid waste cleanup mission, a plan to directly feed the Hanford Tank Waste Treatment and Immobilization Plant (WTP) Low-Activity Waste (LAW) Vitrification Facility before other WTP facilities has been implemented. Implementation requires another facility, the Low-Activity Waste Pretreatment System (LAWPS), to generate LAW from tank waste supernatant, along with upgrades to the existing tank farm facilities to provide waste feed and receive process returns.

The Integrated Waste Feed Delivery Plan (IWFDP) presents the strategy for reliably delivering compliant waste feed to the LAWPS and subsequently WTP to safely and efficiently accomplish the direct feed LAW (DFLAW) mission. Modifications to existing systems and installation of new systems will be coordinated to meet WTP startup, commissioning, and processing needs. The IWFDP presents the process approach, feed campaign plans, and a list of infrastructure projects required to upgrade the DST system in order to support DFLAW start-up and operations.

INTRODUCTION

The Department of Energy (DOE) Office of River Protection (ORP) and Washington River Protection Solutions, LLC (WRPS) have planned for the preparation and delivery of waste feed to the WTP in anticipation of the start of it's hot commissioning and routine operations. To achieve the River Protection Project (RPP) mission, the waste stored in the 149 single-shell tank (SSTs) will be retrieved and consolidated into the 28 Double Shell Tanks (DSTs). Waste feed from the DSTs will be prepared and delivered to the WTP for immobilization into high-level waste (HLW) and LAW glass. In an effort to reduce risk associated with delays to commissioning of the full WTP, DOE-ORP has implemented a plan to begin treatment of LAW many years earlier than the remaining facilities.

The IWFDP focuses on the start-up, commissioning, and initial operating phase of WTP LAW Vitrification Facility as projected by a Tank Operations Contract life-cycle planning tool. The IWFDP is organized into three major sections: (1) the process approach, (2) campaign plan, (3) the project plan. The process approach identifies the WRPS approach on how to prepare and deliver appropriate feed to each treatment facility, with emphasis on those activities that support the current focus of the campaign plan. The campaign plan focus on preparing, pretreating, and delivering appropriate feed to support the LAWPS / DFLAW operating mode of the WTP LAW Vitrification Facility. The project plan describes the infrastructure and facility changes required to support implementation of the campaign plan and summarize the rationale for those changes.

PROCESS APPROACH

WTP LAW vitrification will be performed in the direct-feed mode for nominally 10 years prior to commencement of HLW vitrification. The DFLAW approach involves the delivery of tank farm supernatant to the LAWPS where it is treated to remove suspended solids and soluble cesium via filtration and ion-exchange, respectively, which are then returned to Tank Farms. LAWPS delivers the treated LAW feed to WTP LAW Vitrification Facility for conversion to glass, followed by onsite disposal at the Integrated Disposal Facility. Secondary liquid waste streams are generated during the vitrification process with a small fraction being returned to the tank farms and managed as tank waste.

The delivery and volume management of tank waste during DFLAW operations will require close coordination between the DST system, LAWPS, and WTP operations. The primary goal of DFLAW is to treat liquid waste (colloquially called supernatant) prior to the start of the WTP Pretreatment Facility. When fully operational, the WTP will need to operate at around 70% availability to support processing needs and maintain waste removal and tank closure activities. The existing DST system will require upgrades to support the five functions outlined for the delivery of waste feed to DFLAW.

1. Deliver feed to LAWPS
2. Stage and characterize feed for delivery to LAWPS
3. Receive filtered solids returns from LAWPS
4. Receive cesium effluent returns from LAWPS
5. Receive WTP EMF returns

Five DSTs have been selected to support the DFLAW mission based on a technical evaluation of the current configuration and availability of DSTs and the physical and chemical characteristics of the waste [1]. The overall DFLAW process flow is presented in Figure 1.

