SRR
Savannah River Remediation

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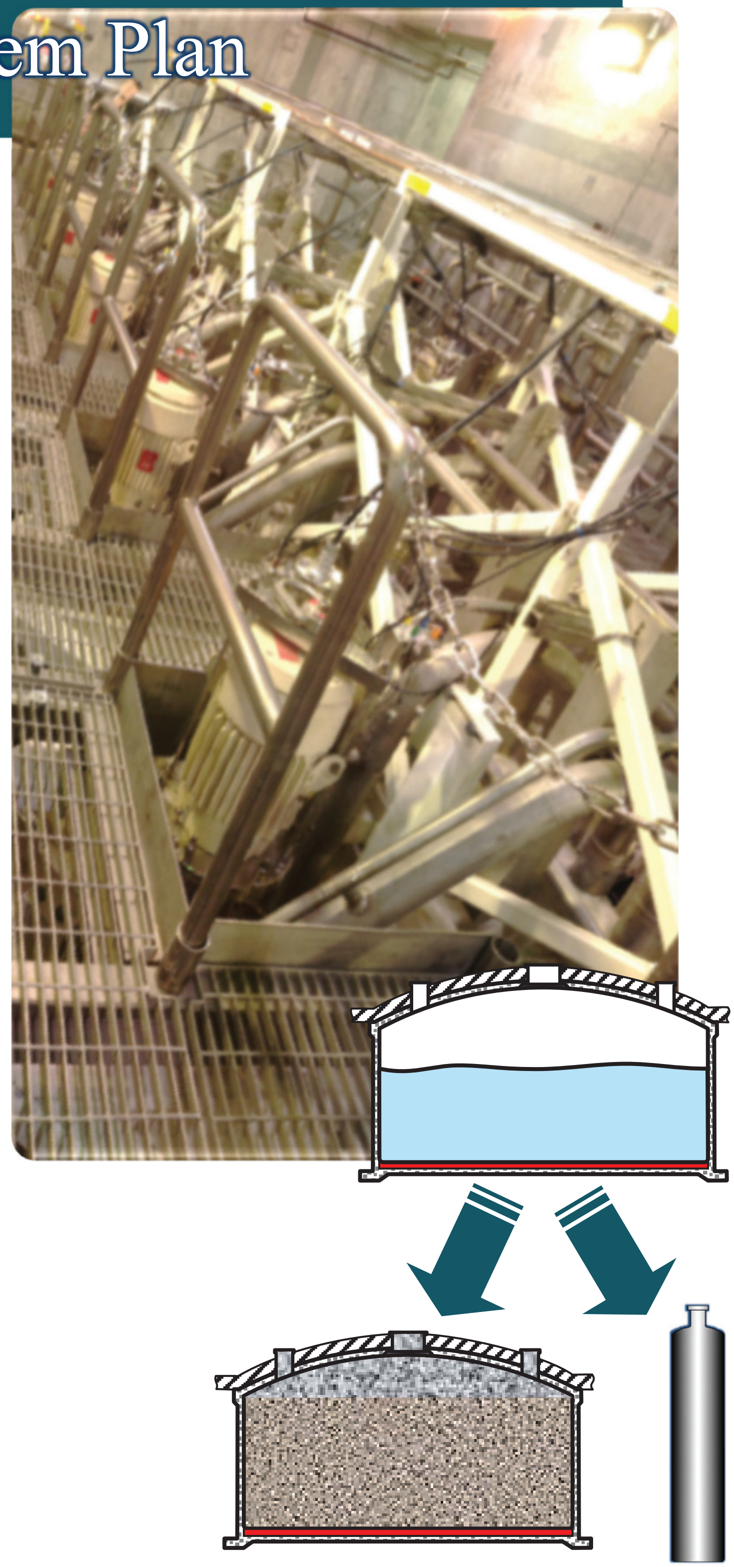
LIQUID Waste System Plan



Integrated Liquid Waste Processing System at Savannah River Site

REVISION 22

September 2021

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Liquid Waste System Plan
Revision 22

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1. Executive Summary

The last *Liquid Waste System Plan,* Revision 21[1] (LWSP–R21) was published in January 2019. Since that time, the Salt Waste Processing Facility (SWPF) completed construction and hot commissioning, beginning full operations in January 2021. With the startup of the SWPF, all the major pieces are in place to complete the mission of the liquid waste program. Additionally, funding received in FY21 and forecast for the next few years is adequate to fully support planned processing rates at SWPF. This 22nd 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) by Savannah River Remediation LLC (SRR). It assumes the conditions extant at the beginning of Fiscal Year (FY) 2021. SWPF initiated hot operations with initial feed transfers from Tank 49 in H-Tank Farm (HTF), transfers of Decontaminated Salt Solution (DSS) to Tank 50 for disposition in the Saltstone Disposal Facility (SDF) via the Saltstone Production Facility (SPF), and transfers of strip effluent (SE) and monosodium titanate (MST) to the Defense Waste Processing Facility (DWPF). Since the tie-ins to SWPF, operations of the Modular Caustic Side Solvent Extraction (CSSX) Unit (MCU) and the Actinide Removal Process (ARP) have been suspended.

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) tank farms. This optimistic case assumes receipt of the funding required to: install removal equipment, process at stated rates, and maintain and replace (as necessary) the equipment and infrastructure. It assumes no major equipment failures other than 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.

Two cases were modeled for consideration in this *Plan*. Both cases acknowledged the expected funding levels received in FY21 and the funding projections for the outyears. The base case used assumptions similar to previous years as regards to future receipts from H-Canyon. An alternate case foresees Accelerated Basin Deinventory (ABD). Acceleration of spent fuel disposition considered at H-Canyon by discontinuing uranium recovery following spent fuel dissolutions. This concept would require reconfiguring an existing waste storage tank to serve as an additional sludge preparation tank to enable timely receipt of ABD material into sludge batches.

This *Plan* results in processing over 11.8 Mgal of salt waste in the "*Agreement*" period of FY16 through FY22; the total amount of salt processed is projected to be under 114 Mgal. Once NGS is deployed at SWPF, salt processing at SRS will exceed 8 Mgal/yr (at 6.44 M Na) as committed to in the "*Agreement*". In addition to the 4,253 canisters that have been poured from FY96 through June FY21, about 3,705 additional canisters are projected for a total production of approximately 7,958 DWPF canisters over the lifetime of the project. If the ABD option is exercised, an additional 435 canisters are forecast.

The completion of waste removal in F-Tank Farm (FTF), in this *Plan*, occurs in 2033 allowing the Inter-Area Line to be shut down in 2033 and FTF closures complete by the end of 2036. Salt Processing at SWPF is forecast to complete in 2033 and Liquid Waste (LW) treatment and disposition in DWPF are completed by 2038. Of the 51 tanks, 48 tanks will have been closed by 2037 and the last of the HTF tanks, the DWPF feed and preparation tanks and the Saltstone feed tank, is closed by 2040.

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 DOE at SRS (DOE-SR). It records a planning basis for waste processing in the LW System through the end of the program mission.

This twenty-second revision (Revision 22) of the *Plan*:

- Supports financial submissions development for the complex-wide Integrated Planning, Accountability, & Budgeting System (IPABS)
- Provides a technical basis for LW Contract and Contract Performance Baseline changes
- Provides input to the development of regulatory agreements.

Common Goals & Values

The overarching principles which govern strategic planning and execution of the SRS Liquid Waste Disposition Program are summarized in the seven "Common Goals and Values" that were agreed upon by key stakeholders almost a decade and half ago (cf. *Progress in Implementation of Common Goals and Values* [3]). These remain the guiding goals and values for program execution and planning:

1. Reduce operational risk and the risk of leaks to the environment by removing waste from tanks and closing the tanks.
2. Remove actinides from waste expeditiously since their impact on the environment is the most significant if a leak occurs.
3. Maximize amount of waste ready for disposal in deep geologic repository. Make significant effort to ensure maximum amount of long-lived radionuclides are disposed in a deep geologic repository.
4. Remove as much cesium as practical from salt waste and dispose in parallel with vitrified sludge.
5. Dispose of cesium as soon as practical to avoid having cesium only waste when sludge vitrification is complete.
6. Limit disposal of radioactive waste onsite at SRS so that residual radioactivity is as low as reasonably achievable.
7. Ensure DOE's strategy and plans are subject to public involvement and acceptance.

Goals

The goals (not necessarily the outcomes) of this *Plan* were to meet the following programmatic objectives:

1. Continual safe storage of liquid waste in tanks and vitrified canisters in storage.
2. Risk Reduction through Waste Disposition, i.e., maximizing processing of waste and minimizing the total life cycle.
3. Completion of waste removal from H-Tank Farm tanks in the water table (i.e., Type I and Type II tanks).
4. Process liquid salt waste (e.g., dissolved salt solution, supernate) through FY22 in accordance with the South Carolina Department of Health and Environmental Control (SCDHEC) "Dispute Resolution Agreement" (including consideration for *Force Majeure* conditions).
5. Complete operational closure of FDB-5 & 6 by the end of FY22, consistent with the Federal Facility Agreement (FFA), Appendix L, 2019 Suspension Agreement [4].
6. Deploy Next Generation Solvent (NGS) at SWPF no later than 28 months after SWPF begins operations, consistent with the SCDHEC "Dispute Resolution Agreement".
7. Complete FTF waste removal within 10 years to enable disconnecting Inter-Area Line (IAL).

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*[5], the *Basis for Section 3116 Determination for Salt Waste Disposal at the Savannah River Site*[6], the *Section 3116 Determination for Closure of F-Tank Farm at the Savannah River Site*[7], the *Basis for Section 3116 Determination for Closure of F-Tank Farm at the Savannah River Site*[8], the *Section 3116 Determination for Closure of H-Tank Farm at the Savannah River Site*[9], and the *Basis for Section 3116 Determination for Closure of H-Tank Farm at the Savannah River Site*[10]
- 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 State-approved Consolidated General Closure Plan[11] (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*[12] (SRS LW Strategy), as amended by letter from the SCDHEC to DOE-SR[13] and the *Basis for Section 3116 Determination for Salt Waste Disposal at the Savannah River Site*[6] and the "*Agreement"*
- Support continued nuclear material stabilization of legacy materials in H-Canyon.

Revisions

The significant updates from the previous version of this *Plan,* the *Liquid Waste System Plan, Revision 21*[1], include:

- **Salt Processing**:
  - SWPF initiated the One Year Operations (OYO) period on January 18, 2021
  - Tank Closure Cesium Removal (TCCR) operation began January 2019
  - Funding adequate to support installation of one TCCR unit instead of two TCCR units
  - MCU operations suspended May 2019
- **Sludge Processing**:
  - Include provisions for ABD in the alternate case
- **DWPF**:
  - Double-stack conversion of Glass Waste Storage Building (GWSB) 2 obviating the need for supplemental canister storage

Results of the Plan

Table 1-1—Results *of Modeled Cases* describes the major results as compared to Revision 21 of the *Plan*:

Table 1-1—*Results of Modeled Cases*

Parameter	Rev 21	Rev 22 No ABD	Rev 22 with ABD/
Date SWPF begins full operations	May 2020	Jan 2021	Jan 2021
Date last LW facility turned over to D&D	2037	2040	2041
Final Type I and II tanks complete operational closure	2030	2033	2033
Complete bulk sludge treatment	2031	2033	2033
Complete bulk salt treatment	2031	2033	2033
Complete heel treatment	2034	2037	2038
TCCR for supplemental salt waste treatment	2 units	1 unit	1 unit
Next generation solvent for increased SWPF throughput	May 2021	Feb 2023	Feb 2023
Throughput exceeds 8 Mgal/yr @ 6.44 M Sodium	May 2021	Jun 2023	Jun 2023
Total number of canisters produced	8,121	7,958	8,393
Year supplemental canister storage required to be ready	2030	n/r	n/r
Radionuclides (curies) dispositioned in SDF within the amended *SRS LW Strategy*	Yes	Yes	Yes
Total number of SDUs	13	12	12

SWPF Processing: This *Plan* assumes SWPF will maintain a 500 thousand gallon (kgal) per month, or six million gallon (Mgal) per year, processing rate through implementation of NGS in February 2023, after which it will ramp up over a period of three months to a processing rate of 750 kgal/mo (9 Mgal/yr) through the end of salt processing at SWPF.

Radionuclides Dispositioned in SDF: This *Plan* is consistent with *SRS LW Strategy* as amended by letter from the SCDHEC to DOE-SR[13] and the *Basis for Section 3116 Determination for Salt Waste Disposal at the Savannah River Site*[6] concerning the total curies dispositioned at SDF.

Supporting Nuclear Material Stabilization: The Tank Farms have assumed, in the base case, receipt space of 300 kgal per year of H-Canyon waste through FY30. Additionally, this *Plan* accommodates receipt of particular H-Canyon waste streams directly to sludge batches through FY30. (Note: after FY30, any H-Canyon waste will be dispositioned by H-Canyon).

Supporting Accelerated Basin Deinventory: An alternative case provides for the disposition of additional fissile material directly into sludge batches from H-Canyon. The ABD case discontinues the receipt of 300 kgal per year of normal H-Canyon waste.

Canister Storage: Double-stack modification similar to GWSB 1 is planned for GWSB 2 to enable stacking two canisters in each storage location, thus obviating the need for supplemental canister storage. Shipment of canisters from SRS is not included in this *Plan* pending identification of a federal repository.

Saltstone Disposal Units (SDU): The current SDU-6 is a single cylindrical cell unit with ~32.8 Mgal grout capacity (~18.7 Mgal of feed). SDU-7 through SDU-12 incorporated design changes recognized from the construction of SDU-6 that reduced internal obstructions and allowed filling to a greater height which will increase the capacity to 34.5 Mgal of grout (19.6 Mgal of feed). Modeling in both cases projects an excess capacity of over 7 Mgal of grout (4 Mgal of DSS) in SDU-12.

2. Introduction

This twenty-second revision of the Liquid Waste System Plan documents a strategy to operate the LW System at SRS to receive, store, treat, and dispose of radioactive LW and to close waste storage and processing facilities. The LW System is a highly integrated operation involving safely storing LW in underground storage tanks; removing, treating, and dispositioning 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 and processing facilities are cleaned and closed. Section 6—*System Description* of this *Plan* provides an overview of the LW System providing the reader some familiarity of the systems and processes discussed herein.

The Tank Farms have received over 160 million gallons of waste from 1954 to the present. Having reduced the volume of waste via evaporation and dispositioned waste via vitrification and saltstone, the Tank Farms currently store approximately 35.6 million gallons of waste containing approximately 232 million curies (MCi) of radioactivity. As of June 30, 2021, DWPF had produced 4,253 vitrified waste canisters. (Note: All volumes and curies reported as current inventory in the Tank Farms are as of June 30, 2021 and account for any changes of volume or curies in the Tank Farms since Revision 21 of the *Plan* and the *Section 3116 Determination for Salt Waste Disposal at the Savannah River Site*[5].)

This *Plan* describes two cases for dispositioning HLW from SRS. One case assumes the disposition of the current inventory in the Tank Farms and H-Canyon and the other case provides for ABD. The ABD case provides for disposition of spent fuel via dissolution at H-Canyon without uranium recovery. Each case forecasts the best possible outcome for dispositioning the waste via optimistic operation of waste removal, TCCR, SWPF, DWPF, and the Saltstone facilities. This optimistic perspective assumes timely receipt of the funding required to: install waste removal equipment, process at stated rates, and maintain and replace equipment, as necessary. It assumes no major equipment failures other than the one 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 several risk events that, were they realized, could adversely affect the successful completion of the program goals in the time described.

2.1 *Common Goals & Values*

The overarching principles which govern strategic planning and execution of the SRS Liquid Waste Disposition Program are summarized well in the seven "Common Goals and Values" that were agreed upon by key stakeholders almost two decades ago[3]. These remain the guiding goals and values for program execution and planning:

1. **Reduce operational risk and the risk of leaks to the environment by removing waste from tanks, and closing the tanks**
   - Curie Work off from ~550 MCi in 1995 to 232 MCi at the end of June 2021 (dispositioning over 62.5 MCi in glass, 0.75 MCi in Saltstone grout, and the remainder due to radioactive decay).
   - Of the 14 SRS tanks with leakage history (all old-style tanks):
     - 6 are operationally closed and grouted (Tanks 5, 6, 12, 16, 19, and 20)
     - 3 are dispositioning waste via the TCCR process (Tanks 9, 10, and 11)
     - 1 is pending heel removal activities (Tank 15)
     - 2 contain essentially dry waste, with little or no free liquid supernate (Tanks 1 and 14)
     - 2 contain liquid supernate at a level below known leak sites (Tanks 4 and 13)
   - Of the 24 SRS old-style tanks:
     - 8 are grouted and operationally closed (Tanks 5, 6, 12, 16, 17, 18, 19, and 20)
     - 5 have bulk waste removal completed (Tanks 4, 7, 8, 11, and 15)
   - Approximately 66% of old-style tank space is currently empty or grouted and approximately 22% of new-style tank space is empty.
2. **Remove actinides (sludge) from waste expeditiously since they affect the environment most significantly if a leak occurs.**
   - Actinides and other high activity components are being immobilized in glass
   - To date, over 4,253 canisters of waste (~53 % of the projected lifecycle total) have been vitrified
   - Canister waste loading was raised from the originally planned ~28%, as appropriate.

