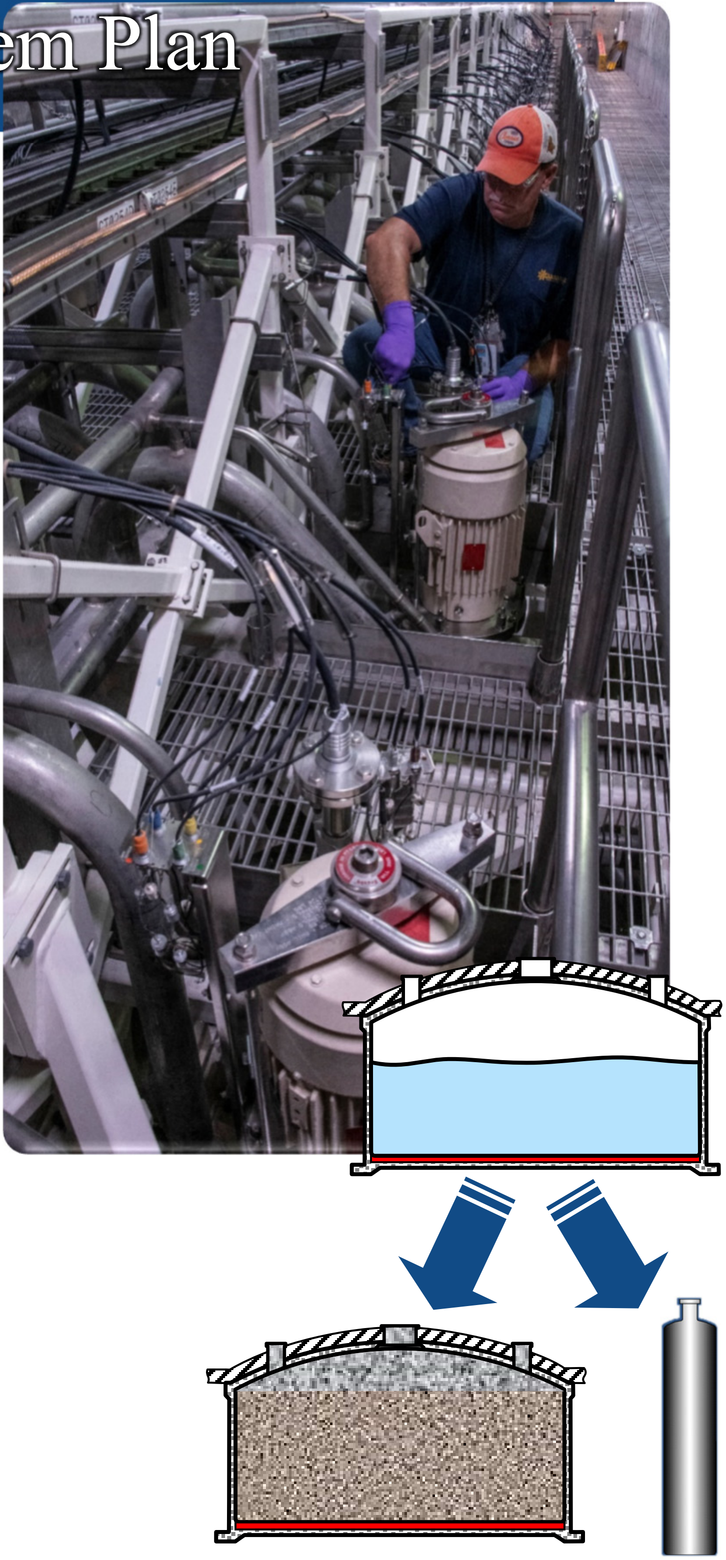
SRMC
SAVANNAH RIVER
MISSION COMPLETION

SRMC-LWP-2023-00001

LIQUID Waste System Plan

Integrated Liquid Waste Processing System at Savannah River Site



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Liquid Waste System Plan
Revision 23

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Savannah River Site
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1. Executive Summary

The last *Liquid Waste System Plan,* Revision 22[1] was published in September 2021. Since that time, Savannah River Mission Completion (SRMC) assumed operational responsibility of the liquid waste (LW) system and facilities. The goal is to complete closure of the LW facilities within fifteen years (by the end of 2037). This 23rd Revision of the *Liquid Waste System Plan* (hereinafter referred to as the *Plan*) forecasts continued progress in achieving the processing goals of the Department of Energy (DOE) at Savannah River Site (SRS). It assumes the conditions extant at the beginning of the SRMC LW contract in February 2022.

This *Plan* assumes aggressive performance of salt and sludge processing to forecast the best possible outcome for dispositioning the waste in the SRS High Level Waste (HLW) F Tank Farm (FTF) and H Tank Farm (HTF). This assumes receipt of the funding required to: install waste removal equipment, process at necessary rates, and maintain and replace equipment and infrastructure as needed. It assumes no major equipment failures other than the Defense Waste Processing Facility (DWPF) Melter replacement. It also assumes no major changes in safety requirements that would negatively affect the current planning basis for the removal, transfer, or processing of waste. As described in the *Risk and Opportunity Management Plan*[2] (ROMP), there are several risk events that could, were they realized, adversely affect the successful completion of the program goals in the time described.

Modeling of the LW system provides a way to predict the performance of the system and allows identification of areas for improvement. Previous versions of the *Plan* utilized various commercially available software to identify bottlenecks and processing capability of the various facilities. Production forecasts were prepared using a suite of Microsoft Excel® spreadsheets. This *Plan* utilizes models developed by DBD Inc., specifically for the SRS LW system, to provide an integrated forecast of the production of the various facilities as well as identifying bottlenecks and opportunities to improve production results. It also includes the Accelerated Basin Deinventory (ABD) program, acceleration of spent fuel disposition at H-Canyon by discontinuing uranium recovery following spent fuel dissolution. ABD program processing requires reconfiguring an existing waste storage tank to serve as an additional sludge preparation tank to enable timely receipt of ABD material into sludge batches. Based on current facility throughputs, the LW mission would complete in 2041. Utilizing our newly developed Program Optimization Model, SRMC has identified improvements, discussed in this *Plan*, which will enable the completion of the LW mission by the end of 2037.

Since Revision 22 of this *Plan*, the Salt Waste Processing Facility (SWPF) began operation and processed over 5 million gallons (Mgal) of dissolved salt solution. After completion of the first year of operations, SRMC took over operation of SWPF from Parsons, the constructor of the facility. At the Saltstone Disposal Facility (SDF), construction of Saltstone Disposal Unit (SDU) 7 was completed; construction of SDU 8 through SDU 12 continues. Three salt blend tanks, Tank 21, Tank 41, and Tank 42 are now in use to prepare feed for SWPF. Additionally, DWPF completed conversion to a glycolic acid flowsheet from a formic acid flowsheet, increasing processing capacity and reliability.

This *Plan* forecasts, in addition to the 4,319 canisters poured in the DWPF from April 1996 through September 2022, almost 3,800 additional canisters for a total production of over 8,100 canisters over the lifetime of the project.

The completion of waste removal in FTF, in this *Plan*, occurs in 2032, allowing the Inter-Area Line (IAL) to be shut down in 2032 as well as FTF closures to complete by the end of 2035. Salt processing at the SWPF is forecast to complete in 2035 and LW treatment and disposition in DWPF are completed in 2036. The last of the HTF tanks, the DWPF feed and preparation tanks, and the Saltstone feed tank, are closed in 2037.

Purpose

The purpose of this *Plan* is to integrate and document the activities required to disposition the existing and future HLW and remove from service radioactive LW tanks and facilities belonging to the Department of Energy Operations Office (DOE-SR). It records a planning basis for waste processing in the LW System through the end of the program mission.

This twenty-third revision of the *Plan*:

- Supports financial submissions development for the DOE-complex-wide Integrated Planning, Accountability, & Budgeting System (IPABS)
- Provides a technical basis for LW Contract and Contract Performance Baseline changes
- Provided input to the development of the Federal Facility Agreement (FFA)[3] Appendix L updates.

Common Values and Goals (2022–2037)

In a meeting held on June 29, 2022, DOE, the South Carolina Department of Health and Environmental Control (SCDHEC), the U.S. Environmental Protection Agency (EPA), and SRMC agreed to the following common values and goals:

VALUES

1. Maintain transparency with open communication between regulators, DOE, and the contractor on program progress, and significant emerging issues.
2. Ensure DOE's strategy and plans are subject to stakeholder engagement and input, including SCDHEC permitting processes, and Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as appropriate.
3. Maximize the amount of curies (especially long-lived radionuclides) vitrified and ready for ultimate disposal out of state.
4. Limit disposal of curies onsite at SRS so that residual radioactivity is as low as reasonably achievable.

GOALS (in priority order)

1. Reduce risk to the environment by removing waste and closing tanks with a goal of completion of the LW program by 2037.
2. Reduce operational and environmental risk by aggressively removing curies from the waste tanks.
3. Reduce operational and environmental risk by optimizing operations to minimize LW program total life cycle.
4. Complete waste removal and subsequent grouting of all waste tanks and ancillary structures with a risk-based priority order: first to tanks in the water table, followed by FTF tanks, followed by remainder of waste tanks, followed by ancillary structures, recognizing the potential for future emergent conditions or opportunities.

Additional principles guiding the development of this Plan include:

- Conduct operations consistent with the Waste Determinations (WD): *Section 3116 Determination for Salt Waste Disposal at the Savannah River Site*[4], the *Basis for Section 3116 Determination for Salt Waste Disposal at the Savannah River Site*[5], the *Section 3116 Determination for Closure of F-Tank Farm at the Savannah River Site*[6], the *Basis for Section 3116 Determination for Closure of F-Tank Farm at the Savannah River Site*[7], the *Section 3116 Determination for Closure of H-Tank Farm at the Savannah River Site*[8], and the *Basis for Section 3116 Determination for Closure of H-Tank Farm at the Savannah River Site*[9]
- Comply with applicable permits and consent orders, including the Modified Class 3 Landfill Permit for the SRS Z-Area SDF (permit ID 025500-1603) and the State-approved Consolidated General Closure Plan[10] (CGCP)
- Minimize the quantity of radionuclides (as measured in curies) dispositioned in the SDF, keeping the total curies at or below the amount identified in *Savannah River Site—Liquid Waste Disposition Processing Strategy*[11] (SRS LW Strategy), as amended by letter from SCDHEC to DOE-SR[12] and the *Basis for Section 3116 Determination for Salt Waste Disposal at the Savannah River Site*[5] and the "*Agreement*"[13]

Revisions

The significant updates from *Revision 22*[1] of this *Plan* include:

- **Salt Processing**:
  - SWPF accelerated processing of higher curie waste to maximize risk reduction in the tank farms
  - Suspended Tank Closure Cesium Removal (TCCR) operations
- **DWPF**:
  - Provision for ABD program
  - Fissile loading in glass is allowed to exceed 2,500 g/m^3 after Sludge Batch (SB) 11
  - Recognize performance enhancements due to the conversion to a glycolic acid flowsheet from a formic acid flowsheet
- **Modeling**:
  - This *Plan* utilizes a modeling suite developed by DBD Inc.

Results of the Plan

Table 1-1—*Results of Modeled Cases* describes the major results as compared to Revision 22 of the *Plan*:

Table 1-1—*Results of Modeled Cases*

Parameter	Rev 22 with ABD	Rev 23
Date last LW facility turned over to Dismantlement and Decommissioning (D&D)	2041	2037
Final Type I and II tanks complete operational closure	2033	2032
Complete SWPF operations	2033	2035
Complete DWPF operations	2038	2036
Last tank closed	2041	2037
Next Generation Solvent (NGS) Implemented For Increased SWPF Throughput	2023	2024
Total number of canisters produced	8,393	8,113
Radionuclides (curies) dispositioned in SDF within the amended *SRS LW Strategy*	Yes	Yes
Total number of SDUs	12	12

SWPF Processing: This *Plan* assumes implementation of "Next Generation Solvent" (NGS) in 2024.
Vitrification of Sludge at DWPF: This *Plan* forecasts completion of salt processing before completion of sludge processing. Processing of the remaining sludge heels will continue past the end of SWPF operations.
Canister Storage: Double-stack modification of Glass Waste Storage Building (GWSB) 1 and GWSB 2 enable stacking two glass-filled canisters in each below-grade storage location, thus obviating the need for supplemental canister storage. Shipment of canisters from SRS is not included in this *Plan*.
Saltstone Disposal Units (SDU): SDU 2, SDU 3 (currently in use), and SDU 5 are dual cylindrical cell units with ~2.8 Mgal grout capacity (~1.6 Mgal of DSS feed) per cell. SDU 2 and SDU 5 are filled. SDU 6 (currently in use) is a single cylindrical cell unit with 32.8 Mgal grout capacity (~18.7 Mgal of DSS feed). Construction of SDU 6 led to subsequent design changes in SDU 7 through SDU 12 that reduced internal obstructions and allowed filling to a greater height, increasing the capacity of each SDU to 34.5 Mgal of grout (19.6 Mgal of DSS). Modeling projects an excess capacity of over 7 Mgal of grout (4 Mgal of DSS) in SDU-12.
Radionuclides Dispositioned in SDF: This *Plan* is consistent with *SRS LW Strategy* as amended by letter from the SCDHEC to DOE-SR[12] and the *Basis for Section 3116 Determination for Salt Waste Disposal at the Savannah River Site*[5] concerning the total curies dispositioned at SDF.
Supporting ABD program: This *Plan* provides for the disposition of fissile material from H-Canyon directly into sludge batches through February 2034.

2. Introduction

This twenty-third revision of the Liquid Waste System Plan documents a strategy to safely operate the LW System at SRS to receive, store, treat, and dispose of radioactive LW; close waste storage tanks and waste transfer systems; and flush waste processing facilities. The LW System is a highly integrated operation involving safely storing LW in underground storage tanks; removing, treating, and solidifying the low-level waste (LLW) fraction in concrete SDUs; vitrifying the higher activity waste at DWPF; and storing the vitrified waste in stainless steel canisters pending permanent disposition. After waste removal and processing, the storage tanks and ancillary equipment will be closed and processing facilities will be cleaned for closure. Section 5—*System Description* of this *Plan* provides an overview of the LW System to give the reader some familiarity of the systems and processes discussed herein.

In total, the Tank Farms have received over 165 million gallons of waste from 1954 to the present. Having reduced the volume of waste via evaporation and dispositioned waste via vitrification and saltstone grouting, the Tank Farms currently store approximately 34.5 Mgal of waste containing approximately 222 million curies (MCi) of radioactivity. As of September 30, 2022, DWPF had poured 4,319 vitrified waste canisters. (Note: All volumes and curies reported as current inventory in the Tank Farms are as of September 30, 2022 and account for any changes of volume or curies in the Tank Farms since Revision 22 of the *Plan* and the *Section 3116 Determination for Salt Waste Disposal at the Savannah River Site*[4].)

This *Plan* describes dispositioning HLW from SRS. It assumes the disposition of spent fuel via dissolution at H-Canyon without uranium recovery. The *Plan* forecasts the outcome for dispositioning the waste via operation of waste removal, the Saltstone Production Facility (SPF), SWPF, and DWPF, with process improvements outlined in this plan. It assumes no major equipment failures other than one DWPF melter replacement. It also assumes no major changes in safety requirements that would negatively affect the current planning basis for the storage, removal, transfer, or processing of waste. As described in the ROMP, there are some challenges that will need to be managed to ensure successful completion of the mission.

2.1 *System Planning Overview*

System Plan Rev. 23 Goals

DOE's goals for development of this *Plan* are:

1. Continual safe storage of LW in tanks and vitrified canisters in storage.
2. Risk reduction through waste disposition, i.e., maximizing processing of waste and completing the LW mission in 2037.
3. Completion of waste removal from H-Tank Farm tanks in the water table (i.e., Type I and Type II tanks).
4. Support ABD program

Constraints

Operations are planned within the boundaries established by applicable regulatory constraints and processing constraints. For more information regarding regulatory constraints, refer to Section 3.2. The capacity of the operating facilities is accounted for in this *Plan* by assuming an availability factor for each of the facilities. This availability factor is based on actual operating history, the age of the facilities, and modeling projections. For example, if a facility has an assumed availability of 75%, that means it is available to operate 75% of the time. Conversely, it is unavailable 25% of the time. This equates to three months of downtime every year. Some of this downtime is for planned outages, such as the site steam outage or other planned maintenance outages (e.g., DWPF bubbler replacement or SWPF contactor replacement); the balance is for unplanned outages resulting from equipment failures. The unavailability is factored into the facility's processing rate.

Processing constraints are primarily addressed within the context of tank space management. There is currently a premium on processing and storage space in the SRS radioactive LW tanks. Space is needed for safe storage of waste, volume reduction initiatives via evaporation, retrieval of waste from old-style tanks and subsequent cleaning of emptied tanks, preparation of sludge and dissolution of salt prior to treatment in downstream facilities, and receipt of influent wastes from both DWPF and H-Canyon. The Tank Farm space management strategy is based on a set of key assumptions involving projections of treatment facility throughput, Tank Farm evaporator performance, and influent stream volumes.

The 27 new-style tanks represent a maximum storage capacity of 35 Mgal of space, of which almost 10 Mgal is empty space (~22%). However, not all that empty space is available for waste storage:

- 4.7 Mgal is margin as defense-in-depth operational control coupled with Safety Class (SC) or Safety Significant (SS) structures, systems, or components (SSC) to facilitate reasonably conservative assurance of more than adequate dilution and ventilation of potentially flammable vapors
- 1.3 Mgal is the procedurally required minimum contingency space for process recovery in the unlikely event of a large waste leak elsewhere in the Tank Farms
- 3.6 Mgal is operational "working" space variously used to provide:
  - Contingency transfer space as operational excess margin above the procedurally required minimum
  - Excess margin to preserve salt batch quality and maintain uninterrupted treatment and disposition through SWPF and SPF
  - Excess margin to preserve sludge batch quality and maintain uninterrupted immobilization through DWPF
  - Excess margin to preserve uninterrupted support for H-Canyon.

Modeling

Previous revisions of the *Plan* utilized a combination of Microsoft Excel® spreadsheets and software such as COREsim® to forecast the facility operations and changes required to complete the LW mission. For this revision of the *Plan*, a new model was developed by DBD Inc. The All Waste Simulation Model II (AWSM II) contains the logistical and chemical information of the LW System, through two sub-models handling different aspects. The Process Optimization Model (POM), developed using AnyLogic, portrays facility behavior through resource loading, material transfer volumes, and timings. The Technical Optimization Model (TOM), developed using gPROMS, portrays facility behavior through theoretical and empirical chemical equations. The two sub-models, sharing transfer data between each other, simulate the logistical behavior and verify the simulation behavior based on chemical principles.

At the current stage of development, the model incorporates facility run rates and operation logic, planned and unplanned outages, transfer prioritization, and salt batching algorithms. This information allows insight into the current state as well as mid- and long-term projections. The model has been benchmarked against previous *Plans* and been found to produce similar results when given similar inputs.