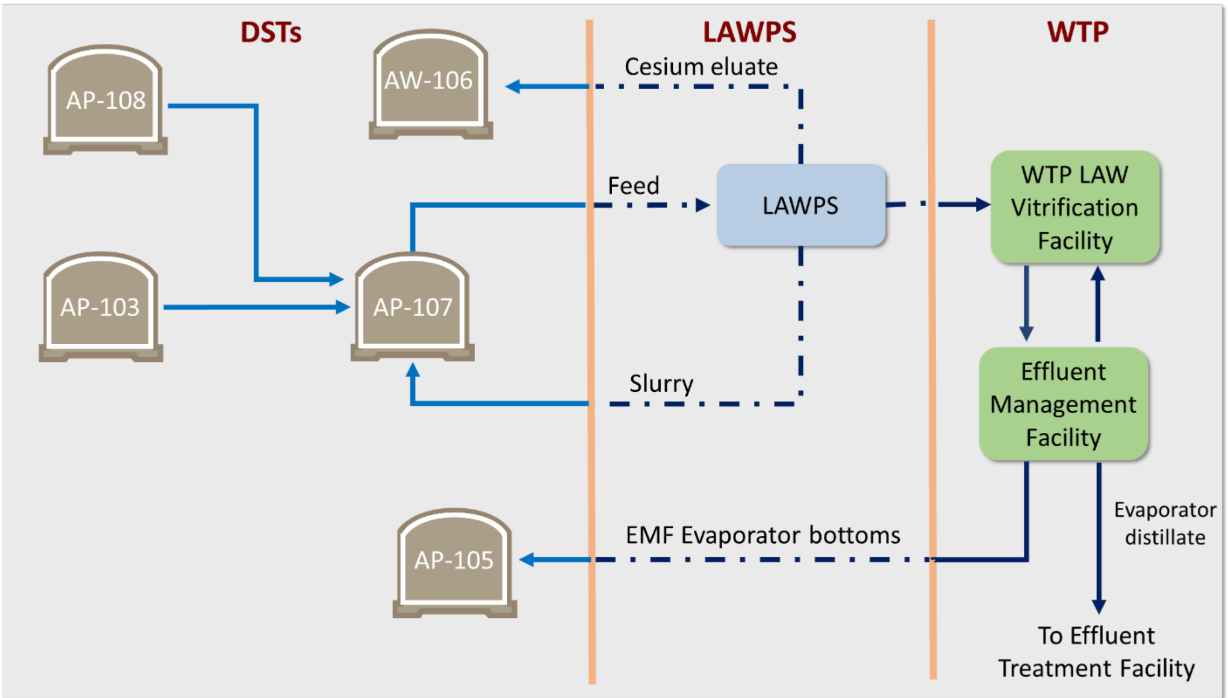

Figure 1. Simplified Low-Activity Waste Feed Delivery Process Flow Diagram

In Tank Farms, feed must be delivered to the staging and characterization tanks (241-AP-103[a] & AP-108) so that they can be sampled, analyzed, and have a glass formulation selected prior to transfer from Tank Farms to LAWPS. Once the sample is determined to meet qualification requirements for the waste to be vitrified, the waste is transferred to the feed tank (AP-107) which pumps it to LAWPS. The LAWPS filters the waste and removes cesium by ion exchange before sending it to WTP LAW. Waste is metered out to WTP LAW in small volumes of waste per glass batch, so the LAWPS has lag storage to maintain a high average throughput. As the LAWPS is primarily a separation treatment facility, the feed concentrated by the filters is sent back to AP-107 and the ion exchange column eluate is sent to AW-106.

One return stream includes the bottoms from the WTP Effluent Management Facility (EMF) evaporator to tank farms, which will have concentrated, contaminated plant wash liquids and off-gas condensate with constituents that do not readily go into glass (i.e. technetium, sulfates). Initial planning was for a continuous return stream of 15% of EMF evaporator output to the DST system. Further refinement of planning and design basis have reduced that fraction such that the DST system will only receive returns from EMF during off-normal conditions.