3. **Maximize amount of waste ready for disposal in deep geologic repository. Make significant effort to ensure maximum number of long-lived radionuclides are disposed in a deep geologic repository.**
   - To date, over 98% of the curies immobilized have been placed in glass in preparation for disposal in a deep geologic repository
   - At mission completion, over 99% of treated curies are projected to have been immobilized in glass.

4. **Remove as much cesium as practical from salt waste and dispose in parallel with vitrified sludge.**
   - A small portion of salt waste (~2%) was treated via Deliquification, Dissolution, and Adjustment (DDA) only
   - Extraction of cesium from salt waste through ARP/MCU began in 2008 and, through 2019, was ~10 times more efficient than the original projection (~7% of forecast salt production)
   - Deployment of NGS at MCU in 2014 improved cesium removal efficiency by more than 200 times, exceeding the original SWPF design; the cesium laden MCU strip effluent (SE) stream is vitrified with sludge and disposed in canisters (~2.8% of forecast salt production)
   - TCCR is forecast to provide supplemental treatment capability to existing and future salt processing and improve confidence in supporting the desired acceleration of waste retrieval and tank operational closure efforts (~16%)
   - SWPF is forecast to treat the highest volume (~ 75%) and activity of the salt waste.

5. **Dispose of cesium as soon as practical to avoid having cesium only waste when sludge vitrification is complete.**
   - To date, almost 12 Mgal of salt waste (approximately 10% of the projected lifecycle total) have been treated and dispositioned
   - Allocation of available resources is focused on maintaining the pace of risk reduction through waste treatment and immobilization
   - The contribution of ARP/MCU was enhanced by deploying NGS to increase cesium removal efficiency
   - TCCR supplements SWPF to accelerate salt processing
   - This *Plan* forecasts completion of salt processing well before completion of sludge processing.

6. **Limit disposal of radioactive waste onsite at SRS so that residual radioactivity is as low as reasonably achievable.**
   - Formal Performance Assessments (PA) of LLW disposal and operational closure of tanks, coupled with cost to benefit evaluations prior to cessation of tank waste removal activities, support that any residual future impacts from onsite waste disposal are within the requirements of applicable federal and state laws and regulations, and are as low as reasonably practical
   - Based on operational experience, over 99% of the radioactive inventory in a tank will have been removed after final cleaning
   - At mission completion, over 99% of treated curies are projected to have been immobilized in glass and packaged for offsite disposal in a deep geologic repository
   - The originally agreed upon projection for onsite emplacement in engineered disposal units from LW treatment of 3 MCi (2.5 MCi from DDA-only; 0.3 MCi from ARP/MCU; and 0.2 MCi from SWPF) was reduced to "… 0.8 MCi from the combination of Interim Salt Treatment (0.6 MCi) and SWPF processing (0.2 MCi) …" in August 2011[14] based on progress as of 2011. As of the suspension of ARP/MCU processing in May 2019, 0.48 MCi were emplaced from Interim Salt Treatment (~0.09 MCi from DDA-only and ~0.39 MCi from ARP/MCU).

7. **Ensure DOE's strategy and plans are subject to public involvement and acceptance.**
   - The formal processes for evaluation, determination, and execution of all tank waste removal, disposal, and operational closure fully involves SCDHEC, the Environmental Protection Agency (EPA), and the Nuclear Regulatory Commission (NRC)
   - Various formal hold points exist in these processes for public involvement and comment
   - All SRS LW disposition activities fall within the purview of Defense Nuclear Facilities Safety Board (DNFSB) oversight, and DNFSB periodically issues publicly accessible reports of their evaluations and conducts periodic meetings to receive public input regarding their activities
   - The SRS Citizen's Advisory Board receives routine updates in a public venue regarding all SRS LW Disposition activities
   - Updates to this *Plan* are provided to all regulatory and oversight entities and made available for public review
   - Regular updates of radiological inventory additions to SDUs are posted to a publicly accessible website
   - SRR monthly and annual reports of progress towards disposition of SRS LW are available to the public.

2.2 System Planning Overview

System Plan Rev. 22 Goals and Priorities

DOE's overarching priorities for development of this *Plan* are:

1. Continual safe storage of liquid waste in tanks and vitrified canisters in storage.
2. Risk Reduction through Waste Disposition, i.e., maximizing processing of waste and minimizing the total life cycle.
3. Completion of waste removal from HTF tanks in the water table (i.e., Type I and Type II tanks).
4. Process liquid salt waste (e.g., dissolved salt solution, supernate) through FY22 in accordance with the SCDHEC "Dispute Resolution Agreement" (including consideration for *Force Majeure* conditions).
5. Complete operational closure of FDB-5 & 6 by the end of 2022, consistent with FFA, Appendix L, 2019 Suspension Agreement[4]
6. Deploy NGS at SWPF no later than 28 months after SWPF begins operations, consistent with the SCDHEC "Dispute Resolution Agreement"[15].
7. Complete FTF waste removal within 10 years to enable disconnecting Inter-Area Line.

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.

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 those 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.

As the Liquid Waste program proceeds, the roles of some tanks will change to maximize efficient use of available space at that time. Currently, the 27 new-style tanks are deployed as follows:

- 5 (Tanks 38, 41, 43, 49, and 50) are dedicated to salt batching, qualification, and disposition (including DWPF recycle beneficial reuse, feeding the SPF, and the 2H Evaporator)
- 2 additional tanks (Tanks 27 and 42) are planned for conversion to salt blend tanks to prepare salt batches. Note that in the ABD case Tank 42 ceases being a salt blend tank and Tank 26 becomes a salt blend tank
- 6 (Tanks 29, 30, 32, 37, 40, and 51) are dedicated to sludge batching, qualification, and disposition (including the 3H Evaporator); note that in the ABD case Tank 42 is converted from salt blend tank service to become an alternate sludge batch preparation tank
- 1 (Tank 39) supports uninterrupted H-Canyon waste receipts
- 13 (Tanks 25, 26, 28, 31, 33, 34, 35, 36, 44, 45, 46, 47, and 48) are dedicated to safe storage of legacy LW pending retrieval and disposition.

These 27 new-style tanks represent a maximum storage capacity of 35 million gallons of space of which about 7.6 Mgal is empty space (~22%). However, not all that space is available for waste storage:

- 3.6 Mgal is margin as defense-in-depth operational control coupled with Safety Class or Safety Significant (SC/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 recovery from the unlikely event of a large waste leak elsewhere in the system
- 2.8 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 Saltstone
  - Excess margin to preserve sludge batch quality and maintain uninterrupted immobilization through DWPF
  - Excess margin to preserve uninterrupted support for H-Canyon.

2.3 ***Risk Assessment***

The *PBS-SR-0014, Radioactive Liquid Tank Waste Stabilization and Disposition, Risk and Opportunity Management Plan* (ROMP) documents the comprehensive identification and analysis of technical risks and opportunities associated with the LW program. It identifies individual technical and programmatic risks and presents the strategies for handling 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 (T&PRA) of several billion dollars. After mitigation overall risk level is reduced, however, some concerns remain:

- Funding—Adequate funding for PBS-SR-0014 throughout its life cycle to permit full execution of the System Plan is uncertain. This is a crosscutting risk for both major contractors at SRS and is addressed at the site level.
- Aging Infrastructure—The System Plan end date places significant stress on what will be an increasingly aging infrastructure. Infrastructure failures, exemplified by the 3H Evaporator pot leak in 2016, provide insight into the problems that may be encountered with operating the HLW System for an additional 20 years.
- TCCR Spent Column Disposition—TCCR is forecast to produce approximately 40 cesium-laden ion exchange columns over the course of its mission. Interim Safe Storage (ISS) will be provided on-site for these columns. This Plan assumes processing the cesium-laden media via DWPF, the final disposition for these highly radioactive columns has not been selected.
- 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 has the potential to interfere with normal operational expectations assumed in the *Plan*.
- DWPF Recycle—For every 1.0 gallon of sludge treated in DWPF, 1.3 gallons of recycle waste is returned to the Tank Farm. This System Plan assumes that in FY26, the DWPF recycle stream will be diverted for treatment outside of the Tank Farm, but a specific treatment path has not yet been selected.

3. Planning Bases

This *Plan* is based on DOE-SR and SRR agreed inputs, assumptions, and priorities[16]. 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 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 required.

3.1 *Funding*

Progress toward the goal of immobilizing all the LW at SRS is highly dependent on available funding. This *Plan* was developed assuming the availability of the funding required as specified in the inputs and assumptions referenced above. It supports justification for requesting necessary funding profiles. 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 *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. This permit also contains 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, ARP/MCU, Effluent Treatment Project [ETP], SPF, SWPF)
  - National Pollutant Discharge Elimination System (NPDES) permit (H-16 Outfall discharges from ETP)
- 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*"[17] 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)[18] 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 EPA, DOE, and SCDHEC executed the SRS FFA 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 amendments since then have modified the original agreement recognizing the realization of previously identified risks (*e.g.*, delays in SWPF start-up date).

National Environmental Policy Act

The National Environmental Policy Act (NEPA) requires federal agencies to assess the potential environmental impacts of proposed actions. Seven 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).

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 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 for disposal in the SDF. For tank removal from service activities, NDAA §3116 governs the Waste Determinations 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[5]
- Basis for Section 3116 Determination for Salt Waste Disposal at the Savannah River Site[6]
- Section 3116 Determination for Closure of F-Tank Farm at the Savannah River Site[7]
- Basis for Section 3116 Determination for Closure of F-Tank Farm at the Savannah River Site[8]
- Section 3116 Determination for Closure of H-Tank Farm at the Savannah River Site[9]
- Basis for Section 3116 Determination for Closure of H-Tank Farm at the Savannah River Site[10]

3.3 *Revisions*

The significant differences from the previous version of this *Plan,* the *Liquid Waste System Plan, Revision 21*[1], include:

- **Salt Processing**:
  - SWPF initiated the OYO period on January 18, 2021
  - TCCR operation began January 2019
  - Funding adequate to support installation of one TCCR unit instead of two TCCR units
  - MCU operations suspended May 2019
- **Sludge Processing**:
  - Include provisions for ABD in the alternate case

- **DWPF**:
  — Double-stack conversion of GWSB 2 obviating the need for supplemental canister storage

3.4 ***Key Milestones***

Key Milestones are those major dates deemed necessary under this *Plan* to remove waste from storage, process it into glass or saltstone, and close the LW facilities. The *LW System Plan, Revision 21* milestones are provided for comparison.

Table 3-1—*Key Milestones*

Key Milestone	Rev 21	Rev 22 No ABD	Rev 22 with ABD
Date SWPF begins hot commissioning *(actual)*	March 2020	*Oct 2020*	*Oct 2020*
Date last LW facility turned over to D&D	2037	2040	2041
Final Type I, II, and IV tanks complete operational closure	2033	2033	2033
Complete bulk sludge treatment	2031	2033	2033
Complete bulk salt treatment	2031	2033	2033
Complete heel treatment	2034	2037	2038
Total number of canisters produced	8,121	7, 958	8, 393
Support Accelerated Basin Deinventory	n/a	No	Yes
DWPF Recycle Treatment available	n/a	Oct 2026	Oct 2026
Initiate TCCR Processing *(actual)*	2019	*Jan 2019*	*Jan 2019*
Initiate SWPF Hot Operations *(actual)*	May 2020	*Jan 2021*	*Jan 2021*
– *Processed via DDA-solely (actual)*	*2.8 Mgal*	*2.8 Mgal*	*2.8 Mgal*
– Processed via ARP/MCU *(actual)*	8.1 Mgal	*7.5 Mgal*	*7.5 Mgal*
– Salt Solution Processed via TCCR	16.8 Mgal	7.1 Mgal	6.1 Mgal
– Salt Solution Processed via SWPF	90 Mgal	96 Mgal	96 Mgal
Throughput exceeds 8 Mgal/yr @ 6.44 M Sodium	May 2021	Jun 2023	Jun 2023
Number of SDU	13	12	12

SWPF Processing: Hot commissioning began October 5, 2020 with the deliberate introduction of radioactive materials into the several subprocesses of SWPF. Beginning January 18, 2021, operations began with a forecast of 500 kgal/mo for the OYO period. After completion of OYO, a 10-week outage allows for conversion to a nitric-glycolic acid flowsheet in DWPF. In February 2023, SWPF will convert to use of the NGS after which operations will ramp up over a three-month period to a forecast rate of 750 kgal/mo.

Vitrification of Sludge at DWPF: This *Plan* forecasts completion of salt processing well before completion of sludge processing. Processing of the remaining sludge heels will continue past the end of SWPF operations.

Canister Storage: This *Plan* recognizes the continued modification of GWSB 1 to allow storage of two canisters in each storage position and similar conversion of GWSB 2, obviating the need to provide supplemental canister storage. Shipment of canisters from SRS is not included in this *Plan* since a federal repository has not yet been identified.

Saltstone Disposal Units (SDU): SDU-2, SDU-3, and SDU-5 are dual cylindrical cell units with ~2.8 Mgal grout capacity (~1.6 Mgal of 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 feed). This *Plan* assumes SDU-7 through SDU-12 will have similar dimensions of SDU-6 with a 34.5 Mgal grout capacity (19.6 Mgal of feed).

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—Tank Farm Influents and Effluents
Appendix C—Bulk Waste Removal Complete
Appendix D—Tank Removal from Service
Appendix E—Sludge Processing
Appendix F—Canister Storage
Appendix G—LW System Plan—Revision 22 Summary (aka the DNA chart)
Appendix H—TCCR Columns Interim Safe Storage

4.1 *Waste Retrieval*

4.1.1 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. Sludge is removed from the waste tank and sent to the feed preparation tank or a hub tank, a tank set up to receive and transfer sludge to the feed preparation tank, ensuring sludge waste is continuously available for treatment at DWPF. Salt is dissolved, removed, and staged in hub tanks and salt preparation blend tanks for treatment at SWPF or TCCR.

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 to a 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 for treatment at SWPF and/or TCCR.

Sludge Removal

Current sludge removal strategies tie into 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 the CSMPs 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*)

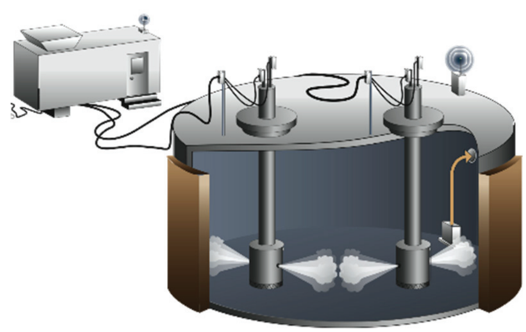


Figure 4-1—*Mechanical Agitation Waste Removal*

Sludge batches were originally configured to preferentially remove sludge from Type I and II tanks. Most of the sludge has been successfully removed from the old-style tanks. Tank 13, a Type II tank in HTF, is being used to store and transfer sludge from other tanks. Final Tank 13 heel removal is planned for FY29. Tanks 33, 34, 35, and 39, Type III tanks, are 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. Prior to salt dissolution, the interstitial liquid in the salt cake layer is often removed by mining into the saltcake and placing a pump and caisson at a lower elevation in the tank. Removal of the interstitial liquid prior to saltcake removal, as it has a higher radioactivity, allows for strategic salt batch planning.

Once the interstitial liquid is removed, 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*). As mentioned above, the Drain step involves the removal of the highly concentrated interstitial liquid salt solution which is segregated from the resultant dissolved salt solution that results from the Add step, to facilitate Salt Batch Preparation. During the Add step, the dissolution liquid may be added in small batches or 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. If 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 must be taken to minimize the formation of preferential flow channels during salt solution removal. The process ends with the removal of dissolved salt solution.