SRMC's plan is to complete the LW mission in 15 years (by the end of 2037). Over 100 scenarios were modeled using the new POM with various process improvements incorporated, 35 of those scenarios met the finish in 2037 objective. One of those 35 scenarios was selected as the basis for this *Plan*. The following potential process improvements are needed to achieve completion of the mission in 2037:

- Improve filtration rate at SWPF
- Reduce monosodium titanate (MST) strike time and quantity of MST added
- Increase Caustic Side Solvent Extraction (CSSX) 100% throughput to 28 gpm from 21.6 gpm (achieved with the deployment of NGS)
- Limit lost production at SWPF resulting from close coupling with DWPF, achieved by a combination of:
  - Decrease SE volume (NGS)
  - Increase DWPF plant availability
  - Accelerate SE consumption in DWPF
  - Increased SE consumption flexibility
    - add more SE to each Slurry Receipt and Adjustment Tank (SRAT) Batch
    - create a transfer path for Strip Effluent Feed Tank (SEFT) to Slurry Mix Evaporator (SME)
    - provide SE lag storage
  - Increased MST/SS consumption flexibility
    - increase the volume of MST/SS per SRAT batch
    - improve availability of MST/SS lag storage
- Improve recycle management within DWPF, achieved by a combination of:
  - Decrease/eliminate sample wait time
  - Decrease/eliminate permanganate strike time
  - Provide redundant Recycle Collection Tank (RCT) capability

In addition to the process improvements described above, the model output was further adjusted to ensure the highest priority items to help achieve the 2037 mission completion objective were completed. The results of those adjustments are summarized as follows:

- Closure related activities were delayed on numerous tanks
    - Closure work ramps up heavily (approximately doubled) in FY31-FY37 to a level of activity not previously demonstrated
    - A third of remaining tanks are operationally closed in the last year of this plan
- No ancillary structure work occurs prior to FY28
- Melter 5 fabrication was delayed; a just in time outage strategy was used
- Modifications to GWSB 2 delayed and will be just in time to meet need date

The output of the modeling is a success-based model that assumes a high number of risks (both technical and financial) are overcome and opportunities are realized. While success is possible, contingencies are significantly reduced and risks are higher. The outcome of those risks could delay LW mission completion (see §2.2 below).

2.2 ***Risk and Opportunities Assessment***

The draft ROMP[2] documents the comprehensive identification and analysis of technical and programmatic risks and opportunities associated with the LW program and presents strategies for handling those risks and opportunities in the near-term and outyears.

The ROMP identifies over 100 risks associated with this *Plan* with a total outyear Technical and Programmatic Risk Assessment of several billion dollars. After mitigation, overall risk level is reduced. Several of the risks, if realized, have the potential to extend the LW program beyond the 2037 mission completion date, including but not limited to:

- Aging Infrastructure—While the assumed availability factor for the facilities addresses expected normal failures of various components, the *Plan* end date places significant stress on increasingly aging infrastructure. Infrastructure failures, exemplified by the 3H Evaporator pot leak in 2016, provide insight into problems that may be encountered while operating the HLW System until the end of the mission
- Infrastructure Capacity—The capacity of the existing Tank Farm infrastructure will be stretched close to its limits in supporting salt batch and sludge batch preparation.
- Emergent Changes to Requirements—Changes to business, project management, or technical requirements may adversely affect plans for the provision of necessary facilities (e.g., SDUs), or performance of necessary activities (e.g., transfers). This could interfere with normal operational expectations assumed in the *Plan*.
- Tank heel mechanical cleaning effectiveness to achieve Preliminary Cease Waste Removal (PCWR)
- Planned improvements do not increase processing rate within SWPF to the required level
- Optimization of MST quantities and strike times is limited by external factors such as the Section 3116 Salt Waste Determination Basis
- Planned improvements to increase DWPF availability are insufficient to relieve the close-coupling bottleneck between SWPF and DWPF, and do not achieve the desired benefit
- Planned improvements to increase DWPF processing flexibility, including recycle management, are insufficient to relieve the close-coupling bottleneck between SWPF and DWPF, and do not achieve the desired benefit
- Ability to concentrate strip effluent (SE) is limited by emergent DSA constraints
- Program funding to permit full execution of the *Plan* is impacted
- Historically, operational closure has taken longer than four years. This *Plan* includes a four-year closure cycle on 27 tanks, a three-year closure cycle on eleven tanks, and a two-year closure cycle on five tanks. Closure starts were delayed, requiring shortened closure cycles to support completion in 2037. This is a future opportunity that must be realized to achieve mission completion in 2037.

FFA milestone dates in this plan are less sensitive to the risks described in this section. More risks were accounted for in the selection of those important commitment dates.

The ROMP identifies 10 opportunities associated with this *Plan.* These opportunities, if realized, could help reduce risks, ensure completion of the mission in 2037, ensure timely completion of FFA milestones, and potentially improve the end dates. New opportunities are also under evaluation that may yield benefits to the mission once they have matured. These opportunities include but are not limited to:

- Design and field work implementation efficiencies
- Improvements in waste removal approach
- Improved technical approaches
- Alternate strategies on disposition
- Optimized methodologies for demonstrating closure requirements are met
- Implementation of cost saving strategies and/or enhanced funding profiles

3. Planning Bases

Dates, volumes, and chemical or radiological composition information contained in this *Plan* are planning approximations only. Specific flowsheets guide actual execution of individual processing steps. The activities described are summary-level activities, some of which have yet to be fully defined. The sequence of activities described herein reflects the best judgment of the planners. The individual activity execution strategies contain full scope, schedule, and funding development. Upon approval of scope, cost, and schedule baselines, modifications of this *Plan* may be necessary.

3.1 *Funding*

Progress toward the goal of immobilizing all the LW at SRS is highly dependent on available funding. With any reduction from full funding, activities that ensure safe storage of waste claim priority. Funding above that required for safe storage enables risk reduction activities, i.e., waste removal, treatment—including immobilization, and removal from service, as described in this *Plan*.

3.2 *Inputs and Assumptions*

The following inputs and assumptions were generated to develop this 23rd revision of the *Plan*. The targets described in these assumptions are the overall goals of the various facilities. Modeling of the LW system, however, may indicate that the targets are not achievable given the processing constraints of various facilities, limits to funding, or other system constraints.

- **Priorities for Scenario Development (these are goals, not necessarily outcomes):**
  1. Continual safe storage of LW in tanks and vitrified canisters in storage.
  2. Risk reduction through waste disposition, i.e., maximizing processing of waste and completing the LW mission in 2037.
  3. Completion of waste removal from H-Tank Farm tanks in the water table (i.e., Type I and Type II tanks).
  4. Support ABD
- **Funding:**
  - Funding for the LW program is provided from PBS-14C
  - Additional funding (other than PBS-14C) will be provided to support
    - Fast Critical Assembly (FCA) disposition
    - Conversion of Tank 42 for sludge batch preparation service
- **Accelerated Basin Deinventory (ABD)**
  - Utilize SRNS-E1122-2020-00021[14] to characterize ABD discard
  - Assume that ABD transfers will be supported only to the degree that they do not impact the overall LW mission (i.e. completion in 2037)
  - Fissile loading in glass is allowed to exceed 2,500 g/m^3 after SB 11
  - The final ABD discard will be received no later than February 2034 to avoid mission impact.

3.3 *Regulatory Drivers*

Numerous laws, constraints, and commitments influence LW System planning. Described below are requirements most directly affecting LW system planning. This *Plan* assumes the timely acquisition of regulatory approvals.

South Carolina Environmental Laws and Permits

Under the South Carolina Pollution Control Act, S.C. Code Ann. §§ 48-1-10 *et seq*., SCDHEC is the delegated authority for air pollution control and water pollution control. The State has empowered SCDHEC to adopt standards for protection of water and air quality and to issue permits for pollutant discharges. Further, SCDHEC is authorized to administer both the federal Clean Water Act and the Clean Air Act. Under South Carolina's Hazardous Waste Management Act, S.C. Code Ann. §§ 44-56-10 *et seq*., SCDHEC is granted the authority to manage hazardous wastes. With minor modifications, SCDHEC has promulgated the federal Resource Conservation and Recovery Act (RCRA) requirements, including essentially the same numbering system. The South Carolina Solid Waste Policy and Management Act, S.C. Code Ann. §§ 44-96-10 *et seq*., provides standards for the management of most solid wastes in the state. For example, SCDHEC issued to DOE-SR permits such as the Class 3 Solid Waste Landfill Permit for SDF. This landfill permit contains conditions for the acceptable disposal of non-hazardous waste in the SDF, including provisions for fines and penalties. Other principal permits required to operate LW facilities pursuant to the state's environmental laws include:

- SCDHEC Bureau of Land and Waste Management
  - Class 3 Solid Waste Landfill Permit for SDF
- SCDHEC Bureau of Water:
  - Industrial wastewater treatment facility permits (e.g., Tank Farms, DWPF, Actinide Removal Process / Modular CSSX Unit [ARP/MCU], Effluent Treatment Facility [ETF], SPF, SWPF)
  - National Pollutant Discharge Elimination System (NPDES) permit (H-16 Outfall discharges from ETF)
- SCDHEC Bureau of Air Quality:
  - Part 70 Air Quality Permit (one Site-wide Air Permit including the LW facilities).

One feature of this *Plan* is incorporation of the provisions of the "*Agreement*"[13] executed in October 2016. That "*Agreement*" designates specific technology incorporation (i.e., TCCR, NGS in SWPF, and sonar mapping demonstration) into the LW disposition matrix. Salt processing goals and deadlines are identified. Along with the goals and timing is a recognition of the challenges of operating a complex set of interdependent facilities, many of which are older, such that documentation of *force majeure* events is allowed.

Site Treatment Plan (STP)

The *Site Treatment Plan* (STP)[15] for SRS describes the development of treatment capacities and technologies for mixed wastes and provides guidance on establishing treatment technologies for newly identified mixed wastes. The STP allows DOE, regulatory agencies, the States, and other stakeholders to efficiently plan mixed waste treatment and disposal by considering waste volumes and treatment capacities on a national scale. The STP identifies vitrification in DWPF as the preferred treatment option for appropriate SRS liquid high-level radioactive waste streams and solidification in Saltstone for low-level radioactive waste streams. In 1996, SRS committed that:

> *"Upon the beginning of full operations, DWPF will maintain canister production sufficient to meet the commitment for the removal of the backlogged and currently generated waste inventory by 2028."*

The commitment for the removal of the waste by 2028 encompasses bulk waste removal and heel removal scope of this *Plan*. Final cleaning, deactivation, and removal from service of storage and processing facilities follow the satisfaction of this commitment. *Note that with the changes in technology and challenges in implementing the various technologies this* Plan *does not meet this commitment, even with additional salt processing.*

Federal Facility Agreement (FFA)

The Environmental Protection Agency (EPA), DOE, and SCDHEC executed the SRS Federal Facility Agreement (FFA)[3] on January 15, 1993, with an effective date of August 16, 1993. It provides standards for secondary containment, requirements for responding to leaks, and provisions for the removal from service of leaking or unsuitable LW storage tanks. Tanks scheduled for operational closure may continue to be used but must adhere to the FFA schedule for operational closure and the applicable requirements contained in the Tank Farms' industrial wastewater treatment facility permit. Several agreements since then have modified the original agreement recognizing the realization of previously identified risks (*e.g.*, delays in SWPF start-up date). Appendix L of the FFA, updated to add the *2022 High Level Waste Tank Milestones Agreement* signed by DOE, SCDHEC, and EPA in December 2022, includes the *Schedule for Remaining Non-Compliant Tanks* (Table 3-1).

Table 3-1—*Schedule for Remaining Non-Compliant Tanks*

Milestone Date	Preliminary Cease Waste Removal (№ of Tanks)	Operational Closure (№ of Tanks)
12/31/2023	–	–
12/31/2024	1	–
12/31/2025	3	–
12/31/2026	2	–
12/31/2027	2	–
12/31/2028	–	3
12/31/2029	2	–
12/31/2030	1	2
12/31/2031	–	3
12/31/2032	–	1
12/31/2033	–	2
12/31/2034	1	–
12/31/2035	1	–
12/31/2036	1	1
12/31/2037	2	4

National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires federal agencies to assess the potential environmental impacts of proposed actions. Eight existing NEPA documents and their associated records of decision directly affect the LW System and support the operating scenario described in this *Plan*:

- DWPF Supplemental Environmental Impact Statement (SEIS) (DOE/EIS-0082-S)
- Final Waste Management Programmatic Environmental Impact Statement (PEIS) (DOE/EIS-0200-F)
- SRS Waste Management Final Environmental Impact Statement (EIS) (DOE/EIS-0217)
- Interim Management of Nuclear Materials EIS (DOE/EIS-0220)
- SRS High-Level Waste Tank Closure Final EIS (DOE/EIS-0303)
- Environmental Assessment (EA) for the Closure of the HLW Tanks in F and H Areas at SRS (DOE/EA-1164)
- SRS Salt Processing Alternatives Final SEIS (DOE/EIS-0082-S2).
- Final EA for the Commercial Disposal of DWPF Recycle Wastewater from SRS (DOE/EA-2115)

Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005

The *Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005* (NDAA) Section 3116 (NDAA §3116) allows determinations by the Secretary of Energy, in consultation with the Nuclear Regulatory Commission (NRC), that certain radioactive waste from reprocessing is not high-level waste and may be disposed of in South Carolina pursuant to a State-approved closure plan or State-issued permit. For salt waste, DOE contemplates removing targeted fission products and actinides using a variety of technologies and combining the removed fission products and actinides with the metals being vitrified in DWPF. NDAA §3116 governs solidifying the remaining low-activity salt stream into saltstone grout for disposal in SDF. For tank removal from service activities, NDAA §3116 governs the WDs for the Tank Farms that demonstrate that the tank residuals, the tanks, and ancillary equipment (evaporators, diversion boxes, etc.) at the time of removal from service and stabilization can be managed as non-high-level waste.

Conduct of operations are planned in accordance with the following applicable portions of the NDAA:

- Section 3116 Determination for Salt Waste Disposal at the Savannah River Site[4]
- Basis for Section 3116 Determination for Salt Waste Disposal at the Savannah River Site[5]
- Section 3116 Determination for Closure of F-Tank Farm at the Savannah River Site[6]
- Basis for Section 3116 Determination for Closure of F-Tank Farm at the Savannah River Site[7]
- Section 3116 Determination for Closure of H-Tank Farm at the Savannah River Site[8]
- Basis for Section 3116 Determination for Closure of H-Tank Farm at the Savannah River Site[9]

3.4 *Revisions*

The significant differences from *Revision 22*[1] of this *Plan* include:

- **Salt Processing**:
  - Salt Waste Processing Facility accelerated processing of higher curie waste to maximize risk reduction in the tank farms
  - Suspended TCCR operations
- **DWPF**:
  - Provision for ABD program
  - Fissile loading in glass is allowed to exceed 2,500 g/m^3 after SB 11
  - Recognizes performance enhancements due to the conversion to a glycolic acid flowsheet from a formic acid flowsheet
- **Modeling**:
  - This *Plan* utilizes a modeling suite developed by DBD Inc.

3.5 *Key Milestones*

Key Milestones are those major dates deemed necessary under this *Plan* to remove waste from storage, process it into glass or grout, and close the LW facilities. The *Revision 22* milestones are provided for comparison:

Table 3-2—*Key Milestones*

Key Milestone	Rev 22 with ABD	Rev 23
Date SWPF begins hot commissioning *(actual)*	*2020*	*2020*
Date last LW facility turned over to D&D	2041	2037
Final Type I and II tanks complete operational closure	2033	2032
Complete salt waste treatment through SWPF	2033	2035
Complete sludge waste treatment through DWPF	2038	2036
Total number of canisters produced	8,393	8,113
Initiate SWPF Hot Operations *(actual)*	*Jan 2021*	*Jan 2021*
– *Processed via DDA-solely (actual)*	*2.8 Mgal*	*2.8 Mgal*
– *Processed via ARP/MCU (actual)*	*7.5 Mgal*	*7.5 Mgal*
– *Salt Solution Processed via TCCR (actual)*	6.1 Mgal	*0.4 Mgal*
– Salt Solution Processed via SWPF	96 Mgal	103 Mgal
Number of SDUs	12	12

SWPF Processing: This *Plan* assumes implementation of NGS in 2024.
Vitrification of Sludge at DWPF: This *Plan* forecasts completion of salt processing before completion of sludge processing. Processing of the remaining sludge heels will continue past the end of SWPF operations.
Canister Storage: Double-stack modification of GWSB 1 and GWSB 2 enable stacking two glass-filled canisters in each below-grade storage location, thus obviating the need for supplemental canister storage. Shipment of canisters from SRS is not included in this *Plan*.
Saltstone Disposal Units (SDU): SDU 2, SDU 3 (currently in use), and SDU 5 are dual cylindrical cell units with ~2.8 Mgal grout capacity (~1.6 Mgal of DSS feed) per cell. SDU 2 and SDU 5 are filled. SDU 6 (currently in use) is a single cylindrical cell unit with 32.8 Mgal grout capacity (~18.7 Mgal of DSS feed). Construction of SDU 6 led to subsequent design changes in SDU 7 through SDU 12 that reduced internal obstructions and allowed filling to a greater height, increasing the capacity of each SDU to 34.5 Mgal of grout (19.6 Mgal of DSS). Modeling projects an excess capacity of over 7 Mgal of grout (4 Mgal of DSS) in SDU-12.
Radionuclides Dispositioned in SDF: This *Plan* is consistent with *SRS LW Strategy* as amended by letter from the SCDHEC to DOE-SR[12] and the *Basis for Section 3116 Determination for Salt Waste Disposal at the Savannah River Site*[7] concerning the total curies dispositioned at SDF.
Supporting ABD program: This *Plan* provides for the disposition of fissile material from H-Canyon directly into sludge batches through February 2034.

4. Planning Summary and Results

This section summarizes the key attributes of this *Plan*. Detailed discussion of risks and associated mitigation strategies are included in other documents such as the ROMP and individual implementation activity risk assessments.

In addition, this *Plan* assumes receiving adequate funding to achieve the required project and operations activities. Failure to obtain adequate funding will have a commensurate impact on the programmatic objectives.

This section summarizes the *Plan*, based on the key assumptions and bases. Tabular results of the lifecycle, on a year-by-year basis, or graphical results of the lifecycle are included in:
Appendix A—*Salt Solution Processing*
Appendix B—*Canister Storage*
Appendix C—*Preliminary Cease Waste Removal*
Appendix D—*Tank Removal from Service*
Appendix E—*LW System Plan—Revision 23 Summary (DNA)*

4.1 *Waste Retrieval*

The first step in the disposition of sludge and salt waste is bulk waste removal. The waste removal phase extracts the bulk of the tank waste, including salt cake, sludge solids, and contaminated liquids, leaving only the residual heel.

Waste Removal

This is a mechanical process using agitation mixer pumps to suspend and potentially dissolve the solids and transfer the waste feeds for further processing. Sludge is removed from the waste tank and sent either to a sludge hub tank, a tank set up to receive and transfer sludge to the feed preparation tank, or directly to the feed preparation tank, ensuring sludge waste is continuously available for treatment at DWPF. Salt is dissolved, removed, and staged in a salt solution storage tank, a salt solution hub tank or a salt solution blend tank, prior to treatment at SWPF.

Sludge Removal

Current sludge removal strategies utilize the local control rooms and use standardized support skids to increase the efficiency of the sludge removal process. The process is completed utilizing several mixer pumps and adding sufficient liquid to the tank to suspend sludge solids. Existing supernate is used, when practical, to minimize introduction of new liquids into the system. Operation of commercial submersible mixing pumps (CSMP) suspends the solids, which are then transferred as a slurry from the tank. This operation is repeated, periodically lowering the CSMPs, until the remaining contents of the tank can no longer be effectively removed by this method (see Figure 4-1—*Mechanical Agitation Waste Removal*).