In order to maintain SST retrievals while processing waste from DSTs, the 242-A Evaporator will remove water from retrieved waste and DST waste blended with

[a] Hereafter the 241- prefix will be omitted for brevity.

returns from the treatment facilities to ensure adequate DST space is available to maintain the safety basis for tank farms (maintaining minimum headspaces in tanks and adequate emergency space for a future identification of a leaking DST). The 242-A Evaporator concentrates tank waste to high sodium molarities for storage, but will require dilution in the staging and characterization tanks before treatment.

CAMPAIGN PLAN

The campaign plan focus is on preparing, treating, and delivering appropriate feed to support DFLAW. The campaign plan will screen projected feed against the waste acceptance criteria, to the extent feasible with available methodologies, in order to identify necessary refinements and systematic concerns. They will also include the projected waste transfer, staging and pretreatment operations necessary for more detailed operational planning.

Campaigns for DFLAW are defined to consist of nominally 3.79E6 liters (1 Mgal) of supernatant waste feed. Waste to be delivered from the LAWPS to the WTP LAW Vitrification Facility consist of 18,900 liter (L) to 26,500 L batches. The DFLAW mission is projected to entail the preparation of 20 campaign volumes via the DST system (Table I).

TABLE I. Direct-Feed Low-Activity Waste Feed Delivery Summary Data.

	Campaigns to LAWPS	**Batches to WTP LAW**
Total Number	20	3,000
Nominal Volume (L)	3.79E6 (1 Mgal)	18,900 to 26,500
Total Volume (L)	74.19E6 (19.6 Mgal)	-
Total Sodium Mass (kg)	9.58E6	12,500 ILAW containers

Waste feed delivered to the WTP during the DFLAW mission will consist entirely of LAW supernatant. The supernatant will be derived from three primary sources, specifically wastes:

1. accumulated in the 200-East Area DSTs at the start of DFLAW,
2. generated from saltcake dissolution of SY-103 and the retrieval of SSTs from S and SX Tank Farms, or
3. derived from secondary liquid effluent returns from the LAW EMF combined with cesium eluate returns from LAWPS.

Supernatant accumulated in AP Tank Farm will be the initial waste feed transferred and will provide nearly 45% of the waste (as mass of sodium) transferred to the WTP during DFLAW. This includes the waste derived from retrievals of the SSTs in both AX and A Tank Farms. Three campaigns will be performed utilizing supernatants accumulated in AW, AY, and AZ Tank Farms. These campaigns account for nominally 15% of waste transferred to the WTP during DFLAW. The AN Tank Farm DSTs are not utilized to support DFLAW, except as necessary for receipt of cross-site waste transfers.

Waste currently in 200-West Area will make up nominally 25% of waste transferred to WTP during DFLAW. West Area waste feed supernatant will consist of saltcake retrieved from SSTs in S and SX Tank Farms and SY Tank Farm DST waste. Upon retrieval, these wastes will be transferred cross-site to Tank AW-102 for processing through the 242-A Evaporator. Work is currently ongoing to evaluate bypassing the evaporator. This would reduce the demand on the evaporator during the DFLAW mission but would result in close coupling between retrieval and DFLAW operations.

The balance of DFLAW feed will be derived from process returns – WTP EMF evaporator bottoms and LAWPS cesium eluate. The source of sodium in this feed is sodium nitrite and caustic added for DST corrosion control. While the aforementioned AW/AY/AZ campaigns will open space for segregating process returns, not all returns may be accommodated. The fraction to be returned to the WTP during DFLAW operations will account for up to 16% (3 campaigns) of the total waste feed (as sodium) to be delivered to the WTP. Opportunities are being pursued to 1) reduce the fraction of WTP EMF bottoms returned through 100% internal WTP recycling, and 2) improve the corrosion control strategy to minimize sodium additions.