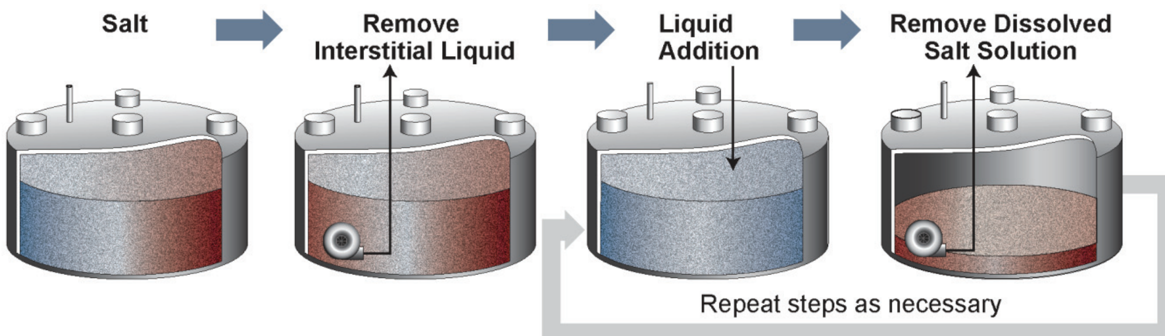


Figure 4-2—*Drain, Add, Remove Method for Salt Waste Removal*

While effective, salt dissolution using Drain, Add, Remove is not a very fast process. With the desire to increase the volume of salt solution produced over time to feed SWPF, the preferred method of salt dissolution involves the use of Commercial Submersible Mixer Pumps (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 render the Drain, Add, Remove process ineffective. Use of CSMPs generally require lower bulk saltcake volume, to ensure the CSMPs have adequate liquid coverage for cooling, and a larger tank vapor space to account for the larger amount of gas release during salt dissolution. Typically, 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.

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 and prevent release to the environment. Specific plans will avoid liquid levels above known leak sites, when feasible, and focused monitoring will be employed where 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 dispositioning waste via the TCCR process (Tanks 9, 10, and 11)
- 1 is awaiting heel removal activities to commence (Tank 15)
- 2 contain essentially dry waste, with little or 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), if needed (in Tank 51 or additionally, in the ABD case, Tank 42)
3. Blending and washing of sludge (in Tank 51)
   Note that Tank 42 will be converted to preparation tank service if ABD processing is commenced
4. Sludge feeding to the DWPF (from Tank 40)
5. Vitrification in DWPF.

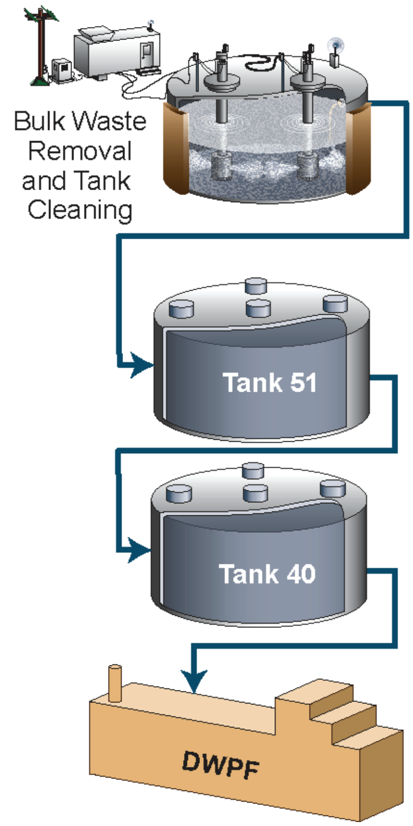


Figure 4-3—*Sludge Feed Preparation*

Low Temperature Aluminum Dissolution

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 subsequent removal by decanting the liquid phase. This reduces the number of canisters needed to disposition the sludge due to lowered sludge solids mass and improved glass waste loading. 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 around 75ºC to achieve the dissolution, as demonstrated for Sludge Batch (SB)5, SB6, and SB10. The dissolved aluminum is processed with the salt waste. Sludge generated by the plutonium uranium reduction extraction (PUREX) process in F-Canyon does not require LTAD.

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 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 for feeding into 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. The DWPF melters had produced an average of 215 canisters/yr before melter bubblers were installed. However, when bubblers were installed in September 2010, the melter capacity improved such that, in FY12 a record 277 canisters were poured and a record 40 canisters poured in August 2013. The feed preparation systems internal to DWPF have demonstrated a capacity of greater than 325 canisters/yr, e.g., the 337 canisters poured from July 2011 thru June 2012. In this *Plan*, the canister production rate is matched to SWPF production rate. DWPF has a demonstrated capability of producing the maximum annual rate forecast in this *Plan* of 276 canisters/yr.

Total Canister Count

Total canister count is primarily based on the mass of sludge in a tank that must be emptied, the ability to perform aluminum dissolution, and the need to add sludge modifiers to meet physical and chemical requirements for DWPF processing. Providing tank space for SWPF and ongoing waste removal may require transfer of sludge to a temporary storage location (sludge hub tank). Limits on the mass of sludge that can be physically managed in a sludge batch may dictate an increase or decrease in both solids loading and canister generation rate. There is also a minimum practical operating rate (approximately five canisters per month) for keeping the DWPF processes functioning. Additionally, a minimum canister production rate is required to support salt processing, based on the amount of SE and MST generated. SWPF processing of 750 kgal/mo with NGS is anticipated to require approximately 276 canisters per year.

Two-step Production Improvement Approach

To support higher glass throughput, the DWPF melter was retrofitted with four bubbler systems and the melter off-gas system was optimized in September 2010. The second step of DWPF production capacity improvement program addresses streamlining the DWPF feed preparation system. Several process improvements are planned to streamline the DWPF feed preparation system which are required to support SWPF operations at a feed rate greater than 7.2 Mgal per year, some of which are:

- Introduction of a new Anti-Foam
- Implementation of an alternate reductant, *i.e.,* the nitric-glycolic acid flowsheet
- Processing of cesium SE in the slurry mix evaporator (SME).

Reduction of liquid addition in DWPF supports receipt of SE from SWPF. Beneficial reuse of DWPF recycle for waste removal and tank cleaning, in lieu of water additions, supplements recycle reduction and supports maintenance of Tank Farm capacity (see §4.5.3 below).

Future estimated canister production, by year, is shown in Appendix D—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.

Failed Equipment Storage Vaults and Melter Storage Boxes

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 will be required in 2029, at which time Melter 3 will have been in service for twelve years.

Disposition of highly radioactive failed melters requires specially designed transport and storage Melter Storage Boxes (MSB) which are 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 has been reserved for construction of up to ten FESVs, if needed.

This Plan assumes FESV 3 and 4 preparation begun in 2020 will be completed in FY24. Construction of MSB 3 is forecast to be completed in FY21. MSB 3 will not be required until Melter 3 is nearing 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 Canister Storage

The canisters of vitrified HLW glass produced by DWPF are currently stored on-site in dedicated interim GWSBs. A Shielded Canister Transporter 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 Storage Building #1*[19]. As of January 1, 2021, GWSB 1 contained 1,917 radioactive canisters and two archived non-radioactive canisters.

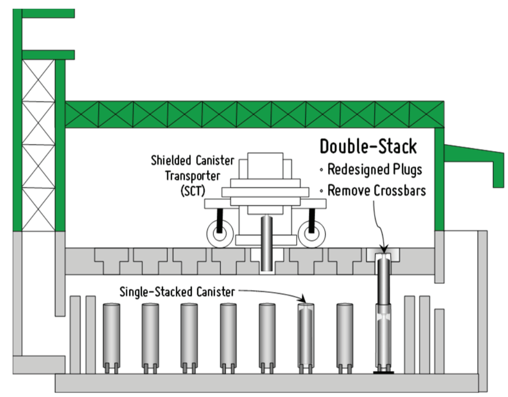


Figure 4-4—*Double Stacking*

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, the current forecast does not foresee the need for all the positions in GWSB 2 to be double stacked so that some of the positions may remain unconverted. As of January 1, 2021, GWSB 2 stored 2,290 radioactive canisters and one archived non-radioactive canister. See Appendix I—*GWSB Utilization* for current utilization of the GWSBs. The schedule for shipment of the canisters from SRS is not included in this *Plan*. It will be developed upon availability of a permanent federal repository.

4.4 *Salt Processing*

As highlighted in the Introduction, this *Plan* includes the continued use of two salt treatment processes for the remainder of the program, TCCR and SWPF. 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 10.5 Mgal were processed via DDA, ARP/MCU and TCCR as of the end of FY20. SWPF is planned to process most of the remaining salt solution waste, supplemented by TCCR.

Salt preparation capability is limited by the number of blend tanks available to prepare salt batches. A single tank can prepare 4 Mgal/yr. In the first year of SWPF operations, Tank 21 (Type IV) and Tank 41(Type IIIA) serve as blend tanks. Thereafter, two Type III tanks, Tank 27 and Tank 42, will be equipped for blend tank service allowing the Tank 21 to be converted for TCCR service. The three blend tanks will support the planned SWPF operating rate of 750 kgal/mo after SWPF is converted to use NGS. In the case of disposition of ABD material, Tank 42 is converted to Sludge Batch preparation service requiring Tank 21 to remain a salt blend tank for an extended period. When FTF is ready for closure, Tank 24 (Type IV) will replace the FTF blend tank, Tank 27, for the last two years of SWPF operations.

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

- **SE & MST processing in DWPF at the planned rates:** Achieving greater than 600 kgal/mo of SWPF processing will require reducing the SE volume through implementation of NGS at SWPF in addition to other facility enhancements
- **Equipment Reliability:** Equipment upgrades such as Tank Farm East Hill Utilities are planned to enhance the reliability of feed to SWPF
- **Salt Dissolution Efficiency:** Increasing the salt dissolution efficiency enhances reliability of salt batch preparation. CSMP utilization is planned to improve salt dissolution
- **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
- **Flammability 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 will be 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 2800 gallons of MST/SS effluent sent to DWPF per week from SWPF.

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 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 is a solvent extraction process for removal of Cs-137 from caustic salt solutions. The solvent used is a four-part solvent with the key ingredient being the cesium extractant (currently BoBCalix and, beginning in FY23, MaxCalix is planned as the NGS). This 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 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 Tank 50 for feed to the SPF, and the cesium-laden solution from the CSSX process, known as strip effluent (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.

Factors limiting SWPF production to 500 kgal/mo include:

- Provision of blend tanks to provide feed to support feeding SWPF at the rated capacity
- Total cycle time in SWPF
- SE & MST processing in DWPF at the planned rates. Achieving greater than 600 kgal/mo of SWPF processing will require reducing the SE volume by increasing the concentration factor to 20 or greater

To mitigate these limitations, modifications to the facilities include:

- **Tank Farms**: Salt dissolution, blending, batching, and qualification at a pace sufficient to provide feed at design rates and enable additional tanks to enter blend tank service
- **DWPF**: Improvements described in Section 4.2 (above) enhance the ability to process SE to support an SWPF feed rate greater than 500 kgal/mo
- **SPF**: 24/7 operations and improved dry feeds preparation contribute to process capacity able to process the DSS from SWPF plus the minor contribution from ETP and TCCR operations.

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 of 750 kgal/mo, three blend tanks are planned to be 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. 22 Goals and Priorities* on page 6. Although these priorities guided the planning of salt dissolution, the technical and financial constraints preclude achieving all the goals.

It should be noted that the remaining Type IV tanks in H-Tank Farm are integral in closing F-Tank Farm 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 (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. Tank 42 (Type IIIA) was outfitted for use as a salt blend tank in FY21. 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 21 as a salt blend tank. This allows a reduction in the number of inter-area transfers required to remove salt from FTF. The salt dissolution in Tank 27 planned to begin in FY21 would, once completed, provide adequate tank space for batch compilation. Installation of CSMPs and a transfer pump should be completed by the end of FY22 with salt dissolution sufficient to convert Tank 27 to a blend tank in FY24. At the end of the program as the FTF salt is depleted, Tank 24 (Type IV) will replace Tank 27 as the third blend tank.

In the ABD case, Tank 27 is planned for blend tank service as in the non-ABD case above. Tank 42, however, is converted from a salt blend tank to a sludge preparation tank in FY24 to support receipt of ABD material from H-Canyon. This requires Tank 21 to continue as a salt blend tank longer than in the non-ABD case. Later, when Tank 21 is converted to support TCCR, Tank 26 (Type IIIA) in FTF becomes the third salt blend tank. At the end of the program in the ABD case as the FTF salt is depleted, Tank 21 ceases TCCR service and it and Tank 24 replace Tank 26 and Tank 27 in blend tank service.

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 Tank Closure Cesium Removal (TCCR)

The TCCR initiative consists of an ion exchange process for the removal of cesium from liquid salt waste to provide supplemental treatment capability and improved confidence in supporting the desired acceleration of waste retrieval and tank operational closure efforts. Building on the experience of modular commercial nuclear plant decontamination and following the disaster response associated with Fukushima, the technology exists to accomplish larger scale, selective removal of the cesium component of the bulk salt waste. A commercial supplier designed, fabricated, tested, and delivered a modular cesium removal system which has been deployed at Tank 10 for the treatment of liquid salt waste.

In FY20, a successful demonstration of the TCCR unit in HTF treated dissolved salt waste from Tank 10. The configuration consisted of temporary process structures located near Tank 10 and Tank 11, so the cesium removal process takes place outside of the tank. The DSS is temporarily stored in Tank 11 before transfer to Tank 50 for disposition at SPF. Next, TCCR processing of Tank 9 salt is planned. After five years of processing Tank 9 materials, relocation of the TCCR to Tank 21 should allow continued utilization of TCCR while Tanks 9, 10, and 11 are closed. Tank 23 is planned as the DSS receipt tank for disposition in Saltstone via Tank 50. The funding profile assumed for this *Plan* did not contain sufficient funding to purchase and deploy a second TCCR unit.

Once the ion exchange media (resin) in a column becomes loaded with cesium to the extent practical ("spent"), that column (with resin) will be removed from the system and replaced with a new ion exchange column loaded with fresh resin. The spent column and resin will be transported to an ISS location adjacent to H-Tank Farm. The spent resin is designed to be dispositioned via DWPF. Currently there is no infrastructure to process the spent TCCR media at DWPF. The ISS concept reduces initial process facilities and costs while also allowing for identification and evaluation of potential future disposal alternatives, such as off-site.

This *Plan* evaluates disposition of spent resin via DWPF. It assumes that funding will be available beginning in FY23 for the design, fabrication, and installation of a TCCR column unloading and resin grinding unit at DWPF, with unit operations beginning in FY27. Ground resin will be collected in a vessel and then added to the Sludge Receipt and Adjustment Tank (SRAT) or SME batches in limited quantities to ensure that canister waste form requirements are met. Three parameters were identified for further evaluation:

- **Titanium loading in glass**: The titanium dioxide (TiO_2) limit in glass is 5.85 wt%. During SWPF operations at 750 kgal/mo, MST generated from single-strike operations will result in TiO_2 glass loading of ~2.5 wt%. With the remaining TiO_2 loading in glass allocated to TiO_2 from TCCR resin grinding, greater than one TCCR column of resin can be ground into each SRAT batch.
- **Niobium loading in glass**: The desired niobium(V) oxide (Nb_2O_5) loading in glass is less than 0.5 wt%. This limits the addition of TCCR resin to one third of a column of resin per SRAT batch.

- **Canister heat generation rate**: To simplify canister double stacking in GWSB 1 and GWSB 2, the contribution to canister heat generation from ground TCCR resin should be below 100 watts per canister. This limits the addition of TCCR resin to about one half of a column of resin per SRAT batch.

The niobium oxide loading in glass is the most limiting constraint at one third of a column of resin per SRAT batch. With SWPF processing waste at a rate of 750 kgal/mo, DWPF will produce between 4 and 5 SRAT batches per month. Therefore, for system planning purposes, it is assumed that the spent resin from no more than one TCCR column per month may be ground and disposed in DWPF.

TCCR is projected to require 40 columns (38 in the ABD case) to complete its mission assuming a 50% cesium loading. The inventory of spent TCCR columns at the ISS on a year-by-year basis is shown in Appendix H—TCCR Columns Interim Safe Storage. The water used to support heel removal and prepare sludge batches at the end of the program will be treated with a TCCR unit relocated to be near Tank 51; the decontaminated wash water will be sent to Tank 50 and then Saltstone for treatment and disposition. This plan assumes any required changes to the Saltstone WAC or regulatory permits will be made.

4.4.3 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 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 (BFS) and fly ash). A slurry of the components is pumped into the SDUs, located in SDF, where the saltstone grout solidifies into a monolithic, non-hazardous, solid LLW form.