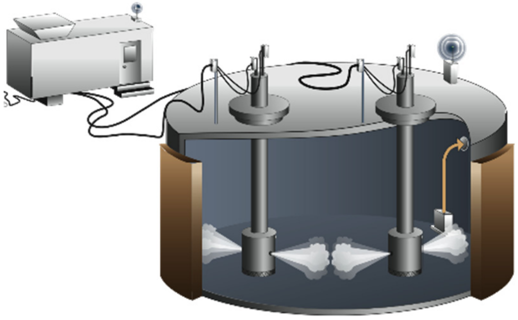


Figure 4-1—*Mechanical Agitation Waste Removal*

Sludge batches were originally configured to preferentially remove sludge from old style, Types I and II, tanks. Most of the sludge has been successfully removed from these old-style tanks. Tank 13, a Type II tank in HTF, is being used as a sludge hub tank to store and transfer sludge from other tanks; final Tank 13 heel removal is planned for 2026. Tanks 33, 26, 35, and 39, all Type III tanks, are also planned as sludge hub tanks, as needed.

Salt Removal

Salt waste removal strategy is developed on a tank-specific basis and may employ a variety of approaches. If liquid supernate is present above the salt layer, it is removed first. After that, tanks that are full of salt and at the beginning of the salt waste removal process may be approached using a Drain, Add, Remove (DAR) method (see Figure 4-2—*Drain, Add, Remove Method for Salt Waste Removal*)

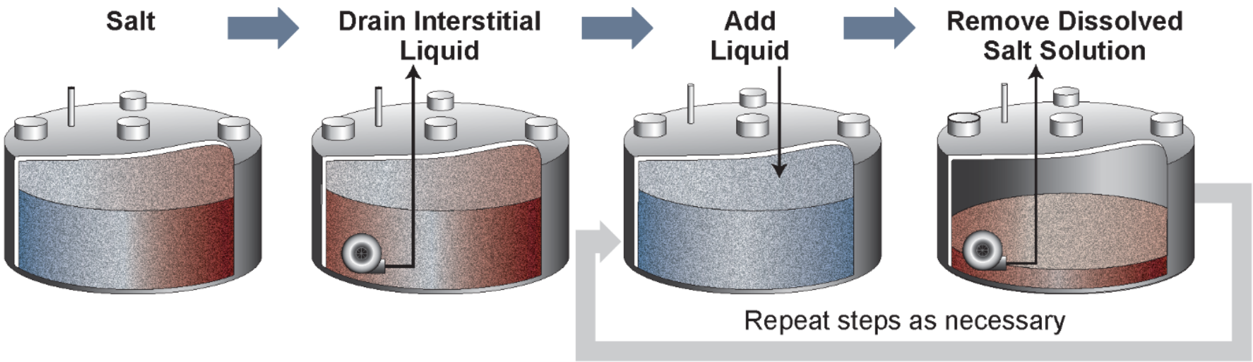


Figure 4-2—*Drain, Add, Remove Method for Salt Waste Removal*

The Drain step involves the removal of the highly concentrated interstitial liquid salt solution, often by mining into the saltcake and placing a pump and caisson at a lower elevation in the tank. This allows the interstitial liquid to drain through the salt and collect where it can be pumped out. The interstitial liquid often has higher concentrations of sodium and higher levels of radioactivity compared to dissolved salt. It may be segregated in collection tanks apart from dissolved salt solution collection tanks for strategic salt batch planning.

During the Add step, liquid is added to dissolve the solid saltcake. This dissolution liquid may be inhibited water (IW), well water to which small quantities of sodium hydroxide and sodium nitrite have been added to prevent corrosion of the carbon steel waste tanks; or dilute LW already existing within the Tank Farms (i.e., DWPF recycle or Tank 51 spent wash water) may be beneficially reused to dissolve salt. The dissolution liquid may be added in small batches, or it may be added at a very slow rate while simultaneously removing dissolved salt solution. The Add step may also be accomplished by using a liquid addition downcomer or a Low Volume Mixing Jet (LVMJ) which entrains existing liquid to promote more contact with the bulk saltcake. When using a downcomer for liquid additions, the Add step is more effective if the dissolution media can be sprayed directly onto the salt surface. Care is taken to minimize the formation of preferential flow channels during salt solution removal.

The Removal step ends the process, with the removal of dissolved salt solution to a collection tank.

While effective, salt dissolution using DAR is a slow process. The preferred, more efficient method of salt dissolution involves the use of CSMPs to increase the contact between the saltcake and the dissolution media, resulting in faster salt dissolution. CSMPs are also effective at disturbing insoluble materials that may blanket the salt surface, which may otherwise reduce the effectiveness of the DAR process. Use of CSMPs generally requires lower bulk saltcake level in the tank to ensure the CSMPs have adequate liquid coverage for cooling, and a larger tank vapor space to account for the higher rate of gas release during salt dissolution. Thus, LVMJs are initially used for water additions when the salt level is too high to effectively operate CSMPs. LVMJs may be used to add water in small batches or, during simultaneous removal of dissolved salt solution using a transfer pump, for semi-continuous dissolution (SCD). During SCD, as the density of the dissolved salt solution decreases, the LVMJs and transfer pump are lowered closer to the bulk saltcake surface to promote more effective salt dissolution. Once the salt level has decreased enough to allow the effective use of CSMPs, the LVMJs are removed and CSMPs are installed to promote faster and more efficient salt dissolution. Enhanced LVMJs (eLVMJs) may also be deployed; the eLVMJs feature a different nozzle design and operate at higher pressure than standard LVMJs.

Tanks with Documented Leak Sites

Several Type I, II, and IV tanks have documented leak sites. All Type IV tanks having documented leak sites have been operationally closed,, however waste removal operations on some of the Type I and II tanks could potentially reactivate old leak sites or expose new leak sites in those tanks. Contingency equipment and procedures will be utilized to contain leakage if it occurs and prevent release to the environment. Tank-specific waste removal plans avoid liquid levels above known leak sites, when feasible, and focused monitoring is employed when these levels cannot be avoided.

Because of program progress to date, of the 14 SRS tanks (all old-style tanks) with leakage history:

- 6 are operationally closed and grouted (Tanks 5, 6, 12, 16, 19, and 20)
- 3 are targeted for accelerated closure (Tanks 9, 10, and 11)
- 1 is undergoing heel removal (Tank 15)

- 2 contain essentially dry waste, with little to no free liquid supernate (Tanks 1 and 14)
- 2 contain liquid supernate at a level below known leak sites (Tanks 4 and 13).

4.2 *Sludge Processing*

Each sludge batch is comprised of sludge from two or more source tanks. Sludge batch planning uses the estimated mass and composition of sludge and known processing capabilities to develop processing sequences. In addition, the need to integrate salt and sludge processing constrains canister production to meet salt processing requirements during some years.

The basic steps for sludge processing (Figure 4-3) are:

1. Sludge removal from tanks
2. Low Temperature Aluminum Dissolution (LTAD) in Tank 51 or, when converted, Tank 42, as needed
3. Blending and washing of sludge in Tank 51 or Tank 42
4. Sludge feeding to the DWPF from Tank 40
5. Vitrification in DWPF.

Low Temperature Aluminum Dissolution (LTAD)

Sludge generated by the plutonium uranium reduction extraction (PUREX) process in F-Canyon produces high-heat sludge with small amounts of aluminum. However, H Canyon uses a modified version of the PUREX process to separate special nuclear material and enriched uranium. High-heat sludge generated from the Canyon H-Modified (HM) process has high amounts of aluminum solids as gibbsite or boehmite. Some of this aluminum can be removed from the sludge by dissolving the aluminum and then decanting the liquid. This reduces the number of canisters needed to disposition the sludge due to lowered sludge solids mass and improved glass waste loading. Aluminum dissolution is achieved by application of added caustic, elevated temperature, mixing, and sufficient reaction time. “Low Temperature” refers to the use of a maximum temperature of approximately 75ºC to achieve the dissolution, as demonstrated for SB5, SB6, and SB10. Preparation of SB11–18 are expected to need the LTAD process step. The dissolved aluminum liquid is processed with the salt waste.

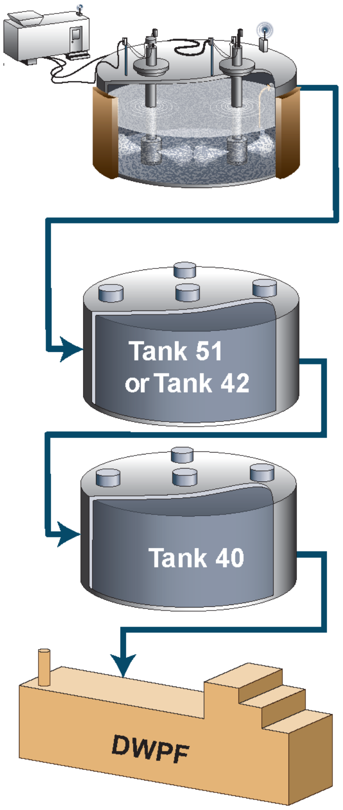


Figure 4-3—*Sludge Feed Preparation*

Sludge Washing

Sodium and other soluble salts (e.g., sulfates, nitrates, nitrites) in DWPF feed are reduced through sludge washing. Sludge washing is performed by adding water to the sludge batch, mixing with slurry pumps, securing the pumps to allow gravity settling of washed solids, and decanting the sodium-rich supernate to a salt preparation tank or an evaporator system for concentration. This cycle is repeated until the desired molarity (typically 1.0 M Na) is reached. Some types of sludge settle slowly, extending wash cycles. Sludge settling and washing typically constitutes ~75% of batch preparation time. The total number of washes performed, and volume of wash water used, are minimized to conserve waste tank space. Sludge batch size and wash volumes are also limited by the hydrogen generation rate associated with radiolysis of water. Tank contents are mixed on a periodic frequency to release hydrogen retained within the sludge layer, resulting in a limited window within operating constraints for gravity settling. Once sludge washing has achieved its chemical composition objective and the batch has been qualified for compliance with the DWPF Waste Acceptance Criteria (WAC), it is transferred to Tank 40 where it feeds DWPF in small (5 kgal–10 kgal) batches.

4.3 *DWPF Operations*

Washed sludge is transferred to the DWPF facility where it is combined with the high-level waste streams from salt processing (discussed below) for vitrification into glass canisters and stored on-site pending disposition.

Historically, melter performance has been the limiting factor for DWPF throughput. To mitigate this throughput limitation, argon bubblers were installed in the melter providing more uniform melt temperatures. The DWPF melters produced an average of 215 canisters/yr before melter bubblers were installed. However, after bubblers were installed in September 2010, the melter capacity improved such that an annual record of 277 canisters were poured in FY12, and a monthly record of 40 canisters were poured in August 2013. The feed preparation systems internal to DWPF have demonstrated a capacity of greater than 325 canisters/yr, specifically the 337 canisters poured from July 2011 thru June 2012.

The DWPF facility is designed to process a defined blend of sludge and salt waste streams, comprised of washed sludge from the Tank Farms, MST/sludge solids from SWPF, and SE from SWPF. For the early years of salt processing, whether with ARP/MCU or SWPF, salt processing paced DWPF production. DWPF processing required to meet the fifteen-year LW facilities closure goal necessitates decoupling DWPF canister production from SWPF processing.

Total Canister Count

Total canister count is primarily based on the mass of sludge in the Tank Farms, the ability to perform aluminum dissolution as needed, and the addition of sludge modifiers, if needed, to meet physical and chemical requirements for DWPF processing. Sludge may be transferred to a hub tank (a temporary storage location) to provide tank space for SWPF feed preparation and ongoing waste removal. Limits on the mass of sludge that can be physically managed in a given sludge batch may dictate an increase or decrease in both solids loading and canister generation rate.

Future estimated canister production, by year, is shown in Appendix B—*Canister Storage*. The canister rates include two one-week outages every year to allow for routine planned maintenance and another two weeks for the annual site-wide steam outage. These outages are included in the model.

Failed Equipment Storage Vaults (FESVs) and Melter Storage Boxes (MSBs)

The major component of the DWPF process is the melter which has a finite operational life. While the original design of the DWPF facility forecast a melter replacement every two years, the first melter operated over eight and a half years before it reached its end of life. Melter 2 had operated fourteen years when it reached the end of life in 2017. This *Plan* assumes one additional melter change occurs in early FY29

Disposition of highly radioactive failed melters requires specially designed transport and storage Melter Storage Boxes (MSB) which are designed to be placed in underground Failed Equipment Storage Vaults (FESVs) for interim storage. The original DWPF design has two FESVs contained within one construction unit. Each FESV is designed to store one MSB containing a failed melter.

Melter 1 was placed in FESV 2 in December 2002. Melter 1 (inside MSB 1) had a relatively low external radiation field. It was placed in the northernmost vault since the next vault pair to be constructed would be adjacent to FESV 2. Melter 2 was placed in FESV 1 in May 2017. Space is reserved for construction of up to ten FESVs, as needed.

This *Plan* assumes a storage location for MSB 3 will be completed prior to Melter 3 reaching its end of life. This will either be by the construction of additional FESVs or an alternative strategy. Alternative strategies are being evaluated to allow the lower dose Melters 1, Melter 2, or both to be removed from the FESVs for above ground storage and utilizing the current FESVs for the presumably higher dose Melter 3 when it reaches end of life.

Currently, the FESV 200-ton gantry crane is designed to interface only with an MSB designed primarily to contain failed melters. The placement of other large failed DWPF equipment (which do not have disposal paths) in FESVs has been considered, but the complete engineered system to move large, contaminated equipment from the 221-S Canyon to the FESV has not been designed or constructed. Alternative methods for disposal of large, contaminated equipment from DWPF (not including melters) are under evaluation.

Glass Waste Storage Building (GWSB)

The canisters of vitrified HLW glass produced by DWPF are currently stored on-site in two dedicated interim GWSBs. A Shielded Canister Transporter (SCT) moves one canister at a time from the Vitrification Building to a GWSB. The schedule for filling the GWSBs is found in Appendix D—Canister Storage.

GWSB 1 consists of a below-grade seismically qualified concrete vault containing support frames for vertical storage of 2,262 standard canisters. In FY15, GWSB 1 began conversion for stacking two canisters in each storage location for a total capacity of 4,524 standard canisters (Figure 4-4—*Double Stacking*) within the guidelines of *Heat Transfer Analysis of Double Stacking of Canisters in the Glass Waste*

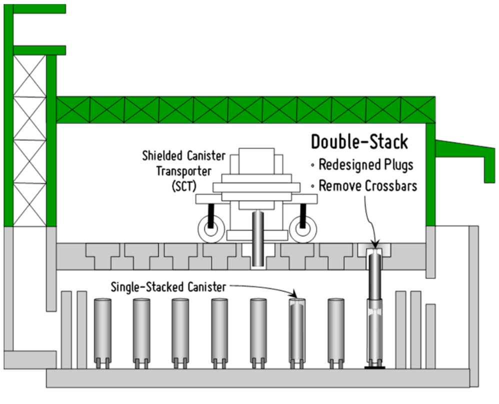


Figure 4-4—*Double Stacking*

Storage Building #1[16]. As of September 30, 2022, GWSB 1 contained 2,045 radioactive canisters and two archived non-radioactive canisters.

GWSB 2, with a similar design to GWSB 1, has 2,340 standard storage locations. The first radioactive canister was placed in GWSB 2 on July 10, 2006. Beginning in FY24, GWSB 2 will begin conversion to double-stack capability. The forecast is for 300 positions to be modified per year with a potential final capacity in GSWB 2 of 4,680 canisters. It may be necessary, however, to keep some of the positions in GWSB 2 as single-stack capable to accommodate any canisters that may have a higher heat generation rate than is allowable in the double-stack configuration. Additionally, this *Plan* does not foresee the need for all the positions in GWSB 2 to be double stacked so some of the positions may remain unconverted. As of January 1, 2022, GWSB 2 stored 2,271 radioactive canisters and one archived non-radioactive canister. The schedule for shipment of the canisters from SRS is not included in this *Plan*.

4.4 ***Salt Processing***

As highlighted in the *Introduction*, this *Plan* includes the continued use of SWPF for the remainder of the program. Appendix A—Salt Solution Processing reflects the breakdown of the volumes treated from each of the processes by year. Using the input assumptions for this Plan, over 100 Mgal of salt solution from the Tank Farms will have been processed over the life of the program. Over 14.6 Mgal were processed via DDA, ARP/MCU, TCCR, and SWPF as of the end of FY22.

Salt preparation capability is limited by the number of blend tanks available to prepare salt batches. A single tank can prepare 4 Mgal/yr. At present, Tank 21 (Type IV) and Tanks 41 and 42 (both Type IIIA) serve as blend tanks. An additional Type III tank, Tank 27, will be equipped for blend tank service allowing Tank 42 conversion to Sludge Batch preparation service in support of ABD processing. Tank 31 is planned for salt blend service, beginning in 2027, to accommodate closure of FTF and, with it, Tank 27.

4.4.1 Salt Waste Processing Facility (SWPF)

The SWPF receives waste from the HTF SWPF feed tank, Tank 49. The waste first goes to an alpha strike process (ASP) where an MST strike occurs. This decontaminates salt solution via adsorption of strontium-90 (Sr-90), actinides, and entrained sludge solids in the salt solution onto MST followed by filtration or settling. The actinides, Sr-90, and MST-laden sludge waste stream are transferred to DWPF for vitrification and the remaining clarified salt solution is transferred to the CSSX process.

The CSSX process uses a four-part solvent for removal of Cs-137 from caustic salt solutions. The key ingredient is the cesium extractant. Currently, SWPF uses the BoBCalix solvent. Beginning in 2024, MaxCalix is planned as the NGS. This solvent is fed to one end of a bank of centrifugal contactors while the waste is fed to the other end in a counter-current flow. The solvent extracts the cesium, with each successive contactor stage extracting more, resulting in a decontaminated salt solution (DSS) stream and a cesium-laden solvent stream. The solvent stream is stripped of its cesium, washed, and the solvent is reused. The DSS is subsequently transferred to feed SPF, currently via Tank 50 in HTF, and the cesium-laden solution from the CSSX process, known as SE, is transferred to DWPF to be combined with sludge from the tank farm for vitrification.

The SWPF processing rate is based on an assumed 100% availability for the Tank Farm feed as well as DWPF and SPF receipt of the SWPF discharge streams. The SWPF treatment process produces DSS that meets the SPF WAC limit.

Blend Tank Selection

“Source” and “Hub” tanks supply and collect the source material to be used in compiling the salt batch. “Blend” tanks receive and mix the source material to create the salt batch. The “Feed” tank receives the batch from the Blend tank and transfers it to SWPF. To support SWPF’s maximum throughput, multiple blend tanks are operated simultaneously.

There are three basic requirements for a tank to be eligible for use as a blend tank. The tank must be able to:

- Accept material from other tanks (receiving capabilities).
- Blend the material from the Source tanks (mixing capabilities)
- Send prepared feed to the Feed tank (transfer capabilities to Tank 49).

Additionally, the salt dissolution campaigns are planned according to the goals listed in the *System Plan Rev. 23 Goals* on page 4.

It should be noted that the remaining Type IV tanks in HTF are integral in closing FTF as they provide much needed usable tank space. Therefore, the model utilized the HTF Type IV tanks to support FTF closure and SWPF feed availability prior to their being scheduled for closure.