If necessary, additional feed may be provided to support DFLAW from other sources. Four DSTs within 200 East Area are restricted from normal use due to the potential for flammable gas release which could be mitigated through saltcake dissolution resulting in additional supernatant feed. SY-103 has similar restrictions and is planned for use during DFLAW following mitigation efforts. There may be particular benefit in the mitigation of AN-104 which is the receipt location for cross-site transfers into 200 East Area.

With many different sources of feed, the variability in feed will be large. The key components for vitrification are sodium, potassium, sulfates, chlorides, fluorides, phosphates, and chromates. Campaigns 1 and 8 contain a higher sulfate to sodium ratio resulting in a relatively low waste oxide loading in LAW glass. For the majority of campaigns, waste oxide loading is projected to be relatively constant. Anticipated sources, volumes, and yields of the 20 DFLAW campaigns are presented in Table II.

TABLE II. Direct-Feed Low-Activity Waste Feed Delivery Campaigns.

Campaign	**Feed Qualification Tank**	**Source DST(s)**	**Volume Delivered to LAWPS (L)**	**Sodium Mass (kg)**	**ILAW Containers**
1	AP-107	AP-105	4.35E6	5.8E5	750
2	AP-108	AP-101[b]	3.86E6	5.0E5	690
3	AP-108	AP-103	3.71E6	4.8E5	570
4	AP-103	AP-104/ AP-105	4.08E6	5.2E5	680

[b] From Campaign 2 onward, projected tank contents, as modeled, are based on the totality of tank farm activity.

Campaign	Feed Qualification Tank	Source DST(s)	Volume Delivered to LAWPS (L)	Sodium Mass (kg)	ILAW Containers
5	AP-108	AP-106	3.71E6	4.8E5	640
6	AP-103	AY-101	4.01E6	5.0E5	590
7	AP-108	AP-101	3.71E6	4.8E5	570
8	AP-103	AZ-102	4.01E6	5.2E5	990
9	AP-108	AP-106	3.71E6	4.8E5	700
10	AP-103	AP-101	3.97E6	5.2E5	670
11	AP-108	AP-106	3.18E6	4.1E5	520
12	AP-103	AP-101	4.47E6	5.7E5	720
13	AP-108	AP-106	3.71E6	4.8E5	600
14	AP-103	AP-104	4.01E6	5.2E5	680
15	AP-108	AP-104	3.71E6	4.8E5	590
16	AP-103	AP-104	4.01E6	5.2E5	670
17	AP-108	AP-104	3.71E6	4.8E5	570
18	AP-103	AP-106	4.01E6	5.2E5	670
19	AP-108	AP-106	3.71E6	4.8E5	570
20[c]	AP-103	AP-102	0.42E6	6.0E4	55
Totals	**–**	**–**	**74.19E6**	**9.58E6**	**12,500**

Feed qualification is expected to take between 120 and 180 days to allow adequate time for sampling, sample analysis, unit operations demonstration, and data reporting prior to sending staged waste from Tank Farms to LAWPS for pretreatment. The LAWPS Waste Acceptance Criteria (WAC) identifies parameters for feed temperature, precipitation control, slurry density, Cs-137 concentration and total ratio, radiological source term, sodium molarity, potassium concentration, suspended solids concentration, and slurry viscosity which must be met to satisfy feed qualification requirements [2]. Additionally, since LAWPS only removes solids and cesium from the waste stream, qualified waste must also meet the requirements for WTP LAW facility acceptance as described within the Interface Control Document for Direct Feed LAW [3]. Confirmatory samples are taken from the LAWPS lag storage tanks to ensure the treated waste meets the requirements for LAW.

[c] Campaign 20 will be a full 1 Mgal volume of feed. The values shown reflect the amount of feed delivered at the end of the 10-year DFLAW mission.

PROJECT PLAN

The project plan describes the infrastructure and facility changes required to support implementation of the campaign plan and summarize the rationale for those changes. This encompasses the full extent of DFLAW operations from preparations for commissioning, initiation of feed to LAWPS and completion of the 10 year mission.