Saltstone Disposal Facility

SDU-6, which is currently the 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 saltstone. With similar external dimensions, SDU-7 through SDU-12, incorporated a design change to remove the column footers and increase fill height, and have a capacity of approximately 34.5 Mgal each. Nominally, 1.76 gallons of grout is produced for each gallon of DSS feed, yielding a nominal cell capacity of approximately 18.7 (SDU-6) to 19.6 (SDU-7–12) Mgal of DSS from SWPF and the other minor contributors to saltstone disposition. SDU-7 is ready for DSS receipt; SDU-8 and SDU-9 are under construction; and SDU-10, SDU-11, and SDU-12 are in the project design phase. The first two SDUs, known as Vault 1 and Vault 4, used during the initial operation of the SPF, are not planned for future placement of radioactive grout, and are slated for closure. SDU-2 and SDU-5 (both of which are full) and SDU-3 each consist of two cells with a nominal useable volume of a cell of approximately 2.8 Mgal or 1.5 Mgal of feed. SDU-3 is available for use as necessary. One additional SDU is forecast but will be designed and sized to accommodate the DSS at the end of the program

4.5 *Tank Closure*

4.5.1 Heel Removal and Cleaning

Heel Removal

After completion of waste removal using the technologies discussed above, heel removal is performed. Heel Removal can consist of a combination of mechanical heel removal and chemical cleaning. In general, mechanical heel removal is done prior to chemical cleaning, and is discussed below in some detail. Depending on tank conditions, however, chemical cleaning may be performed prior to mechanical heel removal or some mechanical heel removal and some chemical heel removal may be performed iteratively to remove the heel solids to the extent technically practicable from an engineering perspective and remove the highly radioactive radionuclides to the maximum extent practical.

Mechanical Heel Removal

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

Chemical Cleaning

Chemical cleaning may be performed on sludge tanks when mechanical heel removal has not removed the material to the extent technically practicable from an engineering perspective and the highly radioactive radionuclides removed to the maximum extent practical. In bulk oxalic acid (OA) cleaning, the tank is modified to address chemical compatibility concerns. OA is added to the tank and mixing pumps are operated. The contents of the tank are agitated for a short period and then transferred to a receipt tank for neutralization. In caustic cleaning, a sludge heel is subjected to LTAD conditions (see § 4.1) to dissolve a significant amount of aluminum solids. This process may be repeated multiple times based on chemical flowsheet projections.

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 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 will take place during heel removal and will be repeated until the environmental risks have been eliminated 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.

4.5.2 Tank Operational Closure and Stabilization

Type I, II, and IV tanks are planned for operational closure in accordance with a formal agreement between the DOE, Region IV of the EPA, and SCDHEC as expressed in the SRS currently approved 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 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* 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 recognizes the Savannah River National Laboratory (SRNL) as the laboratory that performs residual characterization analysis. Concentration and volume data are used to characterize the residual material to produce radiological and non-radiological inventories for the Closure Module (CM). Tank-specific closure documents and other regulatory documentation are prepared to demonstrate compliance with State and DOE regulatory requirements as well as NDAA §3116.

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

An area specific WD approach ensures the NDAA §3116 tank operational closure process is implemented as efficiently as possible. 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. The Tier 1 plans are area-specific and provide the bases and process for moving forward with tank grouting. This document is approved at the DOE-Headquarters level. The Tier 2 documents are tank-specific, follow the approved criteria established in the Tier 1 documents, and are locally approved by DOE-SR.

Development of a tank-specific 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 activities include field modifications, temporary ventilation installation, grout plant mobilization, and grout procurement.

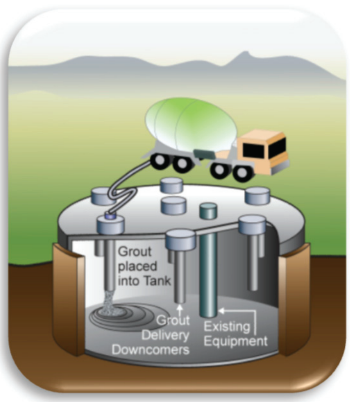


Figure 4-5—*Grout Placement*

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 4-5). A 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 4-6).

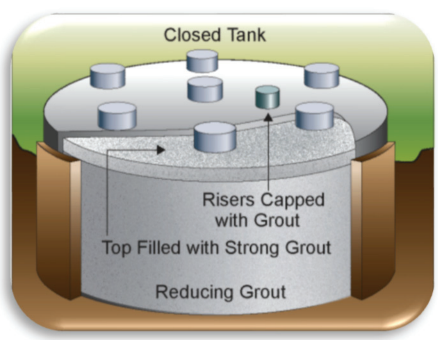


Figure 4-6—*Grouted Tank*

4.5.3 Ancillary Structure Operational Closure and Stabilization

The FTF and HTF both 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 liquid waste 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, however, the ancillary structures 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.

To date no ancillary structures in either FTF or HTF have been operationally closed. FDB-5 & 6 are currently going through the operational closure process and are planned to be closed by the end of FY22 consistent with the Federal FFA, Appendix L, 2019 Suspension Agreement. Other ancillary structures planned for operational closure in the near term are the 1F Evaporator and the associated 242-3F Concentrate Transfer System.

4.6 ***Base Operations***

4.6.1 **Supporting Nuclear Material Stabilization**

A continuing portion of the mission of the Tank Farms is safe receipt, storage, and disposition of waste yet to be received from H-Canyon and HB Line. This *Plan* supports nuclear material stabilization in H-Canyon, receiving normal discards of up to 300 kgal/yr through 2030.

An alternate disposal path for some waste (e.g., U, Pu, or Np bearing waste) allows insertion into a DWPF sludge batch "just-in-time" via receipt into the sludge processing tank (Tank 51) or the DWPF feed tank (Tank 40). These discards from H-Canyon will be supported through FY30 to the extent allowable without negatively impacting planned canister waste loadings or failing to comply with canister fissile material concentration limits.

In the ABD case, normal discards are received through 2033. The volume of normal discards, however, is forecast to be approximately 200 kgal every 18 months, the difference being included in the ABD transfers directly into Tank 42 and Tank 51. Tank 39 will continue to receive H-Canyon waste through FY32.

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.

4.6.2 **DWPF Recycle Handling**

Aside from DSS from SWPF that is received into Tank 50 and transferred directly to Saltstone, DWPF recycle is the largest influent stream received by the Tank Farm. In this *Plan*, disposition of the recycle stream is handled through evaporation in the 2H Evaporator System and through the beneficial reuse of the low sodium molarity (less than 1.0 molar sodium) recycle stream. 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 after the startup of SWPF as a result 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; currently only one SAS stage is operated. DWPF recycle is exclusively evaporated in the 2H Evaporator System due to chemical incompatibility with other waste streams. It may, however, be beneficially reused for salt solution molarity adjustment, salt dissolution, heel removal, etc. Beneficial reuse minimizes the utilization of the 2H Evaporator. DWPF recycle will be supplemented by inhibited water (IW), as required, for salt dissolution and adjustment.

This *Plan* models the diversion of DWPF recycle beginning in FY26. The flowsheet for the treatment and disposition of DWPF recycle after FY26 is being developed.

The decision to minimize DWPF recycle receipts in the Tank Farm provides several opportunities. Since the need to segregate silicate-bearing waste would be eliminated, the 2H Evaporator system can be redeployed for general purpose use. This allows the 3H Evaporator to shut down and undergo waste removal without the need to restore evaporator operations. Sludge removed from the 3H feed tank (Tank 32) can be sent directly to sludge batches as needed instead of being removed to other HTF tanks. This significant simplification of the plan avoids the cost of resuming 3H operations following Tank 32 sludge removal.

Moving the evaporator support function from the HTF West Hill to the HTF East Hill allows the waste removal and closure of the West Hill tanks (Tanks 29–32 and 35–37).

Cleaning the 2H Evaporator is necessary prior to being put in service as a general-purpose evaporator, to remove any residual sodium-aluminum-silicate-bearing waste. Also, Tank 22 will be depleted of the silica rich solution sent from the DWPF. The spent wash water from Tank 51 will be decanted to Tank 22 and either used for salt dissolution or sent for evaporation. Tank 22 contents will undergo evaporator feed qualification before processing in the evaporator. Since the system will no longer be receiving silica there should be no sodium-aluminum-silicate formation within the evaporator vessel nor any solids formation related criticality concerns.

4.6.3 Transfer Line Infrastructure

Although efforts will continue to be made to keep transfers between tanks to a minimum, with the startup of SWPF, executing this *Plan* requires more frequent transfers than have historically occurred in the Tank Farm. Because of the greatly increased pace of transfers to support SWPF, short downtimes due to unexpected conditions requiring repair will be more difficult to accommodate due to the reduced idle time of transfer lines.

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 and projects for new facilities. 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. This *Plan*, however, does not attempt to explain all the modifications needed or anticipate the failure of specific pieces of transfer equipment.

4.6.4 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 saltstone or vitrified glass. Systems Engineering Evaluations will select an appropriate technology to allow Tank 48 treatment to begin in FY32 followed by operational closure.

4.6.5 Effluent Treatment Project

The ETP, 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 ETP 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 ETP to minimize transfer impacts directly to Tank 50 or SPF during SWPF operations.

4.6.6 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.

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

This *Plan*, as did previous revisions of the *Plan*, utilizes Type I, II, and IV tanks to meet program objectives:

- Tank 8 stores aluminum-laden supernate from LTAD of Sludge Batches 5, 6, 10–15, and, in the ABD case, 16
- Tank 7 stores dissolved salt solution
- Tank 7 will support waste removal activities from Tanks 1, 2, and 3
- Tank 11 stores DSS from TCCR operation for transfer to Tank 50 for disposition in Saltstone

- Tank 11 will support waste and heel removal activities from Tanks 9 and 10
- Tank 13 serves as a hub for Sludge Removal from Tanks 14 and 15, supports Heel Removal from Tanks 9, 10, 11, 14 and 15, and supports Tank 14 salt dissolution
- Tank 21 will serve as a salt blend tank for SWPF and support TCCR processing
- Tank 22 will receive DWPF recycle and then support sludge washing
- Tank 23 will stage dissolved salt solution for salt batch preparation and, in the ABD case, store evaporator concentrate before conversion to TCCR service
- Tank 24 will continue to store evaporator concentrate. It replaces FTF Tank 27 as an SWPF blend tank supporting FTF closure.

4.7 ***Closure Sequence for the Liquid Waste 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, ETP).

Following the end of salt processing there remains a large volume of liquid used for completion of heel removal from sludge and salt tanks. Additionally, washing the sludge heels prior to processing through the DWPF will generate spent wash water. This *Plan* assumes the TCCR unit relocated to the HTF East Hill will process approximately 6 Mgal of water that will need to be dispositioned to support heel removal after SWPF and the 2H Evaporator are removed from service. This liquid stream, however, will not be as salty as the feed streams processed through SWPF. The Saltstone WAC will need to accommodate this more dilute stream into saltstone. Additionally, the NDAA must be addressed as this stream is not in the WD.

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

- 3H Evaporator shut down (FY26)
- Waste removal is complete from all Type I and II tanks (FY31)
- All Type I and II tanks are operationally closed (FY33)
- H-Canyon processing influents cease (FY30 or FY34 in the ABD case)
- 2H Evaporator shut down (FY33)
- FTF waste removal is completed (FY33)
- Inter-Area Line (IAL) removed from service (FY33)
- SWPF shut down (FY33)
- HTF (West Hill) waste removal is complete (FY35)
- FTF Type III tanks are operationally closed (FY36)
- HTF (East Hill) waste removal is complete (FY37)
- DWPF shut down (FY38, in the ABD case FY39)
- SPF shut down (FY39, in the ABD case FY40)
- All tanks are operationally closed (FY40, in the ABD case FY41)

Once closure activities are complete, any remaining facilities may be chemically cleaned and flushed as necessary.

5. Description of Assumptions and Bases

The following inputs and assumptions guided the development of the two cases of the 22nd revision of the LW System Plan. The targets described in these assumptions are the overall goals of the various facilities. Modeling of the LW system, however, resulted that all the targets were not achievable given the constraints of the updated SWPF schedule, limits to funding, or other system constraints. Examples include the second TCCR unit which was not included due to funding considerations, DWPF Recycle Diversion which was delayed due to technical and funding considerations, and others. The Assumptions listed herein were the initial assumptions used in the development of the *Plan.* This *Plan* seeks to maximize compliance with the SCDHEC "Dispute Resolution Agreement"[15] case.

- **Priorities for Scenario Development (these are goals, not necessarily outcomes):**
  1. Continual safe storage of liquid waste in tanks and vitrified canisters in storage.
  2. Risk Reduction through Waste Disposition, i.e., maximizing processing of waste and minimizing the total life cycle.
  3. Completion of waste removal from H-Tank Farm tanks in the water table (i.e., Type I and Type II tanks).
  4. Process liquid salt waste (e.g., dissolved salt solution, supernate) through FY22 in accordance with the SCDHEC "Dispute Resolution Agreement" (including consideration for *Force Majeure* conditions).
  5. Complete operational closure of FDB-5 & 6 by the end of FY22, consistent with FFA, Appendix L, 2019 Suspension Agreement.
  6. Deploy NGS at SWPF no later than 28 months after SWPF begins operations, consistent with the SCDHEC "Dispute Resolution Agreement".
  7. Complete FTF waste removal within 10 years to enable disconnecting the Inter-Area Line.

Please note that some of these goals are not forecast to have been achieved within the constraints of this Plan.

5.1 ***Funding***

- FY21 Enacted
- FY22 and beyond $1.046B level funding (no escalation)

5.2 ***Salt Waste Disposition***

- **Salt Waste Processing Facility Integration (SWPF)**
  - SWPF initiated hot commissioning October 5, 2020
  - SWPF initiated radioactive operations on January 18, 2021
  - SWPF processing rates at 6.44 M Na (for modeling purposes) will be:
    - 327,483 gallons during hot commissioning
    - Capacity of 500 kgal/mo (6 Mgal/yr) for the first 12 months of operation (One Year Operations or OYO)
  - After completion of SWPF OYO (January 19, 2022), SWPF will enter a ten-week outage for DWPF to deploy glycolic acid
    - SWPF is assumed to have a capacity of up to 500 kgal/mo (6 Mgal/yr) of SWPF feed after glycolic acid deployment at DWPF prior to NGS deployment at SWPF
    - The DWPF Final Glycolic Documented Safety Analysis (DSA) will be fully implemented in a one-month outage in July 2022
  - NGS will be deployed at SWPF in a one-month outage in February 2023
    - SWPF processing is assumed to ramp up after NGS deployment
      - 150 kgal for the first month
      - 300 kgal for the second month
      - 500 kgal for the third month
    - The SWPF is assumed to have a capacity of up to 750 kgal/mo (9 Mgal/yr) after the NGS ramp up
  - Higher molarity NGS processing can begin January 2024 with a maximum molarity of 7.5M.

- **Saltstone Production Facility (SPF)**
  - SPF staffing and processing capacity will support combined SWPF, TCCR, DWPF, and ETP as necessary
  - Placement of ^{129}I inventory in SDUs does not exceed limits in SRR-CWDA-2017-00042[20] while minimizing the total number of SDUs.

- **Tank Closure Cesium Removal (TCCR)**
  - TCCR 1A will process Tank 9 salt waste per the TCCR Operating Plan
  - The application of a second TCCR Unit should be based upon an optimized processing strategy
  - After bulk salt processing is completed and high-capacity salt processing is no longer needed, a TCCR unit may be used to process salt waste generated by continued DWPF processing
  - This Plan will assume TCCR columns will be dispositioned in borosilicate glass. Opportunities for alternative disposition paths shall also be investigated.

5.3 *Sludge Processing*

- Modeling will determine the optimum number of canisters and the appropriate waste loading required to support salt processing
- The nitric-glycolic acid flow sheet will be implemented as follows:
  - After completion of SWPF OYO (January 19, 2022), DWPF will enter a ten-week outage to deploy glycolic acid
  - DWPF will operate under the Interim Glycolic DSA for 3 months
  - The DWPF Final Glycolic DSA will be fully implemented in a one-month outage in July 2022
  - Transition to Sludge Batch 10 will occur after Final Glycolic DSA implementation
- DWPF canisters will maintain a fissile material concentration limit of no more than 2,500 g/m^3 of glass
- Double stacking will be implemented in GWSB 1 and 2 to the extent necessary
- Shipment of canisters off site for final disposition is not in the scope of this Plan.
- Melter replacement outages shall be projected based on past performance of the melters and projected canister production rates
- Actual FY20 canister production of 8 canisters for a total canister production as of the end of FY20 of 4,215.

5.4 *Support Accelerated Basin Deinventory (ABD)*

This section applies only for the case supporting ABD

- H-Canyon processes spent fuel without uranium recovery through September 2033
- A second sludge batch prep tank will be provided
- Iron and manganese already present in the tank waste and gadolinium added by H-Canyon are sufficient poisons for all LW facilities
- At least 500 kg of fissile material will be discarded into each sludge batch beginning with Sludge Batch 11 with depleted uranium added as needed to meet DWPF WAC limits for enrichment and synthetic sludge added to reduce canister fissile loading to 2,500 g/m^3 as necessary.