Tank 49 is the current Feed tank for SWPF. Tank 41 and Tank 42 (both Type IIIA) and Tank 21 (Type IV) are currently outfitted for service as salt solution blend tanks. The piping within the 2H evaporator cell was modified to reduce transfer conflicts so that Tanks 41 and 42 have direct transfer paths to Tank 49. As Tank 27 (Type IIIA) in FTF provides multiple transfer paths with the other FTF tanks, it is being converted for salt blend tank service and will replace Tank 42 as a salt blend tank. This allows a reduction in the number of inter-area transfers required to remove salt from FTF. The ongoing salt dissolution in Tank 27 would, once completed, provide adequate tank space for batch compilation. Installation of CSMPs and a transfer pump should be completed by the end of 2023 with salt dissolution sufficient to convert Tank 27 to a blend tank in 2024. To support closure of FTF, Tank 31 is added as an additional blend tank in 2027.

As infrastructure improvements occur and demands shift, the selection of blend tanks may change to operate as safely and efficiently as possible.

4.4.2 Saltstone Operations

The Saltstone operation consists of two main components. The SPF contains the tanks and equipment necessary to receive the feed and treat and process it into saltstone grout. The grout is pumped from SPF into the SDF, consisting of several SDUs for final disposition.

Saltstone Production Facility (SPF)

SPF receives DSS and other LLW from Tank 50 in HTF into one of two Salt Solution Receipt Tanks (SSRT). The facility treats the salt solution to produce grout by mixing the liquid feed stream with cementitious materials (blast furnace slag and fly ash). A slurry of the components is pumped into the SDUs, located in SDF, where the grout solidifies into a monolithic, non-hazardous, solid LLW form.

Saltstone Disposal Facility (SDF)

The first two SDUs, known as Vault 1 and Vault 4, used during the initial operation of the SPF, are slated for closure with no plans for future placement of radioactive grout. SDU 2 and SDU 5 (both of which are full) and SDU-3, currently in use, each consist of two cells with a nominal useable volume per cell of approximately 2.8 Mgal. Nominally, 1.76 gallons of grout is produced for each gallon of DSS feed, yielding a nominal cell capacity of approximately 1.5 Mgal of DSS. SDU 6, also a currently active SDU, consists of a single cell 375 feet in diameter by 43 feet high. SDU 6 has the capacity to disposition over 32.8 Mgal of grout. With similar external dimensions, SDU 7, another in use, through SDU 12, incorporated a design change to reduce internal obstructions and increase fill height, which yields a capacity of approximately 34.5 Mgal each. These “mega-SDUs” have a capacity of 18.7 (SDU 6) to 19.6 (SDU-7–12) Mgal of DSS from SWPF and other minor contributors to saltstone disposition. SDU 8 through SDU 12 are under construction.

4.5 *Innovations to Optimize System Performance*

The major SWPF and DWPF improvements that will enable throughput increases up to 9 Mgal/year are depicted in Figure 4-5. A more comprehensive illustration of the optimization plan, including an approximate timeline for implementation, is shown in Figure 4-6—*SRMC Optimization Plan*. The projects are grouped into those that have been implemented, several that are in progress, and others that were identified and are pending modeling results to determine which offer the best opportunity to boost production. Some of the improvements include:

- Improve filtration rate at SWPF
- Decrease monosodium titanate (MST) strike time and quantity of MST added
- Increase CSSX 100% throughput to 28 gpm from 21.6 gpm
  - This will be achieved with the deployment of NGS.
- Limit lost production at SWPF resulting from close coupling with DWPF through a combination of.
  - Decreased SE volume (NGS)
  - Increased DWPF plant availability
  - Accelerated SE consumption in DWPF
  - Increased SE consumption flexibility
    - more SE per SRAT Batch
    - Strip Effluent Feed Tank (SEFT) to SME

        - SE lag storage
    - Increased MST/SS consumption flexibility (volume of MST/SS per SRAT batch, availability of MST/SS lag storage)
- Improve DWPF recycle management within DWPF through a combination of.
    - Decrease/eliminate sample wait time
    - Decrease/eliminate permanganate strike time
    - Provide redundant RCT capability

Other factors limiting salt processing capacity, with the strategy to compensate for the limitation, are:

- **Equipment Reliability:** Equipment upgrades such as Tank Farm East Hill Utilities are planned to enhance the reliability of feed to SWPF
- **Transfer Line Integrity:** Occasionally, transfers are delayed due to Out of Service (OOS) transfer lines from failed pressure tests. Devising improved transfer line integrity is planned
- **Onsite Dry Feed Preparation:** Dry feed preparation at SPF requires the use of the existing silos to mix the components of the dry feed. An offsite dry feeds mixing plant would allow pre-mixing the dry feeds before reaching the Saltstone facility to increase dry feeds capacity and enable more efficient use of all four silos
- **Safety Basis Calculations:** Currently, engineering calculations are required prior to waste transfers to ensure the integrity of the flammability control program. Revision of the Tank Farm flammability program could minimize Engineering calculations and evaluations prior to performing transfers
- **Frit Development:** For each sludge batch, frit compositions are evaluated against projections for coupled operation with SWPF using the Product Composition Control System (PCCS) and the associated Measurement Acceptance Region (MAR) criteria. Recommended frit compositions will be robust enough to accommodate 2,800 gallons of MST/SS effluent sent to DWPF per week from SWPF.

4.5.1 Production Improvements Implemented

DWPF

Several improvements accelerated the DWPF feed preparation system to support SWPF operations at higher feed rates:

- Introduction of a new anti-foam agent
- Implementation of an alternate reductant, i.e., the glycolic acid flowsheet
- Reduced SRAT cycle time
- Beneficial reuse of DWPF recycle for waste removal and tank cleaning, in lieu of water additions,
    - supplements recycle reduction
    - maintains Tank Farm capacity (see §4.6.3 below).
- Reduction of liquid addition in DWPF supports receipt of SE from SWPF.

SWPF

Since the completion of Hot Commissioning and the One Year Operations period, several opportunities to improve the processing rate have been implemented by SRMC:

- Improved integrated operations with the other facilities
- Rebuild DSS Coalescer with improved gaskets
- SWPF ASP cleaning solution disposition
- Improved SE/CSSX coalescer cleaning sequence
- Diversion of SE stream during startup
- Recovery of CSSX solvent

Figure 4-5—*SWPF–DWPF Optimization*

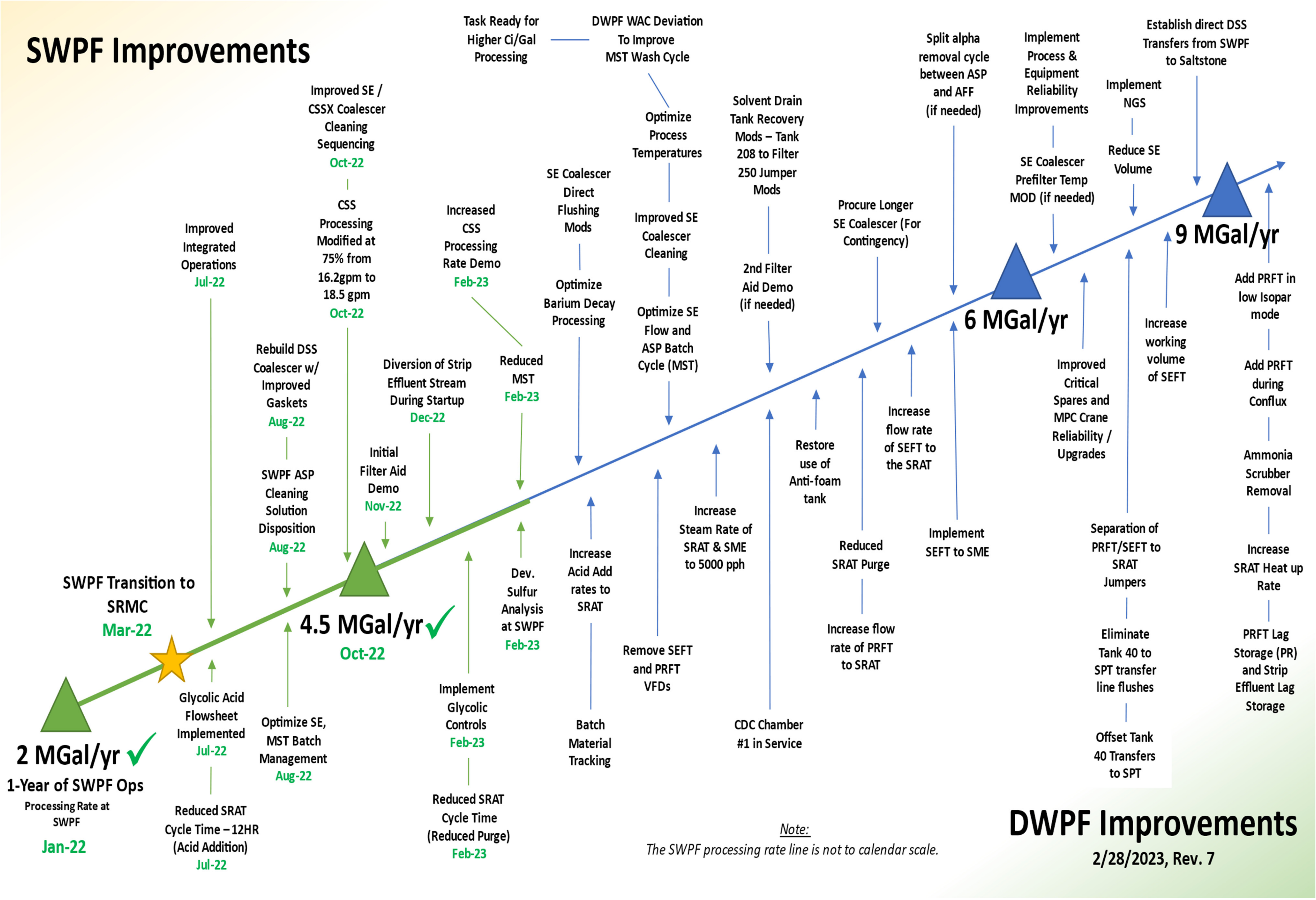
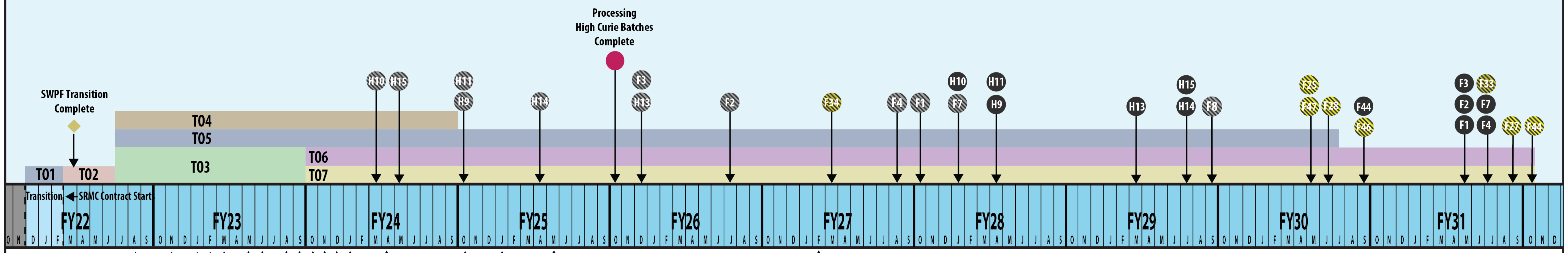


Figure 4-6—*SRMC Optimization Plan*

SRMC Optimization Plan - Base

r21

Closure/Risk Reduction



Optimizations

- IP Reduce time for 2H chemical/mechanical cleaning
- IP Increase Tank 22 recycle space
- Add filter aid
- IP Develop Sulfer Analysis at SWPF
- IP Reduce MST
- IP Use enhanced CSMPs for waste removal
- IP SE Coaslescer Direct Flushing Mods
- IP Improved SE Coalescer Cleaning
- IP Individual batch material tracking program calculations
- IP Optimize Process Temperatures
- IP Optimize SE Flow
- IP Begin acid additions with fewer sample results or assumed minimum additions
- Increase steam rate of the SRAT & SME to 5000 pph
- Optimize Process Streams at Startup
- Insoluble Solids Safety Basis revision
- GC jumper removal
- Remove canister heat as GWSB constraint
- Implement 24/7 staffing (Saltstone/ETF consolidation)
- Restore use of Antifoam tank
- Increase flow rate PRFT to the SRAT
- 2H Chemical Cleaning
- Tank Farm Passive Autocatalytic Recombiners
- Increase flow rate of SEFT to the SRAT
- Split alpha removal cycle between ASP and AFF
- NGS Implementation
- Implement SEFT to SME
- Use CLSM & simplify tank mods for grouting
- Risk based approach to waste removal & closure (23,47,48)
- Minimize heel removal for most tanks
- Add additional salt blend tank (TK27)
- Add 2nd sludge blend tank (ABD)

Legend

🟩 Integrated Priority List Item

Tank Status

- ● Old Style -PCWR Complete
- ● New Style -PCWR Complete
- ● Grouted Tank

Facility

- ◆ SWPF
- ◆ DWPF
- ◆ Saltstone
- ◆ F&H Tank Farms
- ◆ Tank Waste Retrieval & Tank Closure
- ◇ All Facilities
- IP In Progress
- Briefed DOE-SR Manager

Completed Items:

- Reduce SRAT Cycle Time(Reduced Purge)
- Implement Glycolic Controls
- Implement Glycolic Flowsheet
- Optimize use of existing maintenance facilities in LWO: rebuild SWPF contactors in 299H; rebuild SWPF manipulators in DWPF
- Add first frit drop if canisters not ready
- Higher Ci/gal processing
- 3 shift ops
- ASP Cleaning Solution Disposition
- Initiate Accelerated Closure Strategy (Tanks 9-11)
- Implement higher Curie Salt feed batches
- DBD Model Gaps Closed
- Resume SWPF processing (deliberate ops)
- Initiate Waste Retrieval & Tank Closure Optimization Initiatives
- Increase sodium molarity of salt feed
- Use 3rd salt blend tank
- 7 day coverage implemented
- Cement free grout implemented
- Mixer Phase I upgrades complete & being evaluated
- Super SRATs implemented
- Optimize SE, MST batch management
- Reduce DSS cycle times implemented
- Increase recycle beneficial reuse for salt batching
- Enhanced mixing jets with greater cleaning radius implemented
- Recovery of CSSX solvent
- PR in service (feasibility study)
- PPT working volume
- Initiate Waste Retrieval & Tank Closure Design Products Optimization

In Progress:

- Saltstone/ETF Consolidation
- Waste Retrieval & Tank Closure Optimization Initiatives - Design Product Optimizations
- SDU Optimization
- Disposable pumps (pump on a stick)
- GC removal
- Hg cell restoration
- DSS alternate WDA compliance strategy
- MPC Crane controls and cameras
- Double stack GWSB 1&2
- Implement canyon simplification
- MPC Crane Reliability
- Transfer Readiness
- Salt Batch Readiness
- ETAF Process
- Increase critical spares
- Maximize usage of DOE HLW interpretation
- Infrastructure/Reliability Upgrades

Planning (DBD Model to influence):

- Hg removal pump
- Ammonia scrubber removal (canyon simplification)
- Separation of SEFT/PRFT to SRAT jumpers
- Offset Tank 40 transfers to SPT
- Eliminate Tank 40 to SPT transfer line flushes
- Increase SRAT heat up rate
- Adding acid faster
- Flexibility in Engineering calculations
- Eliminate unnecessary lab work
- Add PRFT during Conflux
- Add PRFT in low isopar mode
- Strip effluent lag storage (PR in service)
- Increase working volume of SEFT
- PRFT lag storage (PR)
- Add SWPF sample for soluble sulfur in MST/sludge and SE (this could allow additional additions of both to SRAT batch if soluble sulfur has been removed.)
- Improve decon methods (ice pigging, laser ablation, new REDC soak tank) to allow equipment rebuilds and reduce spare procurements costs
- Establish direct DSS from SWPF to Saltstone
- Reduce volume of SE
- Isopar L destruction
- Establish single control room for SWPF inter-transfers [SWPF]
- Transfer line integrity strategy [Tank Farm]
- Additional control room consolidation [Tank Farms]
- Divert DWPF recycle direct to ETF & shutdown 3H evaporator
- Future mixer upgrades depending on results of Phase I
- Procure pre-blended dry feeds
- Concentrate feed
- Process Room
- Streamlined Engineering Equipment
- Accelerate transition for bulk waste removal to heel removal

Saltstone

The Saltstone facilities have been implementing reliability improvements under the Enhanced Low Activity Waste Disposition (ELAWD) project. The improvement under ELAWD include:

- **Silo bin discharge**—Reworked existing silo bin discharge system to allow silos to operate at full capacity. Implement software changes that will allow air to be pulsed through the silo during downtimes to prevent packing and bridging
- **Knife gate valve or equivalent**—Installed knife gate valve assembly at each silo to enhance the system's abilities to handle inconsistencies with bulk materials and aid in dry material recipe accuracy
- **Screw feeder**—Replaced the existing obsolete screw feeder
- **Weather protection**—Enclosed the Premix Feed Bin and Loss-In-Weight hopper to protect the many flexible couplings and joints that are susceptible to water intrusion
- **Flexible couplings**—Upgraded each flexible coupling to provide improved sealing and weather resistance
- **Dust collectors**—Updated Silo 2 dust collector to improve simultaneous truck unloading capacity for Silos 1, 2, and 3.

Additional SPF improvements include:

- Mixer upgrades
- Cement free grout

Tank Farms

Continuing improvements in Tank Farms have included:

- Introducing a third salt blend tank
- Incorporation of DWPF recycle in salt batches
- eLVMJ's with greater cleaning radius to improve salt dissolution
- Submersible blend pump reliability improvements

Several maintenance improvement initiatives improve reliability and availability of equipment including:

- Utilizing the 299-H maintenance facility to rebuild SWPF contactors
- Utilizing the existing manipulator maintenance facility in DWPF to rebuild SWPF manipulators

4.6 *Tank Closure*

4.6.1 Heel Removal and Cleaning

Heel Removal

After completion of waste removal using the technologies discussed above, the waste heel is removed. Heel removal has consisted of a combination of mechanical heel removal and chemical cleaning. Depending on tank conditions, chemical cleaning has been performed prior to mechanical heel removal, or some mechanical heel removal and some chemical heel removal has been performed iteratively. Heel removal activities end when the heel solids, including any remaining highly radioactive radionuclides, have been removed to the extent technically practicable from an engineering perspective,

Mechanical Heel Removal

For mechanical heel removal, this *Plan* assumes vigorous mixing continues, using mixing pumps. Additional mechanical removal may be achieved through directing pump discharges in specific patterns to impact remaining material, until reaching a point of diminishing returns.

Chemical Cleaning

Chemical cleaning was performed on sludge tanks wherein a sludge heel is subjected to conditions similar to LTAD (see § 4.1). It was, however, determined to be ineffective for the radionuclides of interest, so no further chemical cleaning is planned.

Cooling Coil Flushing

For waste tanks with cooling coils, the inner surface of the cooling coils may be flushed with water to remove any remaining chromated cooling water, residual waste, and other contaminants that may have migrated into the coils. The flush also reduces the corrosion inhibitor (sodium chromate) coating on the interior surface of the coils. The cooling coil flush takes place during heel removal and is repeated until the environmental risks have been reduced to the maximum extent practical.