It is important to distinguish at this point that the LAWPS project is responsible for not only facility design procurement and construction activities but also for the installation of four new underground double walled transfer lines. These transfer lines will terminate near the AP Farm boundary at an interface point. These transfer lines include:

1. LAWPS Feed Line
2. LAWPS Solids Return Line
3. Cesium Eluate Return Line
4. WTP EMF Return Line

A preliminary functions and requirement document was prepared to address the high level needs of the various project activities [4]. This documents will be updated in accordance with existing design maturation processes and procedures and developed into a specification to ensure that key objectives are met throughout the design. As part of initial development Operations Research (OR) modeling of the entire system, including LAWPS, was performed to identify potential pinch points within the system [5]. Modeling results identified a need to establish redundancy and ensure the availability of critical spares in order to meet processing objectives for the waste feed delivery and LAWPS systems.

The LAWPS Feed tank, AP-107, will require new waste transfer jumpers, two new transfer lines from the tank pump pit to the LAWPS interface point and a new variable depth transfer pump. The new dedicated underground transfer lines will be designed and constructed to align with current Hanford Tank Farm standards for supernatant transfer lines. Variable depth transfer pumps will be needed over the full DFLAW mission to ensure that after multiple campaigns any solids accumulation does not interfere with the ability of the pump to feed waste to LAWPS. Tank Farms has operational experience using variable height pumps to support retrieval operations, but these pumps have historically experienced a high failure rate. Conditions within AP-107 and the waste material being pumped during DFLAW partially mitigate the risk of pump failure. Despite this reduction in risk it is prudent to have an available ready spare pump to support feed to LAWPS with minimal down time in the event of unexpected failures.

The staging and characterization tanks, AP-103 and AP-108, will feed into AP-107 when waste has been qualified to meet downstream facilities' acceptance criteria. These tanks will require dedicated sampling systems that allow for convenient and timely sampling to support waste feed qualification. Additionally, each tank will require a DST transfer pump capable of reliably moving supernatant to the feed tank and of mixing the tank to prepare for sampling. Waste will also need to be conditioned prior to being sent to LAWPS in order to meet waste acceptance criteria. Typically conditioning will be done prior to mixing to ensure the sample taken is representative of the waste.

AW-106 is the cesium eluate return tank, which receives neutralized and corrosion inhibited eluate from LAWPS ion-exchange. AW-106 requires a dedicated route for the eluate to travel from LAWPS. The current path for this return stream connects a new underground transfer line from the LAWPS interface point to the AP-105 pump pit, through the AP Farm valve pit, through the AW Farm A and B valve pits, prior to reaching AW-106. This routing takes maximum advantage of the existing transfer line infrastructure but poses a burden on the maintainability for the DST transfer system. While the entire transfer path will utilize dedicated flexible jumpers, during maintenance on other systems within the valve pits, transfers would not be permitted in order to maintain adequate ventilation capacity. Alternatives are being analyzed to evaluate other routing configurations which would improve the overall system availability. A new transfer pump will be required to remove cesium eluate from AW-106 periodically over the DFLAW mission for volume reduction through the 242-A Evaporator. At this time work is ongoing to replace a failed pump in AW-106 to support a near term evaporator campaign. It should be studied to determine if this new pump can be adequately maintained to support the DFLAW mission.

Finally, AP-105, is the WTP EMF return tank which will receive EMF evaporator bottoms during off normal operating conditions. Current planning would utilize this tank infrequently during the DFLAW mission but must be maintained in a ready and available status. A new underground transfer line will be required from the LAWPS interface point that will connect the WTP EMF to the AP-105 pump pit. A new transfer pump will be required to remove WTP EMF returns for volume reduction at the 242-A Evaporator.