5.5 *Tank Closures*

- DOE will obtain SCDHEC and EPA approval such that tanks that have completed bulk waste removal efforts are allowed to be reused for:
  - TCCR operations support regardless of the source of feed from either old-style tanks or new-style tanks
  - movement of waste from old-style tanks
  - storage of other material previously approved by the SCDHEC and EPA (e.g., LTAD aluminum rich leachate)
  - storage of material such as dissolved salt solution or spent wash water.

5.6 *Tank Farm Operations*

- DWPF Recycle Waste shall be diverted from the 2H Evaporator System beginning October 1, 2025
- Tank 48 tetraphenylborate disposition shall be addressed in this system plan
- Sufficient tank space volume shall be maintained to support the receipt of:
  - Normal discards up to 300 kgal per year from H-Canyon operations through 2030 or through 2033 if supporting ABD
  - Special Nuclear Materials transfers (including plutonium, neptunium, etc.) directly into sludge batches from H-Canyon to the extent allowable.

5.7 *Additional Technical Assumptions*

The following technical assumptions were used as input to the modeling of this *Plan*:

Waste Removal

- Heel Removal is assumed to take six months of operations using a combination of available technologies as needed:
  - Mechanical Cleaning uses mechanical agitation
  - Chemical Cleaning uses LTAD, OA, or advanced/specialized mechanical or chemical technology
  - For some tanks with high waste turnover, e.g., Tanks 40, 49, 42 in the ABD case, or 51, mechanical cleaning may not be necessary; however, flushing could be required
  - Monitoring during any cleaning process will inform the decision to utilize additional cleaning processes.

Annulus Cleaning

- All tanks that have experienced leaks will undergo inspection and, potentially, sampling and analysis to determine the necessity for annulus cleaning. The amount and type of material used for annulus cleaning depends on the quantity and type of waste present.

Tank Removal from Service

- Stabilization of a waste tank (i.e., grouting of primary tank, annulus space, and cooling coils) as specified in the applicable CM is to be completed within 30 months of receipt of concurrence to enter the residual waste sampling and analysis phase
  - Sampling (6 months on critical path): including Tank Drying, Sample Prep Documents, Volume Determination, and Sampling
  - Sample Analysis (9 months on critical path): including Lab Analysis and Sample Analysis Report (SAR)
  - Closure Documentation (12 months on critical path): including Data Quality Assessment (DQA), Inventory Determination, Special Analysis, Final Removal Report, Class C Calculation, CM, and Tier 2 Documentation
  - Grouting (3 months on critical path)
- SRNL infrastructure will be enhanced or additional labs will be qualified to enable the receipt, analysis, and report for as many tanks as needed
- Within six months of stabilization, tank waste systems will be removed from the *F and H Area High Level Radioactive Waste Tank Farms Construction Permit No. 17424-IW* in accordance with the applicable and approved Interim Record of Decision.

Regulatory Approvals

- SCDHEC will approve activities associated with waste removal, stabilization, and operational closure. Maintenance and monitoring of waste tank systems will be performed and completed as described in the CGCP. Operational closure activities will be performed and completed as described in tank specific CMs which are generated per the approved CGCP
- EPA will approve the agreement to cease waste removal
- DOE will maintain NEPA documentation necessary to support this *Plan*.

DWPF Production

- The current sludge washing plan assumes washing to 1.0 M Na
- The canister heat load will be less than 834 watts per canister for a canister in a single stack location. Canisters will be double stacked in accordance with the guidance of *Heat Transfer Analysis of Double Stacking of Canisters in the Glass Waste Storage Building #1*[19] which permits storage of canisters up to 500 watts per canister.
- 12,800–21,000 gal of SE per SRAT/SME Batch for SWPF

Base Operations

- <u>Evaporation</u>

  The primary influents into the Tank Farms are DWPF recycle and H-Canyon waste receipts. In addition, sludge batch preparation produces a large internal stream of spent wash water. To continue to maintain space in the Tank Farms to support these missions, these streams must be evaporated. There are two operational evaporators in H-Area.

  DWPF recycle has a high concentration of silica due to the vitrification process. When this stream is mixed with aluminum streams from Plutonium Uranium Reduction Extraction (PUREX) and H Modified (HM) canyon processing, there is a potential for forming sodium aluminosilicate. Experience has shown that sodium aluminosilicate can co-precipitate sodium diuranate in the evaporator, causing a potential criticality concern. To prevent the potential for criticality, a feed qualification program is in place to minimize the formation of sodium aluminosilicate scale in the 3H Evaporator and to prevent accumulation of enriched uranium in the 2H Evaporator. This *Plan* assumes the current recycle limit of 5.5wt% U235 enrichment is maintained. It is assumed that scale may accumulate in the 2H Evaporator, but periodic cleaning maintains uranium enrichments and masses will be well below criticality concerns. It is also assumed that any necessary modifications to evaporator cleaning strategies are developed to ensure no potential for criticality exists.

- <u>*2H Evaporator*</u>
  - The 2H Evaporator System is currently used to evaporate DWPF recycle. The evaporator system feed and concentrate receipt tanks configuration is:
    - Feed–Tank 43; Receipt–Tank 38
  - After diversion of DWPF recycle, the 2H Evaporator will be cleaned and begin service as the general-purpose evaporator allowing the 3H Evaporator to be removed from service
  - Evaporator Capacity based on historical experience is 200 kgal/mo

- <u>*3H Evaporator*</u>
  - The 3H Evaporator is used to process streams that minimize scale production, i.e., canyon wastes and sludge batch decants. The evaporator system feed and concentrate receipt tanks configuration is:
    - Feed–Tank 32; Receipt–Tanks 29, 30, and Tank 37
  - Evaporator capacity based on historical experience is 100 kgal/mo
  - The 3H Evaporator System experienced a leak in the evaporator pot in 2016. After repair and discovery of an additional anomaly, it was determined to be operable with certain administrative controls. This *Plan* assumes the 3H Evaporator continues to operate under the current conditions without a lengthy outage through FY26.
  - Tank 30 has limited cooling capacity due to unrepairable failed cooling coils and Tank 37 has salt accumulations that limit effectiveness. Tank 29 is being equipped for use as an alternate receipt tank beginning in FY22.

- <u>*General Assumptions*</u>
  - A minor influent source is the 299-H Maintenance Facility. The influents mainly consist of a dilute nitric acid stream, decontamination solutions, and steam condensate. These waste streams are produced when equipment is decontaminated. They are collected in the 299-H pump tank, neutralized, and sent to Tank 39
  - Tank Farm infrastructure is maintained to support SWPF, DWPF, and SPF processing rates and tank operational closure schedules.

- <u>*TCCR*</u>

  Of necessity, tank farm operations will continue beyond the end of salt processing. The SWPF process support tanks will need final waste removal and cleaning. Likewise, the sludge processing tanks, including the 2H Evaporator system, must be de-inventoried and cleaned. Remaining sludge will require washing to be acceptable for DWPF processing into glass. This *Plan* includes an allowance for treatment and disposition of final heel and sludge washing solutions using a TCCR and SPF disposal. The waste generated from heel removal and sludge washing will not be high in sodium and can likely be treated with a TCCR unit to remove cesium, so that it can be sent to SPF. The WAC for SPF will need to be modified to handle this lower sodium material. Other options to handle these streams may be developed prior to the end of the program.

- <u>*Effluent Treatment Project*</u>
  ETP is assumed to receive an average of 11 Mgal/yr:
  - LW Evaporators: 5 Mgal/yr
  - Savannah River Nuclear Solutions (SRNS) Facilities: 6 Mgal/yr
    Note: The Agreement between SRNS and SRR for LW Receipt Services provides that the total maximum allocation for waste generated from SRNS facilities including H-Canyon, F-Canyon, and miscellaneous smaller contributors is 15 Mgal/yr.

<u>***Dismantlement and Decommissioning (D&D)***</u>

- LW Areas will be transferred to Area Closure on an area-by-area basis upon closure of their included facilities.

6. System Description

6.1 *History*

The LW System is the integrated series of facilities at 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 160 Mgal of radioactive waste. As of June 2021, over 35.6 Mgal[21] 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 6-2—*Process Flowsheet*). As of January 1, 2021, DWPF had poured 4,226 vitrified waste canisters (see Figure 6-3—*Liquid Waste Program—Current Status*).

6.2 *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. Types I, II, and IV tanks are all referred to as “old-style” tanks.

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 FTF and Tank 12 in 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[22]. 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 dispositioning waste via the TCCR process (Tanks 9, 10, and 11)
- 1 is awaiting heel removal activities to commence (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):

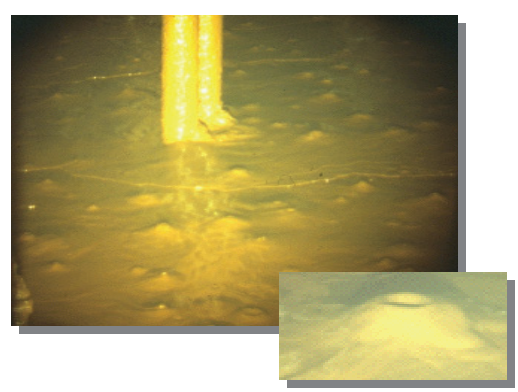
- 2 are operationally closed and grouted (Tanks 17 and 18)
- 2 contain essentially dry waste, with little or no free liquid supernate (Tanks 2 and 3)
- 6 contain liquid supernate. (Tanks 7, 8, and 21 through 24).

When waste disposition began in 1996, the inventory of waste in the SRS tank system contained approximately 550 Million curies (MCi). Currently, 35.6 Mgal of radioactive waste, containing 232 MCi[21] 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. The resulting crystalline solids are commonly referred to as saltcake. The saltcake and supernate combined are referred to as salt waste.

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.

The sludge component of the radioactive waste represents approximately 2.6 Mgal (7% of total) of waste but contains approximately 110 MCi (47% of total). The salt waste makes up the remaining 33 Mgal (93% of total) of waste and contains approximately 122 MCi (53% of total). Of that salt waste, the supernate accounts for 17 Mgal and 110 MCi and saltcake accounts for the remaining 16 Mgal and 12 MCi[21]. The sludge contains the majority of the long-lived (half-life greater than 30 years) radionuclides (e.g., actinides) and strontium. The sludge is currently being stabilized in DWPF through a vitrification process that immobilizes the waste in a borosilicate glass matrix. The salt is separated in SWPF into a higher-level component being stabilized in DWPF and a lower-level component dispositioned in SDF.

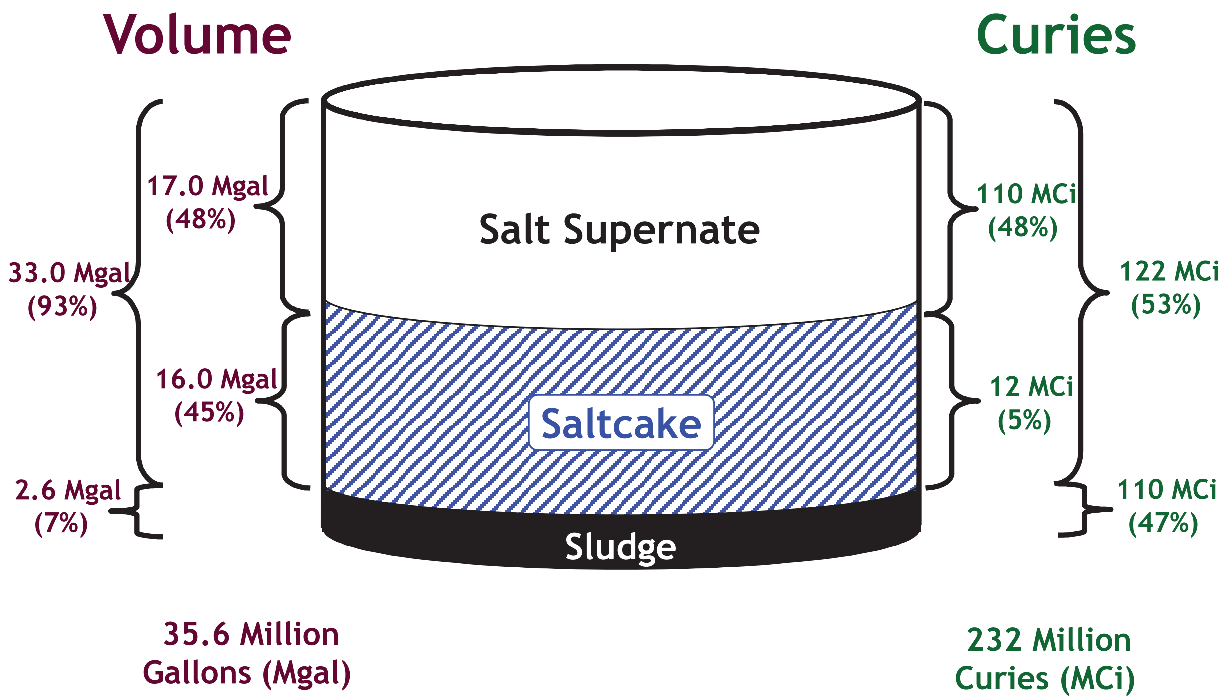
Radioactive waste volumes and radioactivity inventories reported herein are based on the Waste Characterization System (WCS) database, which includes the chemical and radionuclide inventories on a tank-by-tank basis. WCS is a dynamic database frequently updated with new data from ongoing operations such 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.



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

Well over 95%[21] 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[23]. 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 6-1—*Waste Tank Composite Inventory (as of June 30, 2021)*[21]



6.3 *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 160 Mgal of LW, of which over 110 Mgal have been evaporated, leaving approximately 35.6 Mgal in the storage tanks. 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. Since initiation of interim salt waste treatment (DDA and ARP/MCU), the working capacity of the Tank Farms has been maintained. 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: (1) retrieve waste from and clean old-style tanks; (2) prepare, qualify, and treat sludge waste for disposal; (3) prepare, qualify, treat, and dispose salt waste; and (4) 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, 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 to return the resulting low-level salt waste to the Tank Farm. Similarly, salt waste retrieval, preparation, and batching typically require the use of three gallons of tank space per gallon of salt waste treated. 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 DNFSB letter dated January 7, 2010[24].

New-style tank space is a currency used to prepare for permanent immobilization and disposition of HLW 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 disposition via SWPF. Of the 27 new-style tanks (with a total nominal volume of 35.1 million gallons) in the SRS LW System:

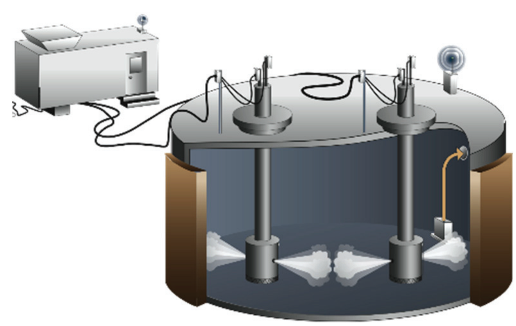
- 6 (Tanks 38, 41, 42, 43, 49, and 50) are dedicated to salt batching, qualification, and disposition (including DWPF recycle beneficial reuse, feeding the Saltstone Production Facility (SPF), and the 2H Evaporator).
- 1 additional (Tank 27) is planned for conversion to a salt blend tank to prepare salt batching
- 6 (Tanks 29, 30, 32, 37, 40, and 51) are dedicated to sludge batching, qualification, and disposition (including the 3H Evaporator) and note that Tank 42 will move from salt to sludge service in the ABD case
- 1 (Tank 39) is dedicated to uninterrupted H-Canyon waste receipts
- 13 (Tanks 25, 26, 28, 31, 33, 34, 35, 36, 44, 45, 46, 47, and 48) are dedicated to safe storage of legacy LW pending retrieval and disposition.

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

- 3.6 Mgal is margin as defense-in-depth operational control coupled with Safety Class or Safety Significant (SC/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
- 2.8 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.

6.4 ***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 TCCR or 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 Drain, Add, Remove (DAR) method. Initially, the highly concentrated interstitial liquid salt solution is drained. Dissolution liquid is then added using a liquid addition 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 removed 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.

6.5 ***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 saltstone, 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. The main separation will be accomplished in SWPF. However, SWPF will be supplemented with TCCR processing to accelerate the disposition of salt waste.