Annulus Cleaning

Some Type I and II tanks have waste in the annular spaces, typically a soluble form of salt appearing as dried nodules on tank walls at leak sites and at the bottom of the annulus pan. These tanks will be inspected to determine if Annulus Cleaning is required. For those tanks requiring annulus cleaning, this waste will be removed from the annulus to the extent technically practicable from an engineering perspective and the highly radioactive radionuclides removed to the maximum extent practical before declaring the tank ready for grouting.

4.6.2 Tank Operational Closure and Stabilization

Type I, II, and IV tanks are planned for operational closure in accordance with a formal agreement among the DOE, EPA Region IV, and SCDHEC as expressed in the approved Federal Facility Agreement (FFA). Eight of these tanks were operationally closed and stabilized (grouted): FTF Tanks 17 and 20 in 1997, Tanks 18 and 19 in 2012, Tanks 5 and 6 in 2013, and HTF Tank 16 in 2015 and Tank 12 in 2016.

Operational closure and stabilization consist of those actions following waste and heel removal that bring liquid radioactive waste tanks and associated facilities to a state of readiness for final closure of the Tank Farms complex, including:

- Sampling and Characterization
- Developing tank-specific regulatory documents
- Isolating the tank from all operating systems in the surrounding Tank Farm (e.g., electrical, instruments, steam, air, water, waste transfer lines, and tank ventilation systems)
- Stabilizing by grouting of the primary tank, remaining equipment, annulus, and cooling coils
- Capping of select tank risers.

This *Plan* generally assumes thirty months from the last removal of any material until completion of grouting.

Sampling and Characterization

Before declaring a tank ready for grouting, the tank and annulus are inspected, the residual volume is estimated, and the residual waste is sampled in accordance with a sample plan. Laboratory analysis of the samples yields concentrations of radiological and non-radiological constituents in the remaining material. The SCDHEC-approved Sampling Analysis Program Plan and associated Quality Assurance Program Plan currently recognize the Savannah River National Laboratory (SRNL) as the laboratory to perform residual characterization analysis. Concentration and volume data are used to characterize the residual material to produce radiological and non-radiological inventories.

Tank Isolation

Tank isolation is the physical process of isolating transfer lines and services from the tank. Isolating the tank from tank farm systems and services prohibits chemical additions or waste transfers into or out of the tank. Further isolation of a tank, after filling with grout, is planned to include cutting and capping or blanking mechanical system components (air piping/tubing, steam piping, etc.) and disconnecting electrical power to process components on the tank.

Closure Documentation Development

Tank-specific closure documents and other regulatory documentation are prepared to demonstrate compliance with State and DOE regulatory requirements as well as NDAA §3116. An area specific WD approach ensures the NDAA §3116 tank operational closure process is implemented as efficiently as possible. A Performance Assessment (PA) and NDAA §3116 Basis Documents were generated for each Tank Farm. The NDAA §3116 Basis Documents include the waste tanks as well as ancillary structures located within the boundary of the respective Tank Farm. The CGCP was developed and approved by SCDHEC.

DOE Radioactive Waste Management Manual 435.1-1 mandates a Tier 1 Closure Plan and associated Tier 2 Closure Plans. Each Tier 1 plan is area-specific and provide the bases and process for moving forward with tank grouting. This document is approved at the DOE-Headquarters level. Each Tier 2 document is tank-specific, follow the approved criteria established in the Tier 1 document, and is locally approved by DOE-SR.

Development of a tank-specific Closure Module (CM), per the State-approved CGCP, follows completion of tank cleaning activities. The CM describes the waste removal and cleaning activities performed and documents the proposed end state. Final characterization data supports the performance of a Special Analysis which determines if final residual inventories continue to support the conclusions of the area-wide PA.

Grout Selection and Manufacture

A reducing grout provides long-term chemical durability and minimizes leaching of residual waste over time. The reducing grout selected is self-leveling, and encapsulates any equipment remaining inside the tank and annulus. The grout also provides for intruder prevention in tanks that do not have a thick concrete roof. Grouting preparation activities include field modifications, temporary ventilation installation, grout plant mobilization, and grout procurement.

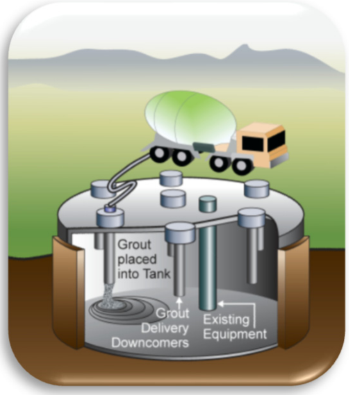


Figure 4-7—*Grout Placement*

Grout Placement

Grout fill operations, including site preparation, pumper truck set up, grout delivery lines, and grout equipment setup are established around the tanks (see Figure 4-7). A grouting sequence for tanks with an annulus ensures voids are filled and the structural integrity of the tank is maintained. Generally, grouting the annulus and primary tank in alternating steps provides structural support for the tank wall.

Equipment Grouting

For tanks with installed equipment or cooling coils, internal voids are filled with a flowable grout mixture. In those tanks where the cooling coils have broken, alternative techniques are used to minimize voids in the grout matrix.

Riser Grouting and Capping

The final step, after filling the tank, may include encapsulating select risers. When necessary, forms are built around the risers and grout is used to encapsulate the risers providing a final barrier to in-leakage and intrusion. The final grouted tank configuration is an integral monolith with minimal voids ensuring long-lasting protection of human health and the environment (see Figure 4-8).

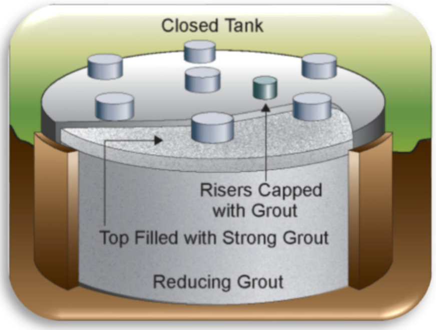


Figure 4-8—*Grouted Tank*

4.6.3 Ancillary Structure Operational Closure and Stabilization

Both FTF and HTF contain ancillary structures with internal equipment that may have a residual contaminant inventory that must be accounted for as a part of final closure of the Tank Farms complex. These ancillary structures include such things as buried transfer lines, pump tanks, and evaporators, many of which have been in contact with LW during the operating life of the facilities. The ancillary structures were used in the FTF and HTF to transfer waste (e.g., transfer lines, pump tanks) and reduce waste volume through evaporation (e.g., the evaporator systems). In some cases, the ancillary structures served as access points for transfer systems and as secondary containment for associated jumpers (i.e., diversion boxes). In this manner, ancillary structures can be compared to the waste tanks which have primary containment (i.e., the primary steel tank) and secondary containment (i.e., the partially/fully lined annulus). The amount of contamination associated with these components depends on such factors as the component service life, its materials of construction, and the contaminating medium in contact with the component. One difference with operational closure of the ancillary structures is that, depending on their final inventory, a reducing grout may not be necessary. The ancillary structures, nonetheless, will need to be filled with an appropriate material that will prevent future collapse of the structure.

As required by the FTF and HTF NDAA §3116 WDs, Tier 1 Closure Plans, and the State-approved CGCP, the ancillary structures must go through the same operational closure process as described above for the waste tanks. All regulatory documentation and associated approvals by SCDHEC, EPA, and DOE required for the waste tanks is also required for operational closure of the ancillary structures, including a CM, Special Analysis, and Tier 2 Closure Plan. A specific listing of the ancillary structures which must follow this process is listed in the CGCP and includes:

- FTF
    - 1F Evaporator
    - 2F Evaporator
    - Transfer line systems, including over 45,000 feet of below grade double-wall pipe
    - Leak Detection boxes and Modified Leak Detection Boxes
    - Three Pump Pits and a Condensate Transfer System pump pit
    - Six Diversion Boxes
    - One Catch Tank

  All flushing of the FTF ancillary structures will be done before closure of the IAL in 2034.

- HTF
    - 1H Evaporator
    - 2H Evaporator
    - 3H Evaporator
    - Transfer line systems, including over 74,750 feet of below grade double-wall pipe
    - Leak Detection boxes and Modified Leak Detection Boxes
    - Ten Pump Pits and two Condensate Transfer System pump pits
    - Eight Diversion Boxes
    - One Catch Tank

  All flushing of the HTF ancillary structures will be done before 2037. Final closure of the ancillary structures in both FTF and HTF will be accomplished after 2037.

Of the ancillary structures in FTF and HTF, F-Diversion Boxes (FDB)-5 & 6 were closed in FY22 consistent with the FFA, Appendix L, 2019 Suspension Agreement. The FTF structures will be flushed and prepared for closure by 2033 when the IAL from FTF to HTF is ready for closure. The HTF structures will be flushed and prepared for closure by 2036. Final operational closure of the ancillary structures will be completed by 2037.

4.7 ***Base Operations***

4.7.1 Supporting Nuclear Material Stabilization

ABD materials, as described in *Accelerated Basin Deinventory Baseline Projection*[14] will be received into the sludge preparation tanks at the beginning of the sludge batch preparation process. The final ABD discard will be received no later than February 2034.

ABD scope includes processing and discard of fuels that have aluminum-based cladding (ASNF), as well as fuels with cladding made with other materials, such as stainless steel and Zircaloy, i.e., Non-Aluminum Spent Nuclear Fuel, (NASNF). The fissile waste stream is expected to be similar for both; metal dissolution products from cladding will necessarily be different. Discard of NASNF is expected to follow last discard from Fast Critical Assembly (FCA) processing.

H-Canyon discards are expected to be received into the remaining planned sludge batches. The fissile material coming from H-Canyon is expected to be mostly U-235, with two batches, SB 12 and SB 13, receiving the majority of the Pu-239 discarded. As shown in Table 4-1 below, the majority of the fissile material in future sludge batches will be from ABD program discards, not the waste currently residing in the Tank Farms. The fissile concentration in glass, while allowed to exceed 2,500 g/m^3 after SB 11, is not forecast to exceed 2,500 g/m^3 until SB 14.

The mass of U-235 received during the ABD program is modeled as coming with an equal mass of U-238 (approximately 50 wt% enrichment). Additional depleted uranium will be added to a sludge batch if nuclear criticality limits are not met.

Table 4-1—*Fissile Material by Sludge Batch*

	ABD Program					Tank Farm					
Sludge Batch	U-235 (kg)	U-233 (kg)	Pu-239 (kg)	Pu-241 (kg)	Assumed U-238 (kg)	Fissile (kg)	U-238 (kg)	U-235eq wt%	Additional DUO Needed	Amount of Additional DUO (kg)	Fissile Loading in Glass (g/m^3)
SB11	556	0	5	0	556	84	2,399	4.90%	Yes	10,186	2,222
SB12	369	0	131	0.92	369	155	26,798	60.1%	Yes	200	2,164
SB13	369	0	131	0.92	369	110	20,078	60.1%	Yes	200	2,156
SB14	590	0	3	0.56	590	176	21,411	48.4%	No		2,718
SB15	586	6	28	0.59	586	152	11,260	52.3%	Yes	3,000	2,830
SB16	615	15	2	0.60	615	114	11,203	49.7%	Yes	4,000	2,732
SB17	658	9	7	0.59	658	108	15,293	49.5%	No		3,149
SB18	574	0	7	0.56	574	104	20,249	48.8%	No		2,894
SB19	953	0	4	1.00	953	57	11,133	47.9%	Yes	8,500	3,555

4.7.2 DWPF Recycle Handling

Aside from the SWPF DSS received into Tank 50 and transferred directly to Saltstone, DWPF recycle is the largest influent stream received by the Tank Farm. The DWPF recycle rate, historically between 1.5 and 1.9 Mgal/yr prior to SWPF, could increase to as high as 3.2 Mgal/yr during SWPF operations because of extra water in the SE and MST slurry received into DWPF. Additionally, higher Cs-137 concentrations could require the operation of two Steam Atomized Scrubber (SAS) stages in the DWPF melter offgas system, whereas currently only one SAS stage is operated.

In this *Plan*, disposition of the recycle stream is handled in one of three ways, depending on processing circumstances:

- Recycle may be evaporated in the 2H Evaporator System, exclusively, due to chemical incompatibility with other waste streams.
- Recycle may be beneficially reused within the LW system. The recycle contains less than 1.0 molar sodium, so it is suitable for salt solution molarity adjustment, salt dissolution, or heel removal (Those needs also may be supplemented by water, as required.) Beneficial reuse minimizes operation of the 2H Evaporator.
- Upon completion of salt waste processing through SWPF, recycle will be diverted away from Tank Farm facilities and dispositioned directly through SWPF, allowing closure of Tank 22, the DWPF recycle receipt tank.

4.7.3 Transfer Line Infrastructure

Efforts will continue to be made to keep transfers between tanks to a minimum. However, with SWPF operation, executing this *Plan* requires more frequent transfers than have historically occurred in the Tank Farm. Therefore, there is less “idle time” in the transfer system to accommodate short downtimes needed to address emergent repair activities.

New infrastructure is required to accomplish transfers to support SWPF, while also continuing activities such as waste removal and evaporation. Discoveries of unexpected conditions in existing transfer systems could impact the installation of new transfer lines and equipment.

The transfers in this *Plan* are generally based on the known current infrastructure. The actions described can be executed as long as the planned modifications are made, and significant failures of key transfer equipment do not occur or can be mitigated quickly enough to allow activities to proceed as planned. While this *Plan* does not attempt to explain all the modifications needed or anticipate the failure of specific pieces of transfer equipment much of this is addressed in the ROMP.

4.7.4 Tank 48 Treatment

Tank 48 contains legacy organic waste from previous salt treatment processes. Several technologies have been considered, including Fluidized Bed Steam Reforming and Copper Catalyzed Peroxide Oxidation, to treat the organic components and enable the waste to be dispositioned as grout or vitrified glass. Systems Engineering Evaluations will select an appropriate technology to allow Tank 48 treatment to begin in FY32 followed by operational closure. To ensure adequate grout capacity is available, this *Plan* assumes Tank 48 waste disposition yields 2 Mgal to be received in SPF.

4.7.5 Effluent Treatment Facility (ETF)

The ETF, located in H-Area, collects and treats process wastewater that may be contaminated with small quantities of radionuclides and process chemicals. The primary sources of wastewater include the 2H and 3H Evaporator overheads and H-Canyon contaminated water. The wastewater is processed through the treatment plant and pumped to Upper Three Runs Creek for discharge at an NPDES permitted outfall. Tank 50 receives ETF residual waste for storage prior to treatment at SPF and final disposal at SDF. A 35-kgal Waste Concentrate Hold Tank provides storage capacity at ETF to minimize transfer impacts directly to Tank 50 or SPF during SWPF operations.

4.7.6 Managing Type III Tank Space

Type III tank space is essential to all the processes described in this *Plan*. Limited waste storage space exists in Type III/IIIA tanks in both FTF and HTF. There is a risk (cf. ROMP) that a leak in a primary tank or other adverse event could occur that might impair execution of this *Plan.*

In the 3H Evaporator System, space is needed for evaporator concentrate receipt to support periodic salt dissolutions and storage of high-hydroxide waste that does not precipitate into salt. This “boiled-down” liquid is commonly referred to as “liquor” or “concentrate” and removing the “liquor” from an evaporator system is referred to as “deliquoring.” Evaporator effectiveness is diminished when the concentrate receipt tank salt level is 330″ or greater—at this point, the evaporator system is said to be “salt bound.” Deliquoring both the 2H and 3H Evaporators and salt removal from Tank 37, a 3H Evaporator concentrate receipt tank, are planned on a regular basis to ensure continued viability of the Evaporators. Tank 29 is being prepared as an alternate 3H Evaporator concentrate receipt tank, requiring occasional salt removal, also.

In addition, this *Plan* incorporates contingency, when allowable, to provide the best opportunity for success. Lack of evaporator working space could hinder tank removals from service, canister production rate at the DWPF, or H-Canyon support.

The 3H Evaporator, which supports both H-Canyon receipts and sludge washing, is assumed to operate using the current configuration, without requiring an evaporator pot replacement. Similarly, no evaporator pot replacement is forecast for the 2H Evaporator. Were an evaporator to need a pot replacement, spare evaporator pots are available for both evaporators.

4.7.7 Closure Sequence for the LW System

After the HTF and FTF tanks and ancillary equipment have been closed, the LW facilities outside the Tank Farm—DWPF, SWPF, ARP/MCU, SPF, SDF, and associated ancillary equipment—will be available for beneficial reuse, if required. Otherwise, these facilities will be available for final removal from service.

While the general priority is to close geographically proximate equipment and facilities, thus minimizing long-term cost, the actual sequence of the shutdowns is predicated on the capability of the facilities to process the particular blends required by the salt and sludge treatment processes. The priority (but not necessarily the sequence) for shutdowns as modeled is:

1. Type I and II tanks
2. F-Area waste tanks, the 2F Evaporator, and ancillary equipment (including 1F Evaporator and the concentrate transfer system)
3. H-Area West Hill waste tanks, the 3H Evaporator, and ancillary equipment (including 1H Evaporator)
4. H-Area East Hill waste tanks, the 2H Evaporator, and ancillary equipment (including any remaining ARP/MCU equipment)
5. Major remaining processing facilities (e.g., DWPF, SWPF, SDF/SPF).

The key elements of the systematic closure sequence for shutting down and closing the LW System are:

- Waste removal is complete from all Type I and II tanks (2030)
- All Type I and II tanks are operationally closed (2033)
- 3H Evaporator shut down (2034)
- H-Canyon processing influents cease (2034)
- 2H Evaporator shut down (2034)
- FTF waste removal is completed (2034)
- IAL removed from service (2034)
- HTF (West Hill) waste removal is complete (2034)
- SWPF shut down (2036)
- FTF Type III tanks are operationally closed (2036)
- HTF (East Hill) waste removal is complete (2036)
- DWPF shut down (2036)
- All facility flushes are complete (2037)
- All tanks are operationally closed (2037)

5. System Description

5.1 *History*

The Liquid Waste (LW) System is the integrated series of facilities at the Savannah River Site (SRS) that safely manage the existing waste inventory and disposition waste stored in the tanks into a final glass or grout form. This system includes facilities for storage, evaporation, waste removal, pre-treatment, vitrification, and disposal.

Since it became operational in 1951, SRS, a 300-square-mile DOE Complex located in the State of South Carolina, has produced nuclear material for national defense, research, medical, and space programs. The separation of fissionable nuclear material from irradiated targets and fuels resulted in the generation of over 165 million gallons (Mgal) of radioactive waste. As of September 2022, over 34.5 Mgal[17] of radioactive waste are stored onsite in large underground waste storage tanks at SRS. Most of the tank waste inventory is a complex mixture of chemical and radioactive waste generated during the acid-side separation of special nuclear materials and enriched uranium from irradiated targets and spent fuel using the Plutonium Uranium Reduction Extraction (PUREX) process in F-Canyon and the modified PUREX process in H-Canyon (HM). Waste generated from the recovery of Pu-238 in H-Canyon to produce heat sources for space missions is also included. The waste was converted to an alkaline solution; metal oxides settled as sludge, and supernate evaporated to form saltcake.

The variability in both nuclide and chemical content occurred because waste streams from the 1st cycle (high heat) and 2nd cycle (low heat) extractions from each Canyon were stored in separate tanks to better manage waste heat generation. When these streams were neutralized with caustic, the resulting precipitate settled into four characteristic sludges presently found in the tanks where they were originally deposited. The soluble portions of the 1st and 2nd cycle waste were similarly partitioned but are blended during waste transfer and staging of salt waste for evaporative concentration to supernate and saltcake. Historically, fresh waste receipts were segregated into four general categories in the SRS Tank Farms: PUREX high activity waste, PUREX low activity waste, HM high activity wastes and HM low activity wastes. Because of this segregation, settled sludge solids contained in tanks that received fresh waste are readily identified as one of these four categories. Fission product concentrations are about three orders of magnitude higher in both PUREX and HM high-activity waste sludges than the corresponding low-activity waste sludges.