The scope of work involved in preparing Tank Farms for DFLAW is significant though familiar in terms of the specific activity scope to be executed. Based on current FY2017 funding projections and the known conditions for performing field work in DST Farms in the near future, the scope has been divided into discrete phases to meet the needs of the DFLAW program with sufficient contingency to account for the realization of risks over the life of the project. Figure 2 presents a high level summary of the overall IWFDP projectized activities.

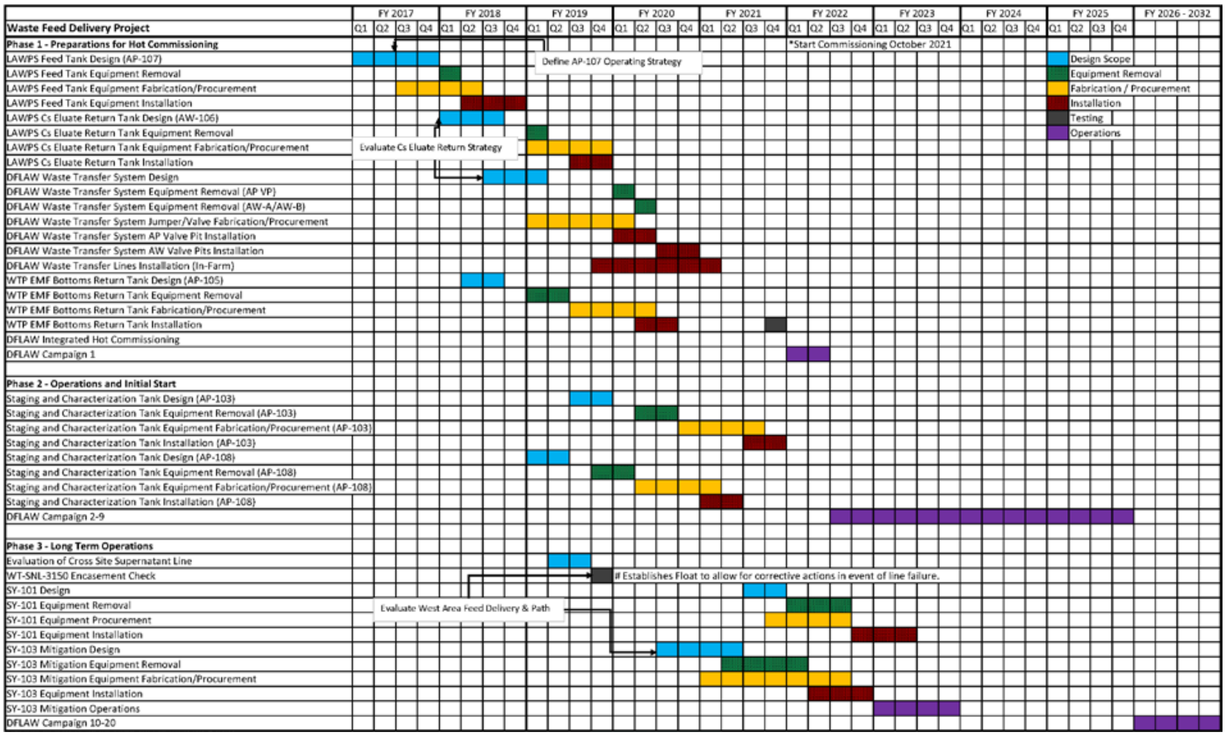

Figure 2. Simplified Low-Activity Waste Feed Delivery Process Flow Diagram

CONCLUSION

The preparations and workscope necessary to support early direct feed to the WTP LAW Vitrification Facility requires an integrated and coordinated effort. Opportunities for improvement persist although, as design of the various facilities matures, benefits of these improvements may lessen and/or potentially be eliminated entirely. Development of the operating strategy, further review and refinement of the feed sources, and improvement of the transfer line routing are recommended near term activities with potential to improve the reliability and maintainability of the waste feed delivery system to support the DFLAW mission.

REFERENCES

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