6.6 ***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) is added to the waste as a finely divided solid. Actinides are sorbed on the MST and then filtered out of the liquid to produce a low-level waste stream that is sent to MCU. The solids, containing the MST with the actinides, are dispositioned at DWPF. In January of 2016, salt processing without using the MST addition was demonstrated to produce effluent capable of meeting the SPF WAC while improving filtration using the then-current feed. Salt processing without MST continued until MCU operation were suspended for SWPF tie-ins.
- **Modular CSSX Unit** (MCU) – The ARP low-level waste stream requires reduction in the concentration of Cs-137 using Caustic Side Sodium eXtraction (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 were suspended in May 2019 to tie in SWPF.
- **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. It began full operations in January 2021 and is planned to process most of the remaining salt waste.
- **Tank Closure Cesium Removal** (TCCR) – TCCR consists of an ion exchange process for the removal of cesium from liquid salt waste to provide supplemental treatment capability. Building on the experience of modular commercial nuclear plant decontamination and following the disaster response associated with Fukushima, technology exists to efficiently accomplish large scale, selective removal of the cesium component of the bulk salt waste. The configuration is an “at-tank” modular arrangement which began operations in January 2019. The configuration consists of temporary process structures located near a tank, so the cesium removal process would take place outside of the tank. The DSS is transferred to Tank 50 for disposition via SPF. Once the ion exchange media in a column becomes loaded with cesium to the extent practical (“spent”), the column (with media) is removed from the system and replaced with a new ion exchange column loaded with fresh media. The spent column is transported to an ISS location within the tank farm. Beginning in FY27, columns will be transported to a column unloading and resin grinding unit installed at DWPF or disposed via an alternate method, such as off-site shipment. Ground resin will be collected in a vessel and then added to SRAT or SME batches in limited quantities to ensure that canister waste form requirements are met. For the last few years of the LW program, after the completion of SWPF processing, the water used to support heel removal and prepare sludge heel batches will be treated via TCCR.

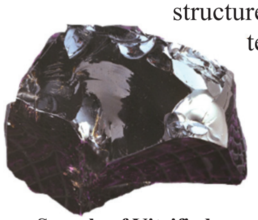
6.7 ***Sludge Processing***

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.

6.8 *DWPF Vitrification*

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

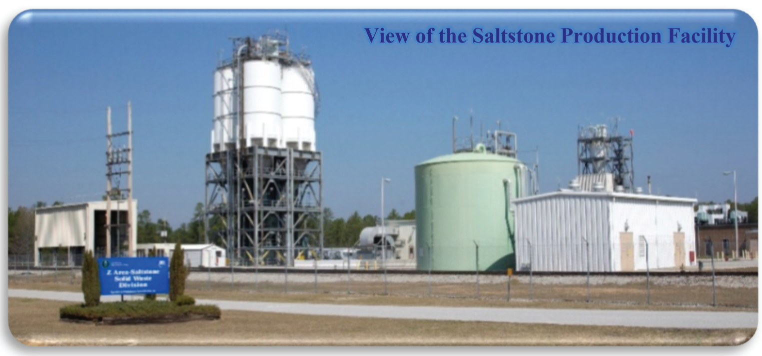
Final processing for the washed sludge and salt waste occurs at DWPF. This waste includes MST sludge and cesium SE from SWPF and the washed sludge slurry from sludge processing. In a complex sequence of carefully controlled chemical reactions, this waste is blended with glass frit and melted to vitrify 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.



Sample of Vitrified Radioactive Glass

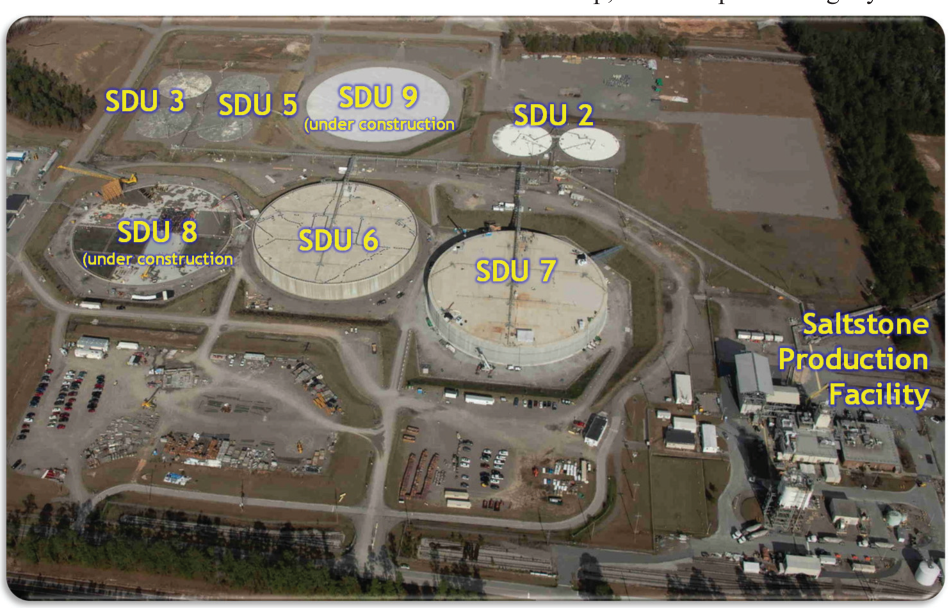
6.9 *Saltstone Disposition*

The Saltstone Facility, located in Z-Area, 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. SDF is permitted as an Industrial Solid Waste Landfill site.



View of the Saltstone Production Facility

With SWPF startup, feed of up to 13 Mgal/yr is expected. 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 saltstone. 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 saltstone monoliths will be at least five feet above the historic high-water table beneath the Z-Area site, 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 were used during the initial operation of the SPF, are not planned for continued placement of saltstone grout, and are slated for closure.

SDU-2 and SDU-5 (which are full), and SDU-3 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 has a capacity of over 32.8 Mgal of contaminated grout or 18.7 Mgal of feed. SDU-7 through SDU-12, with a design change to remove the column footers and increase the fill height, 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 started radioactive operations June 12, 1990. SDU-2, completed 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 and has not yet been completely filled. 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. 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 6-2—*Process Flowsheet*

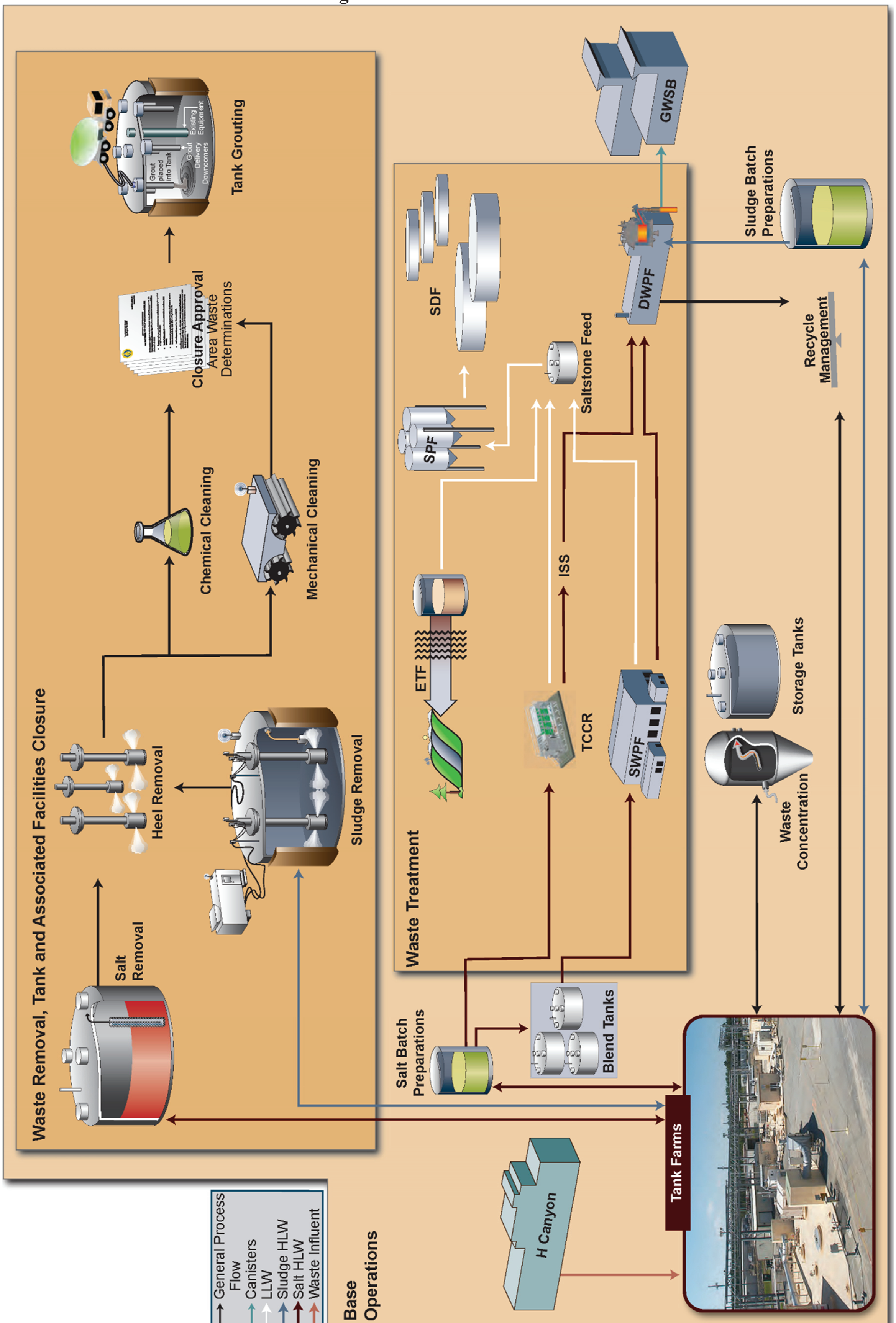
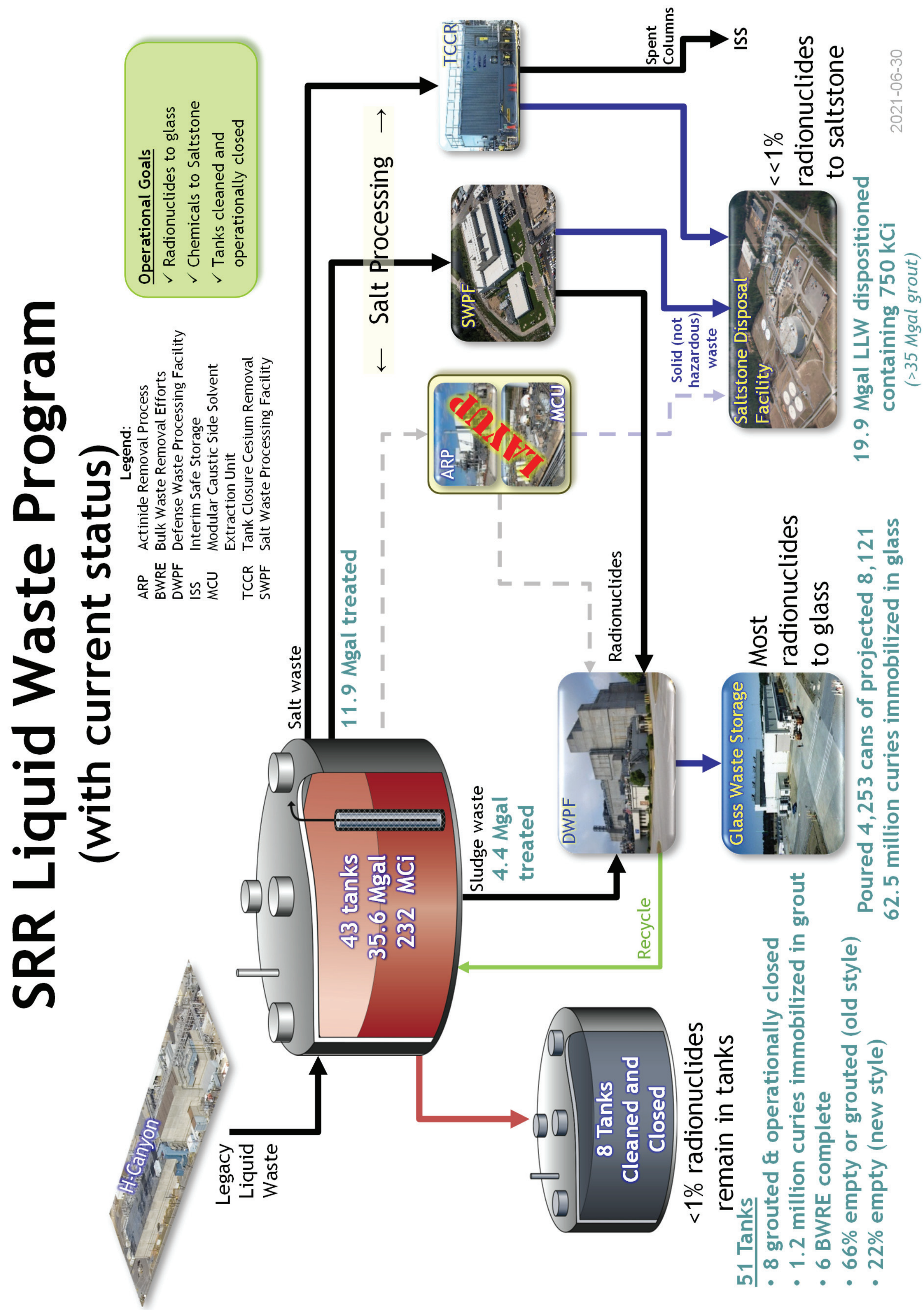
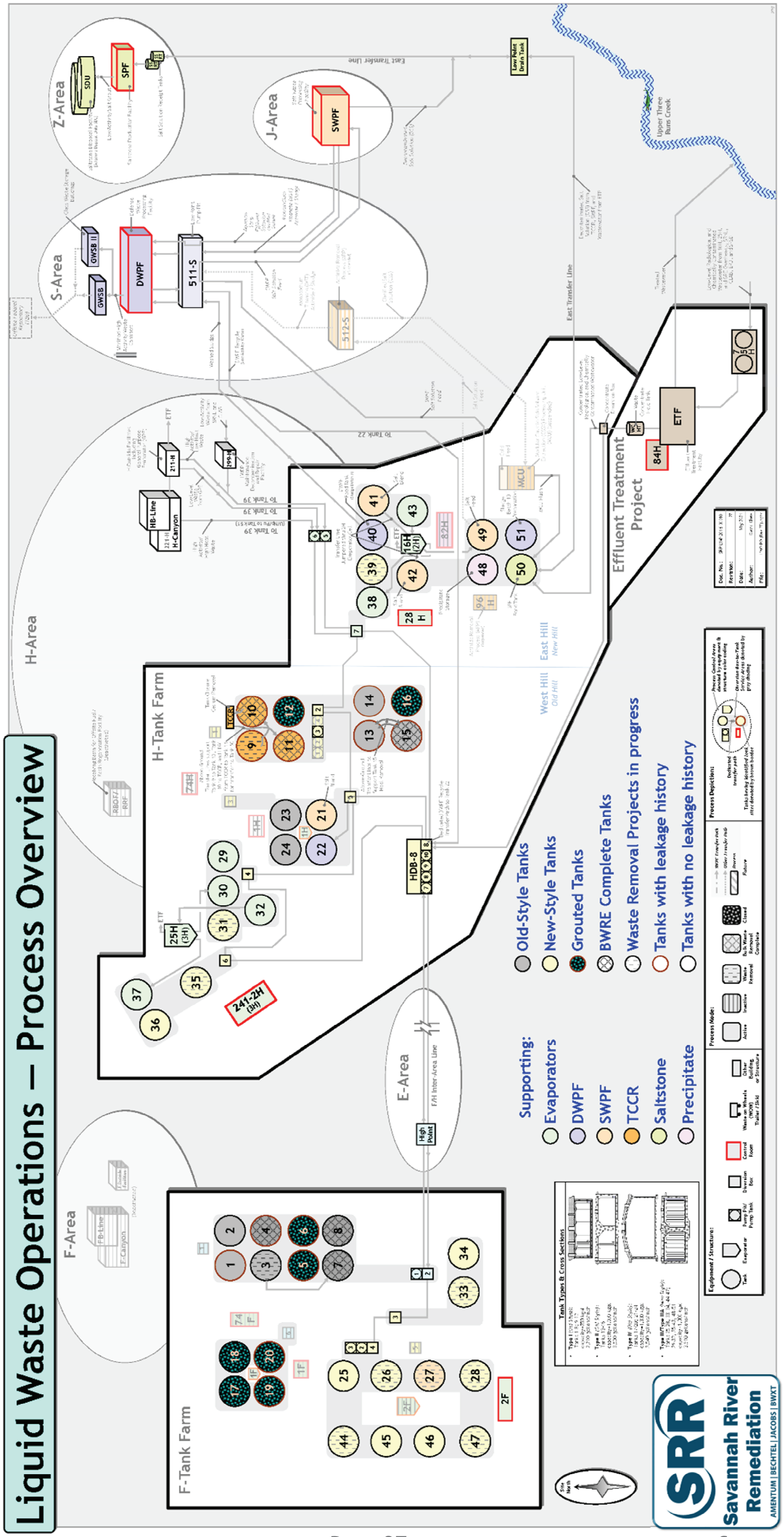