Because of differences in the material processed by PUREX and HM processes, the chemical compositions of principal sludge components (iron, aluminum, uranium, manganese, nickel, mercury, and noble metals) also vary over a broad range between these sludges. Combining and blending salt solutions has tended to reduce soluble waste into blended salt and concentrate, rather than maintaining four distinct salt compositions. Continued blending and evaporation of the salt solution deposits crystallized salts with overlying and interstitial concentrated salt solution in salt tanks located in both Tank Farms. More recently, with transfers of sludge slurries to sludge washing tanks, removal of saltcake for tank removal from service, receipts of DWPF recycle, and space limitations restricting full evaporator operations, salt solutions have been transferred between the two Tank Farms. Intermingling of PUREX and HM salt waste will continue through the end of the program.


Tanks under construction. Note tank size relative to construction workers. Later, dirt is backfilled around the tanks to provide shielding

Continued long-term storage of these radioactive wastes poses a potential environmental risk. Therefore, since 1996, DOE and its contractors have been removing waste from tanks, pre-treating it, vitrifying it, and pouring the vitrified waste into canisters for long-term disposal in a permanent canister storage location (see Figure 5-2—*Process Flowsheet*). As of September 30, 2022, DWPF had poured 4,319 vitrified waste canisters (see Figure 5-3—*Liquid Waste Program—Current Status*).

5.2 *Tank Storage*

SRS has 51 underground waste storage tanks, all of which were placed into operation between 1954 and 1986. There are four types of waste tanks—Types I through IV. Type III tanks are the newer style tanks, placed into operation between 1969 and 1986. There are 27 Type III tanks. The Types I, II, and IV tanks, commonly referred to as "old-style" tanks, lack full secondary containment. Type I tanks are the oldest tanks, constructed in 1952 through 1953.

Type II waste tanks were constructed in 1955 through 1956. There are eight Type IV tanks, constructed in 1958 through 1962. Four Type IV tanks, Tanks 17 through 20; three Type I tanks, Tank 5 and Tank 6 in F-Tank Farm (FTF) and Tank 12 in H-Tank Farm (HTF); and one Type II tank, Tank 16 in HTF have been isolated, grouted, and operationally closed. Fourteen tanks without full secondary containment have a history of leakage[18]. Because of program progress to date, of these 14 SRS tanks (all old-style tanks) with leakage history:

- 6 are operationally closed and grouted (Tanks 5, 6, 12, 16, 19, and 20)
- 3 are in accelerated closure (Tanks 9, 10, and 11)
- 1 is undergoing heel removal (Tank 15)
- 2 contain essentially dry waste, with little or no free liquid supernate (Tanks 1 and 14)
- 2 contain liquid at a level below known leak sites (Tanks 4 and 13).

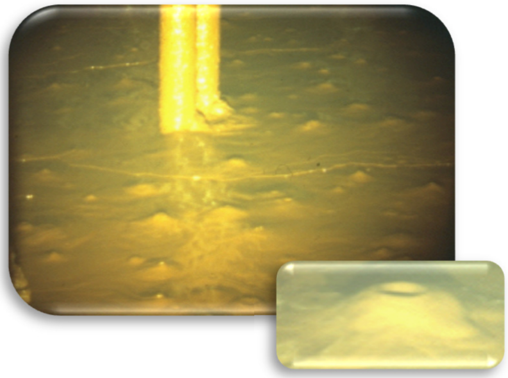
Of the remaining 10 old-style tanks (none of which have any known leakage history):

- 2 are operationally closed and grouted (Tanks 17 and 18)
- 2 contain essentially dry waste, with little or no free liquid supernate (Tanks 2 and 3)
- 6 contain liquid supernate. (Tanks 7, 8, and 21 through 24).

Salt waste is dissolved in the liquid portion of the waste. It can be in normal solution as Supernate (top picture) or, after evaporation, as salt cake (bottom picture) or concentrated supernate. The pipes in all the pictures are cooling coils.

When waste disposition began in 1996, the inventory of waste in the SRS tank system contained approximately 550 million curies (MCi). Currently, 34.5 Mgal of radioactive waste, containing 222 MCi[17] of radioactivity, are stored in 43 active waste storage tanks located in two separate locations, H-Tank Farm (27 tanks) and F-Tank Farm (16 tanks). This waste is a complex mixture of insoluble metal hydroxide solids, commonly referred to as sludge, and soluble salt supernate. The supernate volume is reduced by evaporation, which also concentrates the soluble salts to their solubility limit. The resultant solution crystallizes as salts. These resulting crystalline solids are commonly referred to as saltcake. The saltcake and supernate combined are referred to as salt waste.

The sludge component of the radioactive waste represents approximately 2.5 Mgal (7% of total) of waste but contains approximately 108 MCi (49% of total). The salt waste makes up the remaining 32 Mgal (93% of total) of waste and contains approximately 114 MCi (51% of total). Of that salt waste, the supernate accounts for 16.5 Mgal and 102 MCi and saltcake accounts for the remaining 15.5 Mgal and 12 MCi[17]. The sludge contains the majority of the long-lived (half-life greater than 30 years) radionuclides (e.g., actinides) and strontium. The sludge is being stabilized in the Defense Waste Processing Facility (DWPF) through a vitrification process that immobilizes the waste in a borosilicate glass matrix. The salt is separated in the Salt Waste Processing Facility (SWPF) into a higher-level component being stabilized in DWPF and a lower-level component solidified in the Salt Disposal Facility (SDF).

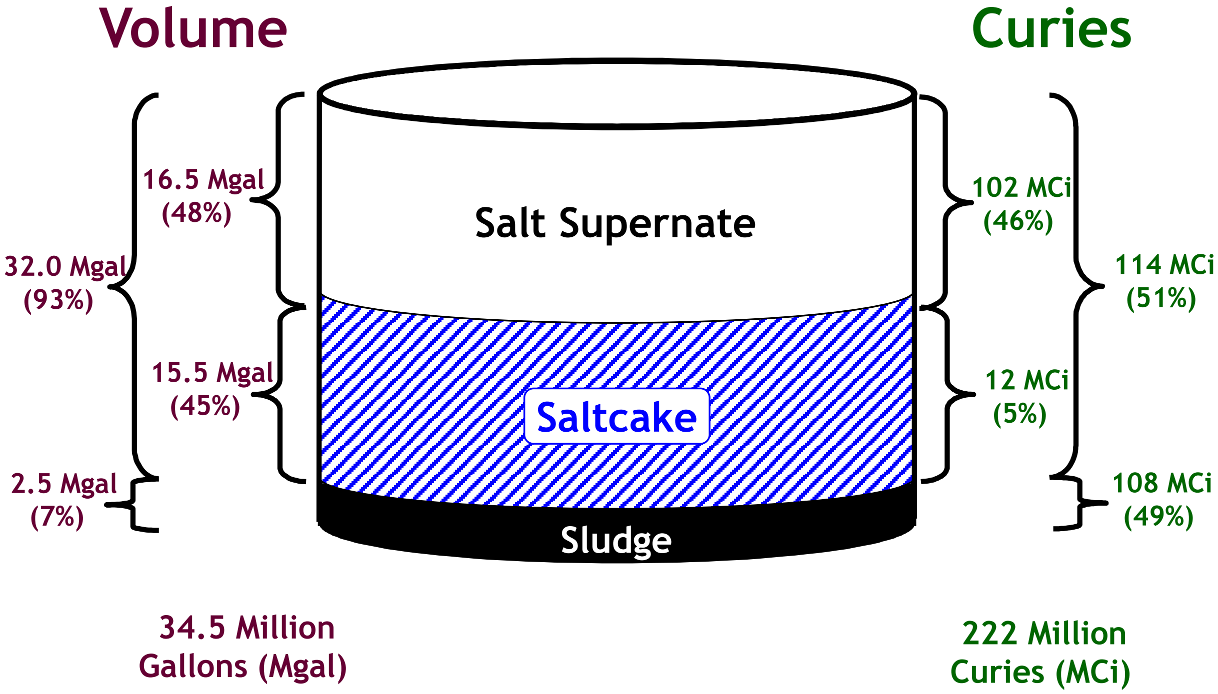


Sludge consists of insoluble solids that settle to the bottom of a tank. Note the offgas bubbles, including hydrogen generated from radiolysis.

Radioactive waste volumes and radioactivity inventories reported herein are based on the Waste Characterization System (WCS) database, which includes estimates of the chemical and radionuclide inventories on a tank-by-tank basis. WCS is a dynamic database frequently updated with new data from ongoing operations such as decanting and concentrating of free supernate via evaporators, preparation of sludge batches for DWPF feed, waste transfers between tanks, waste sample analyses, and influent receipts such as H-Canyon waste and DWPF recycle.

Well over 95%[17] of the salt waste radioactivity is short-lived (half-life less than 30 years) Cs^{137} and its daughter product, Ba^{137m}, along with lower levels of Sr^{90} actinide contamination. The cesium concentration varies according to the waste stream (e.g., canyon waste, DWPF recycle waste). The precipitation of salts following evaporation can also change the cesium concentration. The concentration of cesium is significantly lower than non-radioactive salts in the waste, such as sodium nitrate and nitrite, therefore, the cesium does not reach its solubility limit and only a small fraction precipitates[19]. As a result, the cesium concentration in the saltcake is much lower than in the liquid supernate and interstitial liquid fraction of the salt waste.

Figure 5-1—*Waste Tank Composite Inventory (as of September 30, 2022)*[17]



5.3 *Waste Tank Space Management*

To make better use of available tank storage capacity, incoming LW is evaporated to reduce its volume. This is important because most of the SRS Type III waste storage tanks are already near full capacity. Since 1954, the Tank Farms have received over 165 Mgal of LW, of which over 110 Mgal have been evaporated, leaving approximately 34.5 Mgal in the storage tanks, the balance having been dispositioned via ARP/MCY, SWPF, DWPF, and SPF. Projected available tank space is carefully tracked to ensure that the Tank Farms do not become "waterlogged," meaning that so much of the usable Type III tank space has been filled that normal operations and waste removal and processing operations cannot continue. A contingency allotment of 1.3 Mgal is not included as working space. This amount is equivalent to the size of the largest tank and is reserved for the unlikely event that a full tank failed such that all its material had to be removed. Waste receipts and transfers are normal Tank Farm activities as the Tank Farms receive new or "fresh" waste from the H-Canyon stabilization program, LW from DWPF processing (typically referred to as "DWPF recycle"), and wash water from sludge washing. The Tank Farms also make routine transfers to and from waste tanks and evaporators. Two evaporator systems are currently operating at SRS—the 2H and 3H systems.

Space in new-style tanks is used for various operations for waste processing and disposal. Tank space is recovered through evaporator operations, DWPF vitrification, SWPF treatment, and Saltstone disposal. This valuable space has been used to:

- retrieve waste from and clean old-style tanks
- prepare, qualify, and treat sludge waste for disposal
- prepare, qualify, treat, and dispose salt waste for treatment
- support nuclear materials stabilization and disposal in H-Canyon.

The Tank Farm space management strategy is based on a set of key assumptions involving projections of DWPF canister production rates, SWPF Processing rates, influent stream volumes, Tank Farm evaporator performance, and space gain initiative implementation. The processing of salt and sludge utilizes existing tank space to retrieve and prepare waste. Sludge processing through DWPF removes the highest risk material from the old-style tanks. However, for every gallon of sludge processed, 1.3 gallons of salt waste is formed due to sludge washing and DWPF processing operations with the resulting low-level salt waste returned to the Tank Farm. Similarly, salt waste retrieval, preparation, and batching typically require the use of three gallons of tank space per gallon of saltcake processed. Given these parameters, the "key to reducing the overall risk is processing high-level waste as expeditiously as possible and managing the total tank space efficiently," as recognized by the Defense Nuclear Facilities Safety Board (DNFSB) letter dated January 7, 2010[20].

New-style tank space is used to prepare HLW for permanent immobilization and disposition in a vitrified waste form and low-level waste in a grouted waste form. Additionally, several "old-style" tanks support immobilization and disposition of high-level waste. The tank space management program maintains sufficient space to allow continued DWPF operations. The tank space management program also provides the necessary tank space to support staging of salt solutions to sustain salt waste treatment via SWPF.

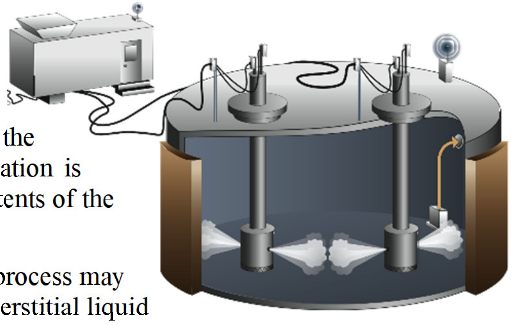
There are currently ~7.6 Mgal of empty space (~22%) in these new-style tanks as of September 30, 2022:

- 4.7 Mgal is margin as defense-in-depth operational control coupled with Safety Class (SC) or Safety Significant (SS) structures, systems, or components (SSC) to facilitate reasonably conservative assurance of more than adequate dilution and ventilation of potentially flammable vapors
- 1.3 Mgal is procedurally required minimum contingency space for recovery from the unlikely event of a large waste leak elsewhere in the system
- 3.6 Mgal is operational "working" space variously used to provide:
    - Additional contingency transfer space as operational excess margin above the procedurally required minimum
    - Excess margin to preserve salt batch quality and maintain uninterrupted treatment and disposition through SWPF and Saltstone
    - Excess margin to preserve sludge batch quality and maintain uninterrupted immobilization through DWPF
    - Excess margin to preserve uninterrupted support for H-Canyon.

5.4 *Waste Removal from Tanks*

The first step in the disposition of sludge and salt waste is waste removal. Sludge is removed from the tank and transferred to a sludge hub tank or feed preparation tank ensuring sludge waste is continuously available for treatment at DWPF. Salt is dissolved, removed, and staged for treatment at SWPF.

For sludge removal the process is completed utilizing several mixer pumps and adding sufficient liquid to the tank to suspend sludge solids. Existing supernate is used, when practical, to minimize introduction of new liquids into the system. Operation of the mixer pumps suspends the solids, which are then transferred as a slurry from the tank. This operation is repeated, periodically lowering the mixer pumps, until the remaining contents of the tank can no longer be effectively removed by this method.



Tanks that are full of salt and at the beginning of the salt waste removal process may be approached using a DAR method. Initially, the highly concentrated interstitial liquid salt solution is drained. **D**issolution liquid is then added using a liquid **A**ddition downcomer or a Low Volume Mixing Jet (LVMJ) which entrains existing liquid to promote more contact with the bulk saltcake. The resulting dissolved salt solution is **R**emoved simultaneously. Subsequent use of Commercial Submersible Mixer Pumps (CSMP) provides more vigorous mixing, resulting in improved dissolution. The process ends with the transfer of the dissolved salt solution to a salt solution hub tank until it is ready to be assembled into a salt batch in one of the blend tanks.

5.5 *Safe Disposal of the Waste*

The goal is to convert the majority of the waste into one of two final waste forms: glass, which will contain over 99% of the radioactivity, and grout, which will contain most of the volume. Each of the waste types at SRS needs to be treated to accomplish disposal in these two waste forms. The sludge must be washed to remove non-radioactive salts that would interfere with glass production. The washed sludge can then be sent to DWPF for vitrification. The salt must be treated to separate the bulk of the radionuclides from the non-radioactive salts in the waste. This separation occurs in SWPF, with the treated waste combined with the washed sludge in DWPF.

5.6 *Salt Processing*

Five different processes will have been used to treat salt:

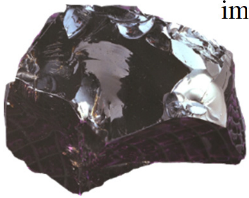
- **Deliquification, Dissolution, and Adjustment** (DDA) – In this process, the salt was first **D**eliquified by draining and pumping, and then **D**issolved by adding water and pumping out the salt solution. The resulting salt solution was aggregated with other Tank Farm waste to **A**djust batch chemistry for processing at SPF. This process was used in FY07 and FY08 to treat a limited amount of salt that met the SPF WAC using DDA-solely. No further DDA-solely treatment is planned.
- **Actinide Removal Process** (ARP) – For salt, even though extraction of the interstitial liquid reduces Cs-137 and soluble actinide concentrations, the Cs-137 or actinide concentrations of the resulting salt are too high to meet the SPF WAC. In ARP, monosodium titanate (MST) was added to the waste whereupon actinides sorbed on the MST and were then filtered out of the liquid to produce a low-level waste stream sent to MCU. The solids, containing the MST with the actinides, were dispositioned at DWPF.
- **Modular CSSX Unit** (MCU) – The ARP low-level waste stream requires reduction in the concentration of Cs-137 using CSSX. The solvent used is a four-part solvent with the key ingredient being the cesium extractant. When it started in 2008, MCU used the solvent BoBCalix but, beginning September 2013, a Next Generation Solvent (NGS), MaxCalix was introduced. The solvent is fed to a bank of centrifugal contactors while the waste is fed to the other end in a counter-current flow. The solvent extracts the cesium, with each successive contactor stage extracting more, resulting in a DSS stream and a cesium-laden solvent stream. The solvent stream is stripped of its cesium, washed, and the solvent is reused. The cesium-laden strip effluent (SE) is transferred to DWPF. ARP and MCU piloted the processes used in the design of the SWPF. Operations at ARP/MCU were suspended in May 2019 to tie in SWPF.
- **Tank Closure Cesium Removal** (TCCR) – TCCR consisted of an ion exchange process for the removal of cesium from liquid salt waste to provide supplemental treatment capability. The configuration was an “at-tank” modular arrangement which began demonstration in January 2019. The demonstration was suspended to accelerate the closure of the associated tanks.
- **Salt Waste Processing Facility** (SWPF) – SWPF incorporates both the ARP and CSSX processes in a full-scale shielded facility capable of handling salt with higher levels of radioactivity. Hot commissioning began in October 2020; full operations began in January 2021. It will process the remaining salt waste.

5.7 *Sludge Processing*

Sludge is washed to reduce the amount of non-radioactive soluble salts remaining in the sludge slurry. During sludge processing, large volumes of wash water are generated and must be volume-reduced by evaporation or beneficially reused. Over the life of the waste removal program, the sludge currently stored in tanks at SRS will be blended into separate sludge batches to be processed and fed to DWPF for vitrification.