Figure 6-3—*Liquid Waste Program—Current Status*




Liquid Waste Operations – Process Overview
F-Area
F-Tank Farm
E-Area
H-Area
H-Tank Farm
S-Area
Z-Area
J-Area
DWPF
511-S
512-S
GWSB
GWSB II
SPF
SDU
SWPF
MCU
ETF
HDB-8
241-2H
Effluent Treatment Project
East Transfer Line
Upper Three Runs Creek
West Hill
East Hill
Supporting:
Evaporators
DWPF
SWPF
TCCR
Saltstone
Precipitate
Old-Style Tanks
New-Style Tanks
Grouted Tanks
BWRE Complete Tanks
Waste Removal Projects in progress
Tanks with leakage history
Tanks with no leakage history
SRR
Savannah River Remediation
AMENTUM | BECHTEL | JACOBS | BWXT

Appendix A1—*Salt Solution Processing*

End of Fiscal Year	Salt Solution (kgal) DDA-solely	ARP/MCU	TCCR	SWPF	Total [a]	to Tank 50 (kgal) DSS	H-Can	MCU Flush	TCCR	ETP	Tank 50 to SPF	SDU Numbers [c]
Total as of end of FY10	*2,800*	*985*			*3,785*	*3,151*	*682*		*Sludge Heel decants*	*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*	*1,429*	*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*			*42*	*-0-*	*6*
FY21			190	4,827	5,017	6,376		9		60	6,446	6
FY22			190	4,250	4,440	5,636				60	5,696	6
FY23			525	5,950	6,475	8,150				60	8,210	6-7
FY24			525	9,000	9,525	12,059				60	12,119	7
FY25			525	9,000	9,525	12,059				60	12,119	7-8
FY26			350	9,000	9,350	11,884				60	11,944	8
FY27			500	9,000	9,500	12,034				40	12,074	8-9
FY28			1,000	9,000	10,000	12,533				40	12,573	9-10
FY29			1,000	6,000	7,000	8,689				40	8,729	10
FY30			1,000	9,000	10,000	12,533				40	12,984	10-11
FY31			1,000	9,000	10,000	12,533				35	12,568	11
FY32			-	9,000	9,000	11,534			-	35	11,569	11-12
FY33			-	3,000	3,000	3,845			537	30	4,412	12
FY34			-		-	-			2,778	20	2,798	12
FY35			-		-	-			1,748	20	1,768	12
FY36			-		-	-			528	20	548	12
Total	**2,800**	**7,454**	**7,104**	**96,027**	**113,386**	**141,283**	**989**	**152**	**5,592**	**4,140**	**150,302**	

[a] *Salt Solution* is a total of salt solution treated via the DDA-solely, ARP/MCU, TCCR, and SWPF processes. Each gallon of salt solution treated via ARP/MCU yields ~1.26 gal of DSS, ~1.28 gallons for SWPF and ~1 gallon for TCCR.

[b] LLW receipts to Tank 50 include the DSS from salt processing, LLW from H-Canyon, ARP (512-S) filter cleaning discards, and the ETP low level stream.

[c]
- SDU-2 and SDU-5 (being full), SDU-1, and SDU-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 DSS and SDU-7 through SDU-12 are capable of receiving ~19.7 Mgal of DSS
- Each gallon of Tank 50 feed, when added to the cement, fly ash, and slag, generates approximately 1.76 gallons of grout

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

Appendix B1—*Tank Farm Influents and Effluents*

End of Fiscal Year	Influents (kgal)				Effluents (kgal)		Total Inventory[e]
	H-Canyon[a] HLW	DWPF Recycle[c]	299-H	ETF	DSS to SPF	Sludge to DWPF	
FY21	210	1,556	12	60	6,443	117	**31,176**
FY22	300	1,428	12	60	5,696	122	**30,689**
FY23	300	1,901	12	60	8,210	240	**30,057**
FY24	300	2,628	12	60	12,119	341	**27,907**
FY25	300	1,314	12	60	12,119	340	**25,886**
FY26	300	1,550	12	60	11,944	341	**24,098**
FY27	300	-	12	40	12,074	335	**20,531**
FY28	300	-	12	40	12,573	330	**18,803**
FY29	300	-	12	40	8,729	223	**17,982**
FY30	300	-	12	40	12,984	339	**14,784**
FY31	-	-	[d]	35	12,568	343	**10,290**
FY32	-	-	-	35	11,569	344	**6,064**
FY33	-	-	-	30	4,412	302	**4,021**
FY34	-	-	-	20	2,798	263	**2,560**
FY35	-	-	-	20	1,768	259	**1,419**
FY36	-	-		20	548	204	**718**
FY37	-	-		-	-	119	**711**

a H-Canyon receipts consist of HLW, received into Tank 39.

b Various nuclear materials, including plutonium, uranium, neptunium, etc., from H-Canyon may be introduced directly into sludge batches, via either the sludge preparation tank (Tank 51) or the DWPF feed tank (Tank 40) to the extent allowable without negatively impacting planned canister waste loadings while continuing to comply with the canister fissile material concentration limits. The H-Canyon forecast for these materials will be included in future versions of this *Plan*, as it is made

c DWPF Recycle receipts may be received into Tank 22 or used for Beneficial Reuse in salt dissolution or sludge washing. After FY23 DWPF recycle is planned to be treated by ETP.

d Maintenance Facility (299-H) receipts mainly consist of dilute nitric acid stream, decontamination solutions, and steam condensate. Waste streams from decontaminating equipment are collected in the 299-H pump tank, neutralized, and sent to Tank 39. Beginning in FY31, 299-H services supported by H-Canyon will cease and maintenance activities will be performed in the DWPF maintenance cell.

e Volumes are not additive after accounting for jet dilution, expansion of sludge during sludge slurrying operations (sludge becomes less dense), and other volume changes during the processing of waste. During a transfer, steam eductor jets are used to transfer LW from tank to tank. Volume from the transfer steam accounts for 4% of the volume being transferred for intra-area transfers and 6% for IAL. Additionally, mixing waste forms of different compositions are not mathematically additive.

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

Appendix C1—*Sludge Processing*

Sludge Batch	Source Tanks [a]	Projected SOL (weight %)	Actual Cans @ Projected SOL	Date Batch Finished @ Projected SOL[b]
Actual canister poured through June 2021 (SB1 through SB9)			4,253	
SB9 (continued)	13, 12 Chemical Cleaning, 22 (solids from DWPF)	32%	206	Sep 2022
SB10	15 (via 13) (HM HAW), LTAD, 26 (PUREX)	36%	364	Mar 2024
SB11	22 (DWPF Recycle), 15 via 13 (HM HAW), 35 (HM HAW), LTAD, 26 (PUREX)	36%	414	Sep 2025
SB12	35, 39 (HM HAW), LTAD 33 (PUREX), 26 via 13 (MIXED HM/PUREX), 33 (PUREX)	36%	414	Mar 2027
SB13	35, 39 (HM HAW), LTAD, 14 via 13 (HM HAW), 33 (PUREX)	36%	414	Sep 2028
DWPF Melter Replacement			Oct 2028 thru Jan 2029	
SB14	39, 32 (HM HAW), LTAD, 34 via 33(PUREX)	36%	322	Mar 2030
SB15	39, 32 (HM HAW), LTAD, 43 (MIXED HM HAW/LAW), 47 via 33(PUREX)	36%	414	Sep 2031
SB16	32, 39 (HM HAW), LTAD, 47 via 33 (PUREX)	36%	408	Mar 2033
SB17	39 (HM HAW)(incl 23 Solids), 33 (PUREX),	36%	288	Sep 2034
Heel Batch 1 [c]	35 (HM HAW plus DWPF Solids), 39 (Incl 32 HM HAW, 24 Zeolite, 23 Solids) 33 (incl 47) (PUREX), 43 (HM LAW)	36%	288	Mar 2036
Heel Batch 2 [c]	42, 43, 35, 39 including Heels (Mixed HM HAW, HM LAW)	32%	63	Sep 2036
Heel Batch 3 [c]	Heel Removal to 40	30%	60	Mar 2037
Heel Batch 4 [c]	40 Heel Material	30%	50	Sep 2037
			7,958	

[a] The indicated tanks are the sources of the major components of each sludge batch, not necessarily the sludge location just prior to receipt for sludge washing. Tanks 33 and 35, for example, are also used to stage sludge that is removed from other tanks. Some BWRE may be accelerated with respect to this table as conditions dictate.

[b] Dates are approximate and represent when Tank 40 gets to heel level. Actual dates depend on canister production rates

[c] Longer processing assumed for dilute heel processing

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

Appendix D1—*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 FY20. FY21 and future 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*	*21*	*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	146	4,361	146	2,060		2,292	
FY22	132	4,493	282	2,342	(150)	2,142	Remaining capacity:
FY23	192	4,685	192	2,534		2,142	2,178
FY24	276	4,961	276	2,810		2,142	2,202
FY25	276	5,237	276	3,086		2,142	2,226
FY26	276	5,513	276	3,362		2,142	2,250
FY27	276	5,789	276	3,638		2,142	2,274
FY28	276	6,065	276	3,914		2,142	2,298
FY29	184	6,249	184	4,098		2,142	2,414
FY30	276	6,525	276	4,374		2,142	2,438
FY31	276	6,801	126	4,500	150	2,292	2,403
FY32	276	7,077		4,500	276	2,568	2,127
FY33	228	7,305		4,500	228	2,796	1,899
FY34	192	7,497		4,500	192	2,988	1,707
FY35	192	7,689		4,500	192	3,180	1,515
FY36	159	7,848		4,500	159	3,339	1,356
FY37	110	7,958		4,500	119	3,458	1,246
FY38		7,958		4,500		3,458	1,246

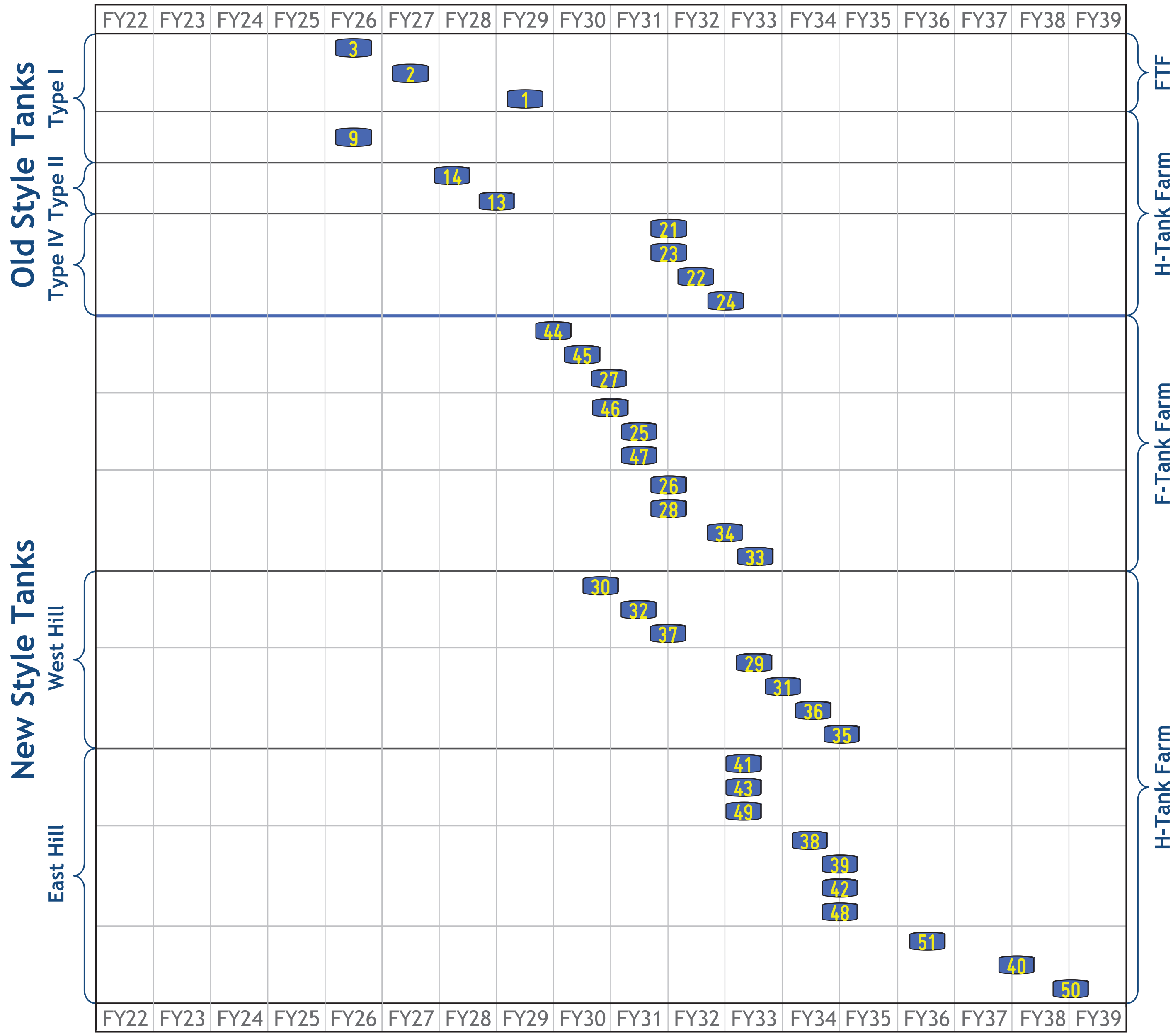
[a] GWSB 1 filling began in May 1996. Beginning in FY15, conversion of the 2,262 standard canister storage locations enable, via double stacking, each position to hold two cans for a total capacity of 4,524 canisters.

[b] GWSB 2 was built with 2,340 standard storage locations. LWSP R22 assumes 150 canisters will be moved from GWSB 2 to GWSB 1 by the end of FY23 to allow double stacking conversion to begin in FY24 at 300 positions per year for a total capacity of 4,680 canisters. Enough positions are planned to be converted to allow storage of all canisters produced. Over capacity may be minimized at management discretion.

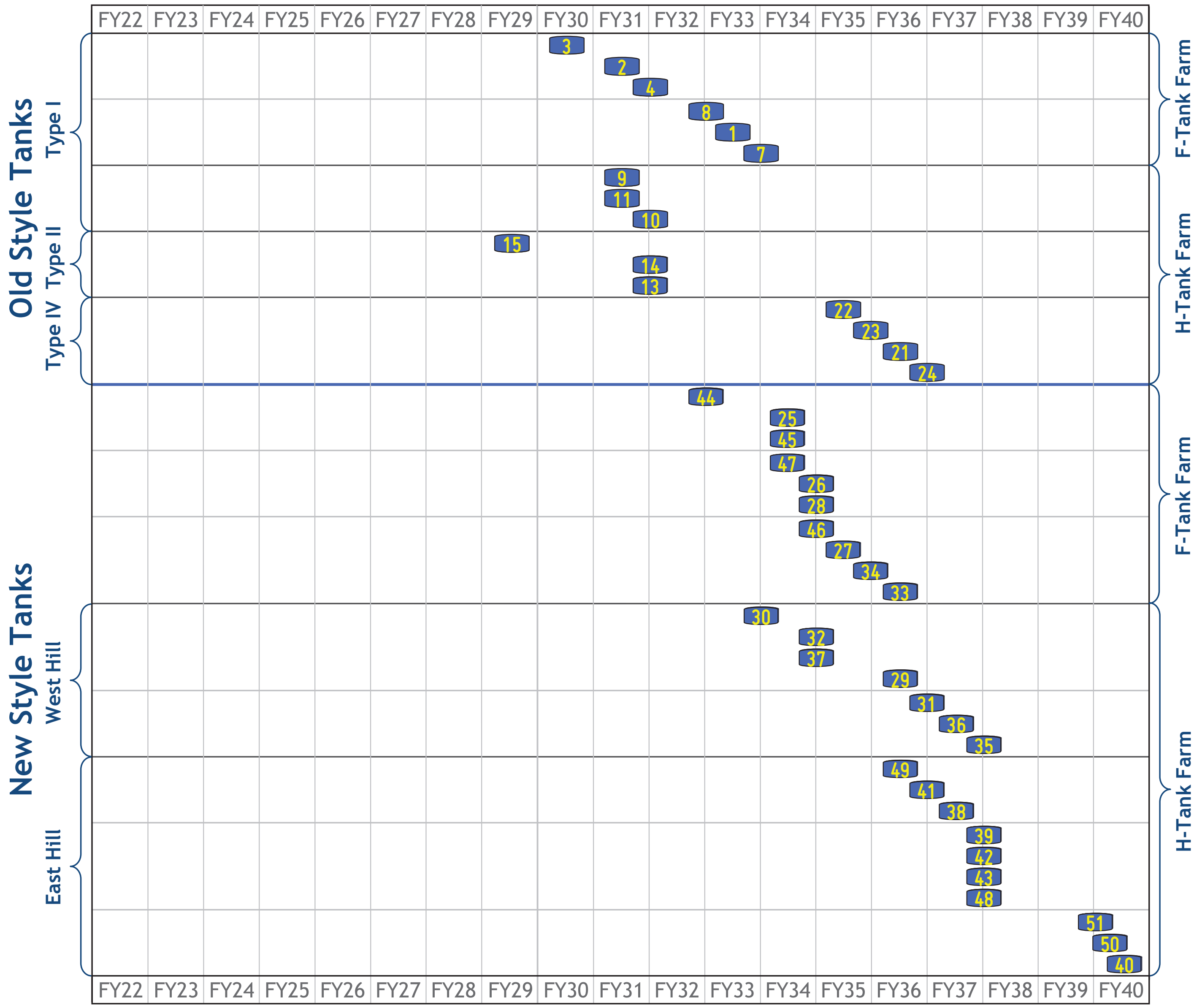
[c] At the end of each year, a certain number of cans are not emplaced in the GWSBs, being retained in the vitrification building. At the end of the program, all canisters will be stored in the GWSBs pending final disposition. The remaining capacity is the number of additional canisters that could be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

Note: These canister estimates are calculated based on the best information available at the time and many assumptions about future waste inventory and processing. The canister numbers are calculated based on all of the assumptions and constraints, but are not intended to be more than a rough discriminator between cases. The number should be expected to change for cases with different assumptions and in general there are no cases that are identical.