5.8 *DWPF Vitrification*

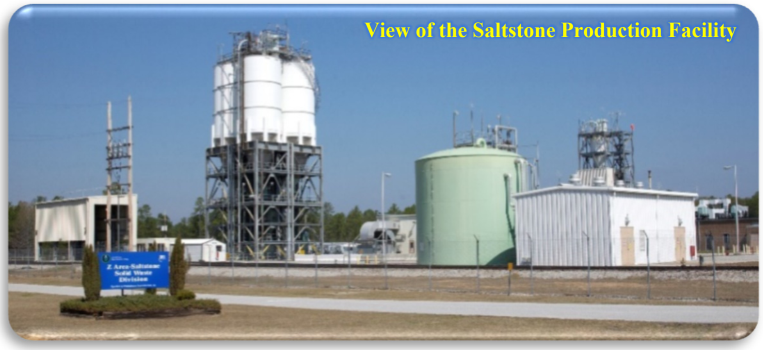
Canisters being received
(prior to being filled with radioactive glass)



Sample of Vitrified Radioactive Glass

Final processing for the washed sludge and salt waste occurs at DWPF. This waste includes MST sludge and cesium SE from SWPF and the washed sludge slurry from sludge processing. In a complex sequence of carefully controlled chemical reactions, this waste is blended with glass frit and melted to vitrify it into a borosilicate glass form. The resulting molten glass is poured into stainless steel canisters. As the filled canisters cool, the molten glass solidifies, immobilizing the radioactive waste within the glass structure. After a canister has cooled, it is sealed with a temporary plug, the external surfaces are decontaminated to meet United States Department of Transportation requirements, and the canister is then permanently seal welded. The canister is then ready to be stored on an interim basis on-site. A low-level recycle waste stream from DWPF is returned to the Tank Farms. DWPF has been operational since 1996.

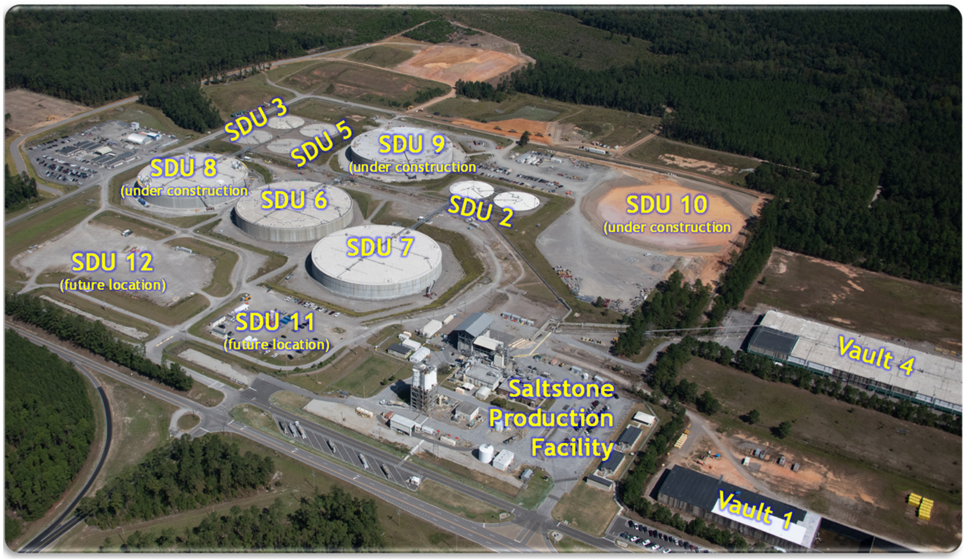
5.9 *Saltstone Disposition*



View of the Saltstone Production Facility

The Saltstone Facility consists of two facility segments: the Saltstone Production Facility (SPF) and the Saltstone Disposal Facility (SDF). SPF is permitted as a wastewater treatment facility per SCDHEC regulations. SPF receives and treats the salt solution to produce grout by mixing the LLW liquid stream with cementitious materials (fly ash, and slag). A slurry of the components is pumped into Saltstone Disposal Units (SDU), located in SDF, where the grout solidifies into a monolithic, non-hazardous, solid LLW form known as saltstone grout. SDF is permitted as an Industrial Solid Waste Landfill site.

With SWPF startup, SPF is expected to receive up to 12 Mgal/yr. In anticipation of this future demand, SRS completed installation of Enhanced Low Activity Waste Disposal (ELAWD) including equipment modifications to increase operating margins, reliability, and controls, dry feeds system modifications, larger capacity salt solution feed receipt tanks, and conversion to 24/7 capable operations.



The SDF contains several large concrete SDUs. Each of the SDUs will be filled with grout. The grout itself provides primary containment of the waste and the walls, floor, and roof of the SDUs provide secondary containment.

Approximately 15 feet of overburden were removed to prepare and level the site for SDU construction. All SDUs are built at or slightly below the grade level that exists after overburden and leveling operations are complete. The bottom of the grout monoliths will be at least five feet above the historic high-water table, thus avoiding disposal of waste in a zone of water table fluctuation. Run-on and run-off controls are installed to minimize site erosion during the operational period.

The first SDU (Vault 1), ~100 feet by 600 feet by 25 feet high, is divided into six cells. The second SDU (Vault 4), ~200 feet by 600 feet 26 feet high, has twelve cells. These two vaults, used during the initial operation of the SPF, are slated for closure with no plans for future placement of grout.

SDU-2 and SDU-5 (which are full), and SDU-3 (currently in use) each have two cells, each cell being 150 feet in diameter by 22 feet high. This design is used commercially for storage of water. After accounting for interior obstructions (support columns, drain water collection systems, etc.), the nominal useable volume of a cell is 2.8 Mgal. Recent operating experience averages 1.76 gallons of grout produced for each gallon of feed, yielding a nominal cell capacity of approximately 1.6 Mgal of feed.

For SDU-6 through SDU 12, each SDU is a 375-foot diameter 43-foot tall single-cell design. SDU 6 (also in use) has a capacity of over 32.8 Mgal of contaminated grout or 18.7 Mgal of feed. SDU 7 (in use, as well) through SDU 12, with a design change to remove column footers and increase the fill height, each has a capacity of about 34.5 Mgal (19.6 Mgal of feed).

Construction of the SDF and the first two vaults were completed between February 1986 and July 1988. The SDF initiated radioactive operations June 12, 1990. SDU-2, completed in June 2012, began filling in September 2012 and completed filling in July 2014. SDU-3 and SDU-5 were completed in September 2013. SDU-5 began filling in December 2013 and completed filling in February 2017. SDU-3 began filling in February 2017. The large SDU 6 began construction in December 2013, was construction complete in June 2018, and began filling in August 2018. SDU 7 construction was complete in the third quarter of FY21 and began filling in March 2022. SDUs 8 through 12 are in various phases of construction.

Closure operations will begin near the end of the active disposal period in the SDF, i.e., after most or all the SDUs have been constructed and filled. Backfill of native soil will be placed around the SDUs. The present closure concept includes two moisture barriers consisting of clay/gravel drainage systems along with backfill layers and a shallow-rooted bamboo vegetative cover.

Figure 5-2—*Process Flowsheet*

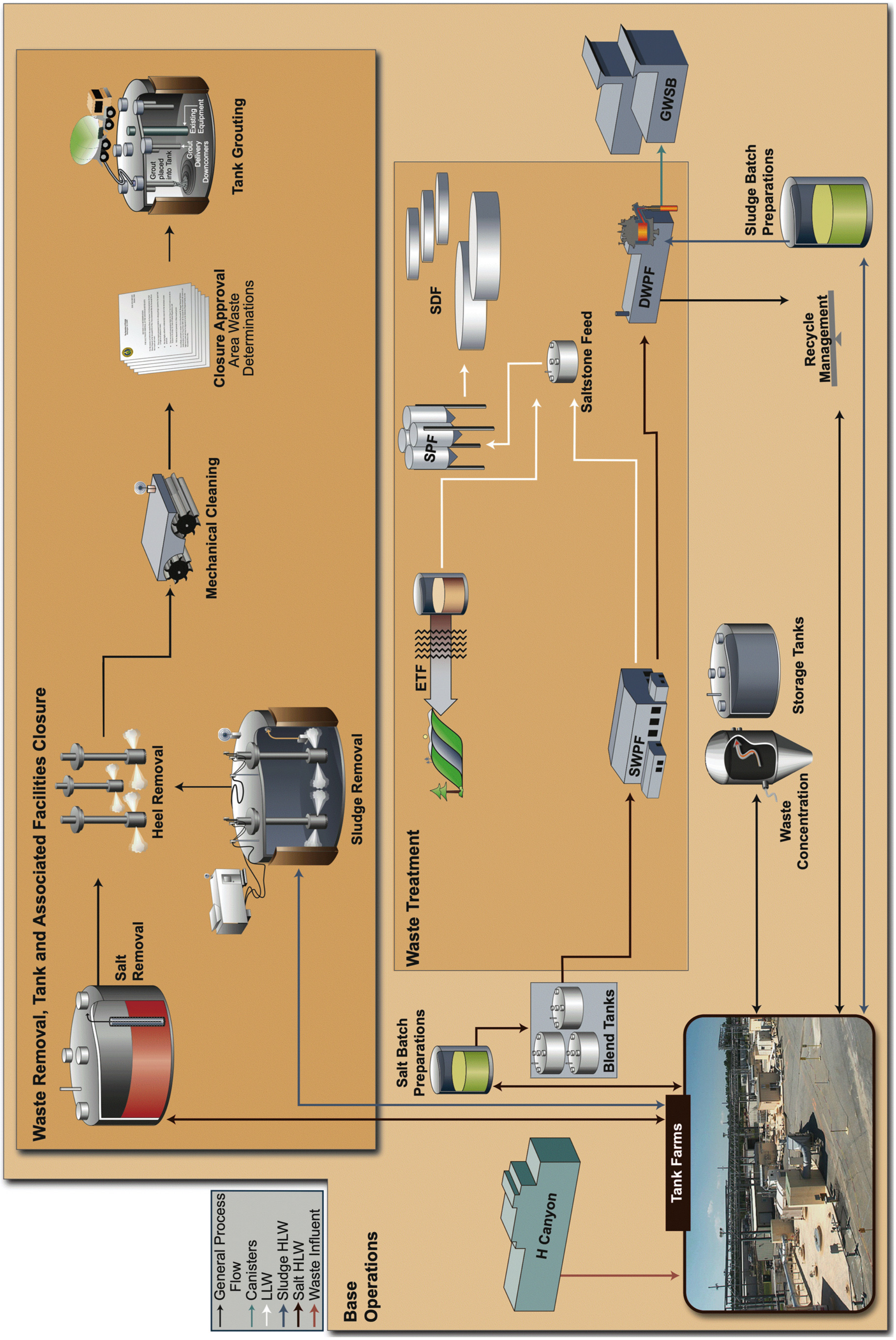


Figure 5-3—*Liquid Waste Program—Current Status*

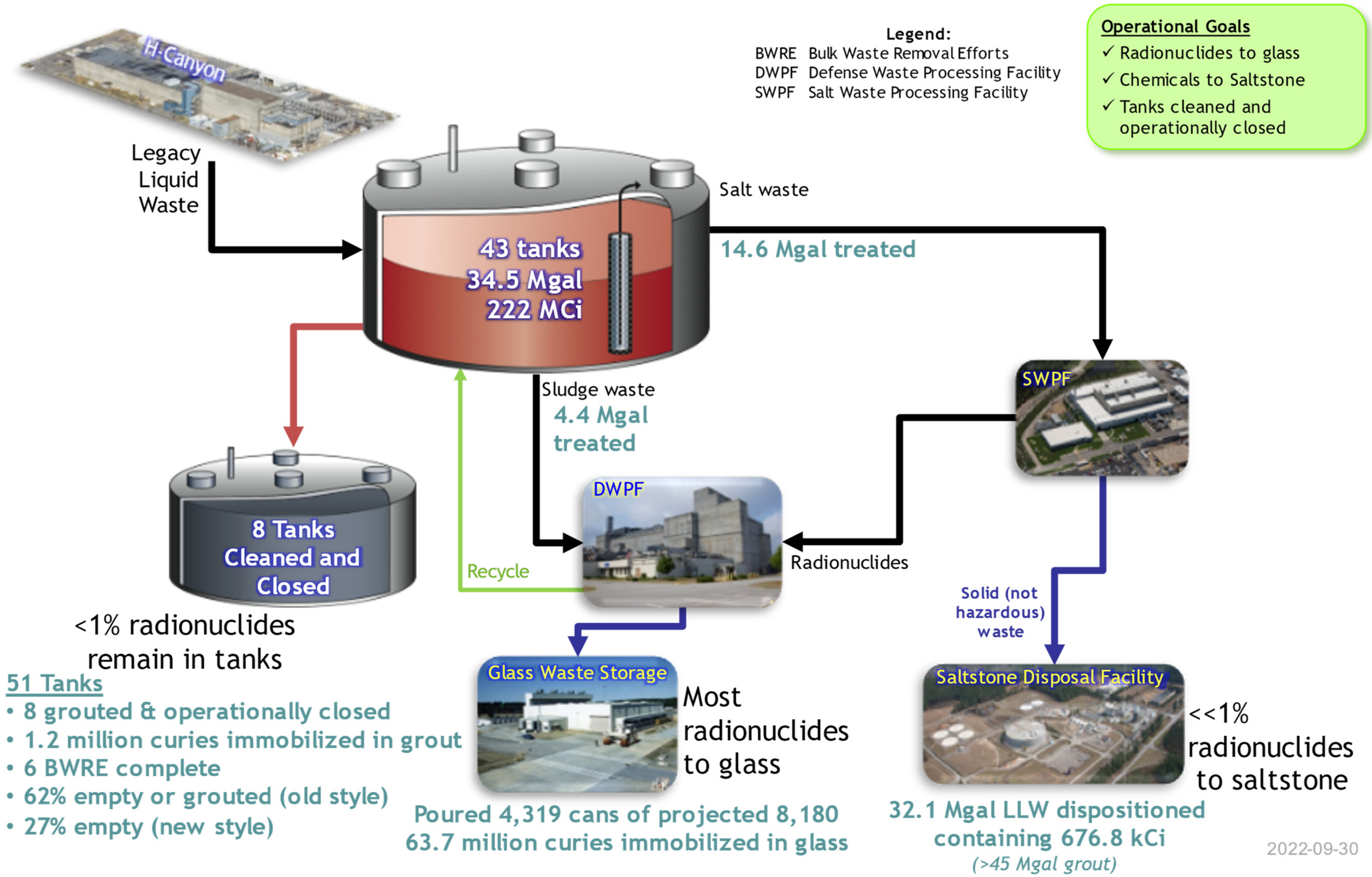
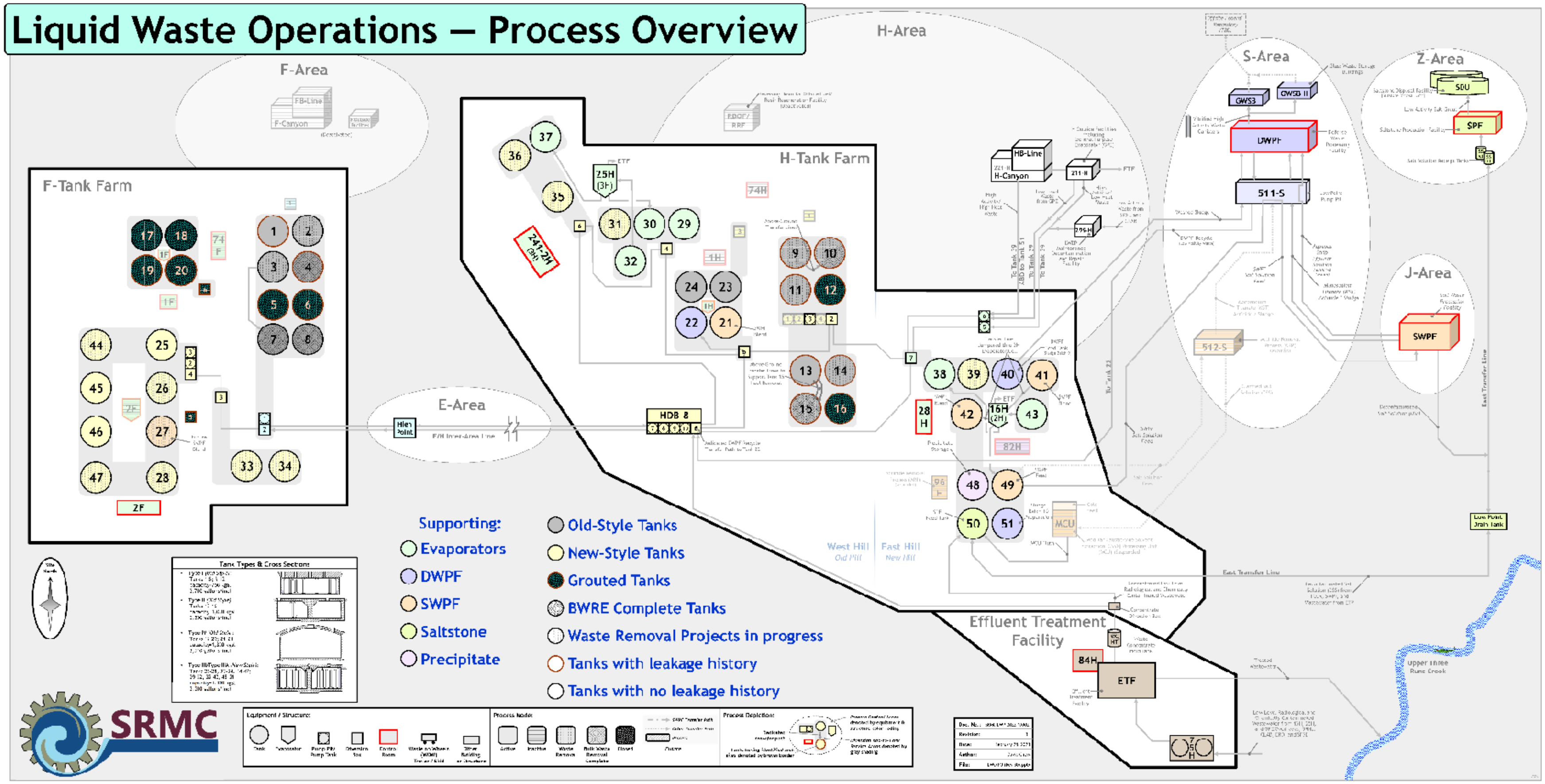


Figure 5-4—*Liquid Waste Process Overview*



Appendix A—*Salt Solution Processing*

End of	Salt Solution (kgal)					to Tank 50 (kgal)						Tank 50	SDU
Fiscal Year	DDA	ARP/MCU	TCCR	SWPF	Total [a]	DSS	H-Can	Tank 48	Flush MCU	SWPF/DWPF/SPF [b]	ETF	to SPF	Numbers [c]
Total as of end of FY10	*2,800*	*985*			*3,785*	*3,151*	*682*				*3,019*	*3,881*	*4*
FY11		*1,064*			*1,064*	*1,487*	*200*				*64*	*1,487*	*4*
FY12		*705*			*705*	*901*	*19*				*24*	*1,252*	*4 & 2*
FY13		*1,320*			*1,320*	*1,566*	*24*		*65*		*69*	*2,005*	*2*
FY14		*551*			*551*	*697*	*15*		*12*		*47*	*1,167*	*2 & 5*
FY15		*753*			*753*	*919*	*12*		*18*		*45*	*828*	*5*
FY16		*1,126*			*1,126*	*1,382*	*11*		*9*		*42*	*1,506*	*5*
FY17		*397*			*397*	*442*	*5*		*5*		*46*	*500*	*5*
FY18		*149*			*149*	*171*	*11*		*3*		*19*	*384*	*5-6*
FY19		*404*	*210*		*614*	*657*	*10*		*29*		*46*	*734*	*6*
FY20			*89*		*89*	*-0-*	*0.1*		*-0-*		*42*	*-0-*	*6*
FY21			*-0-*	*2,304*	*2,304*	*2,981*			*9.4*		*91*	*3,143*	*6*
FY22			*72*	*1,649*	*1,720*	*2,279*					*60*	*2,803*	*3, 6, 7*
FY23				4,752	4,752	6,090					111	6,201	3, 6, 7
FY24				5,795	5,795	7,426					88	7,514	6-7
FY25				8,311	8,311	10,651					89	10,740	7
FY26				8,826	8,826	11,311					111	11,421	7-8
FY27				8,581	8,581	10,996					89	11,085	8
FY28				6,650	6,650	8,522					89	8,611	8-9
FY29				5,933	5,933	7,603					89	7,692	9
FY30				8,924	8,924	11,436					111	11,958	9-10
FY31				9,120	9,120	11,688					89	11,776	10
FY32				8,777	8,777	11,248					89	11,337	10-11
FY33				8,998	8,998	11,531					89	11,619	11
FY34				8,875	8,875	11,373	[e]	500			111	11,984	11-12
FY35			[d]	3,901	3,901	4,999		1,500			89	6,588	12
FY36				1,320	1,320	1,691					93	1,784	12
FY37										3,000	-	3,000	12
Total	**2,800**	**7,454**	**371**	**102,716**	**113,341**	**143,196**	**989**	**2,000**	**152**	**3,000**	**4,946**	**153,002**	

[a] Salt Solution is a total of salt solution treated via the DDA, ARP/MCU, TCCR, and SWPF processes. Each gallon of salt solution treated via ARP/MCU yielded ~1.23 gallons of DSS; each gallon of SWPF yields ~1.28 gallon of DSS. Note the DSS from TCCR in FY20 was stored in Tank 11 and not transferred to Tank 50 until FY21.

[b] SWPF, DWPF, and SPF Facility flushes are flushed directly to SPF to grout, not via Tank 50.

[c]
- SDU 2 and SDU 5 (being full), Vault-1, and Vault-4, are no longer planned to receive contaminated grout
- SDU-3 has two ~2.8-Mgal cylindrical cells, each capable of receiving ~1.5 Mgal of feed
- SDU-6 (32.8 Mgal capacity) and SDU 7 thru SDU 12 (34.5 Mgal capacity) are single cylindrical cells; SDU 6 can receive ~18.7 Mgal of feed and SDU 7 through SDU 12 can receive ~19.7 Mgal of feed
- Each gallon of Tank 50 feed, when added to the fly ash and slag, generates approximately 1.76 gallons of grout

[d] After the end of SWPF processing via Tank 49 in mid-FY35, DWPF recycle is received by SWPF via 511-S, bypassing the Tank Farm .

[e] To forecast grout production, disposition of Tank 48 material is assumed to yield 2 Mgal of DSS for processing in SPF

Note Dates, volumes, and chemical or radiological composition information are planning approximations only.

Appendix B—*Canister Storage*

End of Fiscal Year	SRS Cans Poured		SRS Cans in GWSB 1 (4,524 capacity)[a]		SRS Cans in GWSB 2 (4,680 capacity)[b]		SRS Cans pending storage [c] /remaining
	Yearly	Cum.	Added	Cum.	Added	Cum.	
FY96	*64*	*64*	*64*	*64*			
FY97	*169*	*233*	*169*	*233*			
FY98	*250*	*483*	*250*	*483*			
FY99	*236*	*719*	*236*	*719*			
FY00	*231*	*950*	*231*	*950*			
FY01	*227*	*1,177*	*227*	*1,177*			
FY02	*160*	*1,337*	*160*	*1,337*	*Numbers in italics are actuals through FY22. FY23 and beyond are forecast based on modeling assumptions*		
FY03	*115*	*1,452*	*115*	*1,452*			
FY04	*260*	*1,712*	*260*	*1,712*			
FY05	*257*	*1,969*	*257*	*1,969*			
FY06	*245*	*2,214*	*244*	*2,213*	*1*	*1*	
FY07	*160*	*2,374*	*28*	*2,241*	*132*	*133*	
FY08	*225*	*2,599*		*2,241*	*225*	*358*	
FY09	*196*	*2,795*		*2,241*	*196*	*554*	
FY10	*192*	*2,987*	*3*	*2,244*	*183*	*737*	*Cans in Vit Bldg: 6*
FY11	*264*	*3,251*		*2,244*	*260*	*997*	*Cans in Vit Bldg: 10*
FY12	*277*	*3,528*		*2,244*	*277*	*1,269*	*Cans in Vit Bldg: 15*
FY13	*224*	*3,752*		*2,244*	*224*	*1,493*	*Cans in Vit Bldg: 15*
FY14	*125*	*3,877*		*2,244*	*125*	*1,629*	*Cans in Vit Bldg: 4*
FY15	*93*	*3,970*	*(193)*	*2,051*	*281*	*1,910*	*Cans in Vit Bldg: 9*
FY16	*136*	*4,106*	*(153)*	*1,898*	*291*	*2,201*	*Cans in Vit Bldg: 7*
FY17	*52*	*4,158*	*14*	*1,912*	*34*	*2,235*	*Cans in Vit Bldg: 11*
FY18	*15*	*4,173*		*1,914*	*19*	*2,254*	*Cans in Vit Bldg: 5*
FY19	*34*	*4,207*		*1,914*	*34*	*2,288*	*Cans in Vit Bldg: 5*
FY20	*8*	*4,215*		*1,914*	*4*	*2,292*	*Cans in Vit Bldg: 9*
FY21	*59*	*4,274*	*131*	*2,045*	*(66)*	*2,226*	*Cans in Vit Bldg: 3*
FY22	*45*	*4,319*		*2,045*	*44*	*2,270*	*Cans in Vit Bldg: 4*
FY23	129	4,448	60	2,105	69	2,339	
FY24	260	4,708	260	2,365		2,339	
FY25	278	4,986	278	2,643		2,339	Remaining capacity:
FY26	282	5,268	282	2,925		2,339	2,495
FY27	292	5,560	292	3,217		2,339	2,503
FY28	301	5,861	301	3,518		2,339	2,502
FY29	183	6,044	183	3,701		2,339	2,619
FY30	295	6,339	295	3,996		2,339	2,624
FY31	303	6,642	303	4,299		2,339	2,562
FY32	282	6,924	203	4,502	79	2,418	2,280
FY33	280	7,204		4,502	280	2,698	2,000
FY34	299	7,503		4,502	299	2,997	1,701
FY35	319	7,822		4,502	319	3,316	1,382
FY36	291	8,113		4,502	295	3,611	1,091

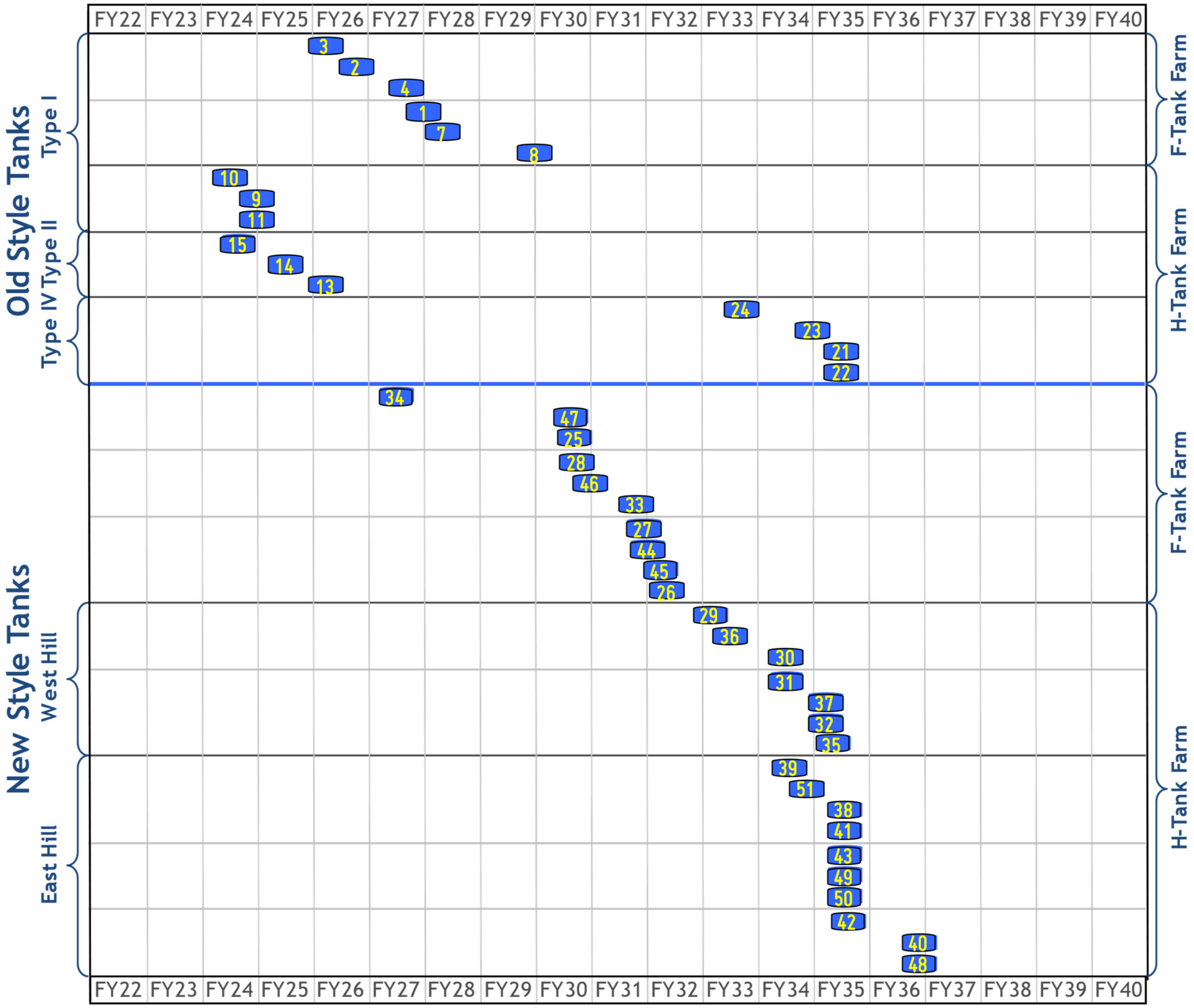
[a] GWSB 1 filling began in May 1996. Beginning in 2016, conversion of the 2,262 standard canister storage locations enable, via double stacking, each position to hold two cans for a total capacity of 4,524 canisters.

[b] GWSB 2 was built with 2,340 standard storage locations and filing began in 2006. Beginning in 2024, conversion of the 2,262 standard canister storage locations will enable, via double stacking, each position to hold two cans for a potential capacity of 4,680 canisters. Enough positions are planned to be converted to allow storage of all canisters produced.

[c] At the end of each year, a certain number of cans are not emplaced in the GWSBs, being retained in the vitrification building. At the end of the program, all canisters will be stored in the GWSBs pending final disposition. The remaining capacity is the number of additional canisters that could be stored.

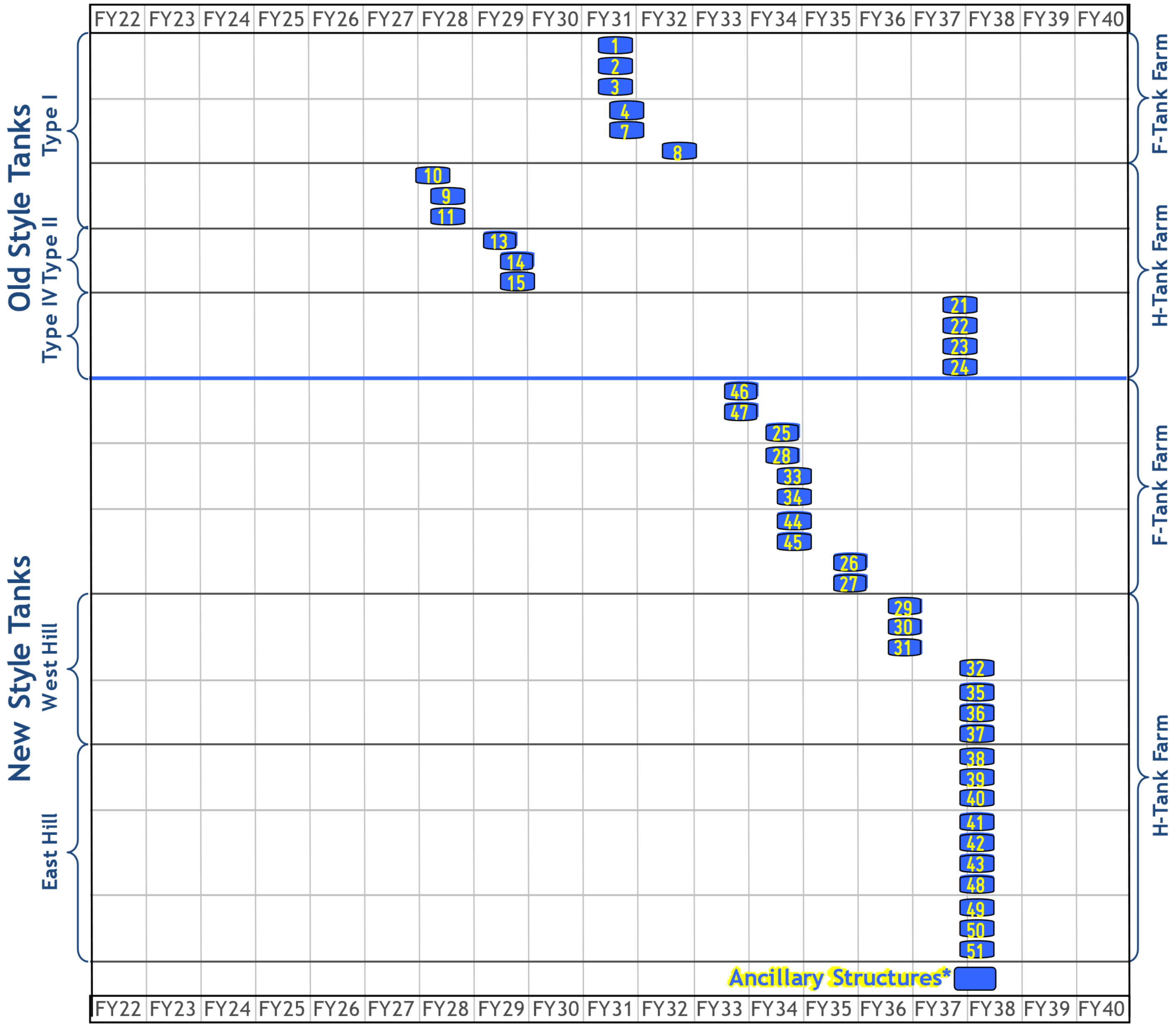
Notes:
- While DWPF canister production supports SWPF production, DWPF canister production is planned to minimize the life-cycle, so more canisters may be produced than necessary to support SWPF. Furthermore, after SWPF processing of Tank 49 waste is complete in FY35, canister production continues to process sludge heels.
- These values are estimates based on the best inventory information available at the time and assumptions about future waste inventory and processing.

Appendix C—*Preliminary Cease Waste Removal*



Note: this is a graphical representation of the relative PCWR for the tanks. For a more precise depiction see Appendix E—*LW System Plan—Revision 23 Summary (DNA)*

Appendix D—*Tank Removal from Service*



* Ancillary structures include:

- FTF
  - 1F Evaporator
  - 2F Evaporator
  - Transfer line systems
  - Leak Detection boxes
  - Three Pump Pits
  - One Condensate Transfer System pump pit
  - Six Diversion Boxes
  - One Catch Tank
- HTF
  - 1H Evaporator
  - 2H Evaporator
  - 3H Evaporator
  - Transfer line systems
  - Leak Detection boxes
  - Ten Pump Pits
  - Two Condensate Transfer System pump pits
  - Eight Diversion Boxes
  - One Catch Tank

Note: this is a graphical representation of the relative removal from service of the tanks. For a more precise depiction see Appendix E—*LW System Plan—Revision 23 Summary (DNA)*

Appendix E—*LW System Plan—Revision 23 Summary (DNA)*

(see attached foldout chart)

Abbreviations

ABD	Accelerated Basin Deinventory
ARP	Actinide Removal Process
ASP	Alpha Strike Process
AWSM II	All Waste Simulation Model II
Ci/gal	Curies per gallon
CGCP	Consolidated General Closure Plan
CM	Closure Module
CSMP	Commercial Submersible Mixing Pumps
CSSX	Caustic Side Solvent Extraction.
D&D	Dismantlement and Decommissioning
DAR	Drain, Add, Remove
DDA	Deliquification, Dissolution, and Adjustment
DNA	Distributed Network Algorithm (refer to Appendix F of the *Plan)*
DNFSB	Defense Nuclear Facilities Safety Board
DOE	Department of Energy
DOE-SR	DOE Savannah River Operations Office
DSS	Decontaminated Salt
DWPF	Defense Waste Processing Facility
EA	Environmental Assessment
EIS	Environmental Impact Statement
eLVMJ	Enhanced Low Volume Mixing Jet
EPA	Environmental Protection Agency
ETF	Effluent Treatment Facility
FCA	Fast Critical Assembly
FFA	Federal Facility Agreement
FESV	Failed Equipment Storage Vault
FTF	F Tank Farm
FY	Fiscal Year
GWSB	Glass Waste Storage Building
HLW	High Level Waste
HM	H Modified
HTF	H Tank Farm
IPABS	Integrated Planning, Accountability, & Budgeting System
IAL	Inter-Area Line
IW	inhibited water
kgal	thousand gallons
LTAD	Low Temperature Aluminum Dissolution
LLW	Low Level Waste
LVMJ	Low Volume Mixing Jet
LW	Liquid Waste
MCi	Million Curies
MCU	Modular CSSX Unit
Mgal	million gallons
M&O	Maintenance and Operations
MSB	Melter Storage Box
MST	monosodium titanate
NDAA	Ronald W. Reagan National Defense Authorization Act for Fiscal Year 2005
NDAA §3116	Section 3116 – Defense Site Acceleration Completion—of the NDAA
NEPA	National Environmental Policy Act
NGS	Next Generation Solvent
NPDES	National Pollutant Discharge Elimination Systems
NRC	Nuclear Regulatory Commission
OOS	Out of Service
PA	Performance Assessment
PCCS	Product Composition Control System
PCWR	Preliminary Cease Waste Removal
PEIS	Programmatic Environmental Impact Statement
POM	Process Optimization Model
PUREX	Plutonium Uranium Reduction Extraction
RCRA	Resource Conservation and Recovery Act
RCT	Recycle Collection Tank
ROMP	Risk and Opportunity Management Plan
SAS	Steam Atomized Scrubber
SB	Sludge Batch
SC	Safety Class
SCDHEC	South Carolina Department of Health and Environmental
SDF	Saltstone Disposal Facility –
SDU	Saltstone Disposal Units
SE	Strip Effluent
SEFT	Strip Effluent Feed Tank
SEIS	Supplemental Environmental Impact Statement
SME	Slurry Mix Evaporator
SPF	Saltstone Production Facility
SRAT	Slurry Receipt and Adjustment Tank
SRMC	Savannah River Mission Completion
SRNL	Savannah River National Laboratory
SRNS	Savannah River Nuclear Solutions
SRS	Savannah River Site
SS	Safety Significant
SSC	Structure, System, or Component
SSRT	Salt Solution Receipt Tanks
STP	Site Treatment Plan
SWPF	Salt Waste Processing Facility –
T&PRA	Technical and Programmatic Risk Assessment
TOM	Technical Optimization Model
WAC	Waste Acceptance Criteria
WCS	Waste Characterization System
WD	Waste Determination
wt%	weight percent

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