Appendix E1—*Bulk Waste Removal Complete*



Appendix F1—*Tank Removal from Service*



Appendix G1—*LW System Plan—Revision 22 Summary (DNA)*

(see attached foldout chart)

Appendix H1—*TCCR Columns Interim Safe Storage*

End of Fiscal Year	TCCR Columns transported to Interim Safe Storage[a]			TCCR Columns dispositioned in DWPF[b]	
	Added	Cum.	Remaining	Ground	Cum.
FY19					
FY20					
FY21	4	4	4		
FY22	2	6	6		
FY23	2	8	8		
FY24	2	10	10		
FY25	2	12	12		
FY26	2	14	14		
FY27		14	10	4	4
FY28	4	18	10	4	8
FY29	2	20	9	3	11
FY30	2	22	7	4	15
FY31	4	26	7	4	19
FY32		26	3	4	23
FY33		26		3	26
FY34	8	34	4	4	30
FY35	4	38	4	4	34
FY36	2	40	2	4	38
FY37		40		2	40

TCCR Ion Exchange Column Assumptions

- TCCR IX column design remains the same (mass of CST is ~515 kg)
- Adsorption kinetics supports a loading of 75,000 Ci of Cs-137 per IX column
- The capacity of CST for cesium adsorption is unaffected by salt solution makeup or UOP manufacturing process
- Temperature of salt solution/columns is maintained constant so CST resin kinetics/capacity is constant
- Resulting decontaminated salt solution meets the Saltstone Waste Acceptance Criteria

[a] Maximum ISS Capacity: 16 Columns

[b] Grinding cap at DWPF: 12 columns/year

Note: These column estimates are calculated based on the best information available at the time and many assumptions about future waste inventory and processing. They are not intended to provide a bounding analysis of TCCR column production.

Appendix A2—*Salt Solution Processing (ABD Case)*

End of	Salt Solution (kgal)					to Tank 50 (kgal)					Tank 50	SDU
Fiscal Year	DDA-solely	ARP/MCU	TCCR	SWPF	Total [a]	DSS	H-Can	MCU Flush	TCCR	ETP	to SPF	Numbers [c]
Total as of end of FY10	*2,800*	*985*			*3,785*	*3,151*	*682*		*Sludge Heel decants*	*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*	*1,429*	*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*			*42*	*-0-*	*6*
FY21			190	4,827	5,017	6,376		9		60	6,446	6
FY22			190	4,250	4,440	5,636				60	5,696	6
FY23			525	5,950	6,475	8,150				60	8,210	6-7
FY24			525	9,000	9,525	12,059				60	12,119	7
FY25			525	9,000	9,525	12,059				60	12,119	7-8
FY26			350	9,000	9,350	11,884				60	11,944	8
FY27			500	9,000	9,500	12,034				40	12,074	8-9
FY28			1,000	9,000	10,000	12,533				40	12,573	9-10
FY29			1,000	6,000	7,000	8,689				40	8,729	10
FY30			1,000	9,000	10,000	12,533				40	12,984	10-11
FY31			-	9,000	9,000	11,534				40	11,574	11
FY32			-	9,000	9,000	11,534				40	11,574	11-12
FY33			-	3,000	3,000	3,845			600	30	4,475	12
FY34			-		-	-			2,632	20	2,652	12
FY35			-		-	-			2,476	20	2,496	12
FY36			-		-	-			728	20	748	12
Total	**2,800**	**7,454**	**6,104**	**96,027**	**112,386**	**140,283**	**989**	**152**	**6,437**	**4,150**	**150,157**	

[a] *Salt Solution* is a total of salt solution treated via the DDA-solely, ARP/MCU, TCCR, and SWPF processes. Each gallon of salt solution treated via ARP/MCU yields ~1.26 gal of DSS, ~1.28 gallons for SWPF and ~1 gallon for TCCR.

[b] LLW receipts to Tank 50 include the DSS from salt processing, LLW from H-Canyon, ARP (512-S) filter cleaning discards, and the ETP low level stream.

[c]
- SDU-2 and SDU-5 (being full), SDU-1, and SDU-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 DSS and SDU-7 through SDU-12 are capable of receiving ~19.7 Mgal of DSS
- Each gallon of Tank 50 feed, when added to the cement, fly ash, and slag, generates approximately 1.76 gallons of grout

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

Appendix B2—*Tank Farm Influents and Effluents (ABD Case)*

End of Fiscal Year	Influents (kgal)				Effluents (kgal)		Total Inventory[e]
	H-Canyon[a] HLW	DWPF Recycle[c]	299-H	ETF	DSS to SPF	Sludge to DWPF	
FY21	210	1,556	12	60	6,441	139	**31,172**
FY22	300	1,428	12	60	5,696	140	**30,773**
FY23	192	1,901	12	60	8,210	261	**29,691**
FY24	20	2,628	12	60	12,119	371	**26,713**
FY25	278	1,314	12	60	12,119	368	**23,920**
FY26	135	1,550	12	60	11,944	365	**23,158**
FY27	135	-	12	40	12,074	364	**21,452**
FY28	135	-	12	40	12,573	367	**18,173**
FY29	135	-	12	40	8,729	240	**17,386**
FY30	135	-	12	40	12,984	369	**14,633**
FY31	126	-	12	40	11,574	375	**11,241**
FY32	130	-	12	40	11,574	372	**7,022**
FY33	131	-	12	30	4,475	321	**4,795**
FY34	192	-	12	20	2,652	359	**3,653**
FY35		-	d	20	2,496	364	**1,536**
FY36		-		20	748	365	**909**
FY37		-		-	-	330	**904**
FY38					-	135	**842**

a H-Canyon receipts consist of: HLW, received into Tank 39 and, beginning in FY23, ABD, received into Tanks 42 and 51

b Various nuclear materials, including plutonium, uranium, neptunium, etc., from H-Canyon may be introduced directly into sludge batches, via either the sludge preparation tank (Tank 51) or the DWPF feed tank (Tank 40) to the extent allowable without negatively impacting planned canister waste loadings while continuing to comply with the canister fissile material concentration limits. The H-Canyon forecast for these materials will be included in future versions of this *Plan*, as it is made

c DWPF Recycle receipts may be received into Tank 22 or used for Beneficial Reuse in salt dissolution or sludge washing. After FY23 DWPF recycle is planned to be treated by ETP.

d Maintenance Facility (299-H) receipts mainly consist of dilute nitric acid stream, decontamination solutions, and steam condensate. Waste streams from decontaminating equipment are collected in the 299-H pump tank, neutralized, and sent to Tank 39. Beginning in FY31, 299-H services supported by H-Canyon will cease and maintenance activities will be performed in the DWPF maintenance cell.

e Volumes are not additive after accounting for jet dilution, expansion of sludge during sludge slurrying operations (sludge becomes less dense), and other volume changes during the processing of waste. During a transfer, steam eductor jets are used to transfer LW from tank to tank. Volume from the transfer steam accounts for 4% of the volume being transferred for intra-area transfers and 6% for IAL. Additionally, mixing waste forms of different compositions are not mathematically additive.

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

Appendix C2—*Sludge Processing (ABD Case)*

Sludge Batch	Source Tanks [a]	Projected SOL (weight %)	Actual Cans @ Projected SOL	Date Batch Finished @ Projected SOL[b]
Actual canister poured through June 2021 (SB1 through SB9)			4,253	
SB9 (continued)	13, 12 Chemical Cleaning, 22 (solids from DWPF)	32%	206	Jun 2022
SB10	15 (via 13) (HM HAW), LTAD, 26 (PUREX)	36%	456	Jul 2024
SB11	15 via 13 (HM HAW), 35 (HM HAW), LTAD, 26 (PUREX)	36%	414	Jan 2026
SB12	35, 39 (HM HAW), LTAD 33 (PUREX), '14, 26 via 13 (MIXED HM/PUREX)	36%	414	Jul 2027
SB13	32, 35, 39 (HM HAW), LTAD, 34 via 33 (PUREX)	36%	322	Sep 2028
DWPF Melter Replacement			Oct 2028 thru Jan 2029	
SB14	35, 39, 32 (HM HAW), LTAD, 47 via 33(PUREX)	36%	299	Feb 2030
SB15	39, 32 (HM HAW), LTAD, 43 (MIXED HM HAW/LAW), 47 via 33(PUREX)	36%	529	Jan 2032
SB16	32, 39 (HM HAW), LTAD, 47 via 33 (PUREX)	36%	366	Jul 2033
SB17	39 (HM HAW)(incl 23 Solids), 33 (PUREX),	36%	352	Jan 2035
SB18	35 (HM HAW plus DWPF Solids), 39 (Incl 32 HM HAW, 24 Zeolite, 23 Solids) 33 (incl 47) (PUREX), 43H (HM LAW)	36%	378	Jul 2036
Heel Batch 1 [c]	42, 43, 35, 39 including Heels (Mixed HM HAW, HM LAW)	32%	294	Sep 2037
Heel Batch 2 [c]	Heel Removal to 40	30%	60	Mar 2038
Heel Batch 3 [c]	40 Heel Material	30%	50	Sep 2038
			8,393	

[a] The indicated tanks are the sources of the major components of each sludge batch, not necessarily the sludge location just prior to receipt for sludge washing. Tanks 33 and 35, for example, are also used to stage sludge that is removed from other tanks. Some BWRE may be accelerated with respect to this table as conditions dictate.

[b] Dates are approximate and represent when Tank 40 gets to heel level. Actual dates depend on canister production rates

[c] Longer processing assumed for dilute heel processing

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

Appendix D2—*Canister Storage (ABD Case)*

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 FY20. FY21 and future 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	21	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	146	4,361	146	2,060		2,292	
FY22	132	4,493	282	2,342	(150)	2,142	Remaining capacity:
FY23	192	4,685	192	2,534		2,142	2,178
FY24	276	4,961	276	2,810		2,142	2,202
FY25	276	5,237	276	3,086		2,142	2,226
FY26	276	5,513	276	3,362		2,142	2,250
FY27	276	5,789	276	3,638		2,142	2,274
FY28	276	6,065	276	3,914		2,142	2,298
FY29	184	6,249	184	4,098		2,142	2,414
FY30	276	6,525	276	4,374		2,142	2,438
FY31	276	6,801	126	4,500	150	2,292	2,403
FY32	276	7,077		4,500	276	2,568	2,127
FY33	222	7,299		4,500	222	2,790	1,905
FY34	236	7,535		4,500	236	3,026	1,669
FY35	244	7,779		4,500	244	3,270	1,425
FY36	252	8,031		4,500	252	3,522	1,173
FY37	252	8,283		4,500	261	3,783	921
FY38	110	8,393		4,500	110	3,893	811

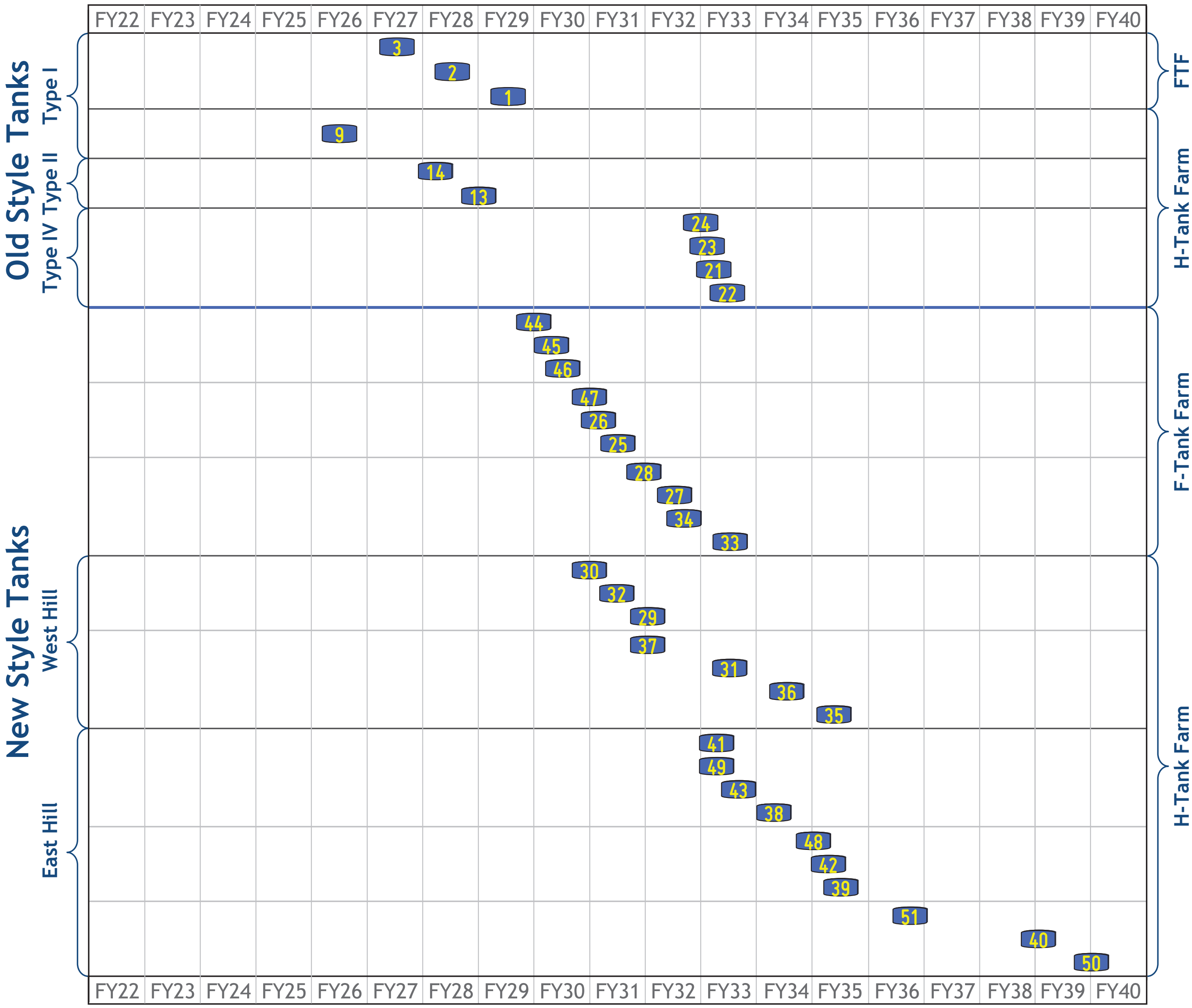
[a] GWSB 1 filling began in May 1996. Beginning in FY15, conversion of the 2,262 standard canister storage locations enable, via double stacking, each position to hold two cans for a total capacity of 4,524 canisters.

[b] GWSB 2 was built with 2,340 standard storage locations. LWSP R22 assumes 150 canisters will be moved from GWSB 2 to GWSB 1 by the end of FY23 to allow double stacking conversion to begin in FY24 at 300 positions per year for a total capacity of 4,680 canisters. Enough positions are planned to be converted to allow storage of all canisters produced. Over capacity may be minimized at management discretion.

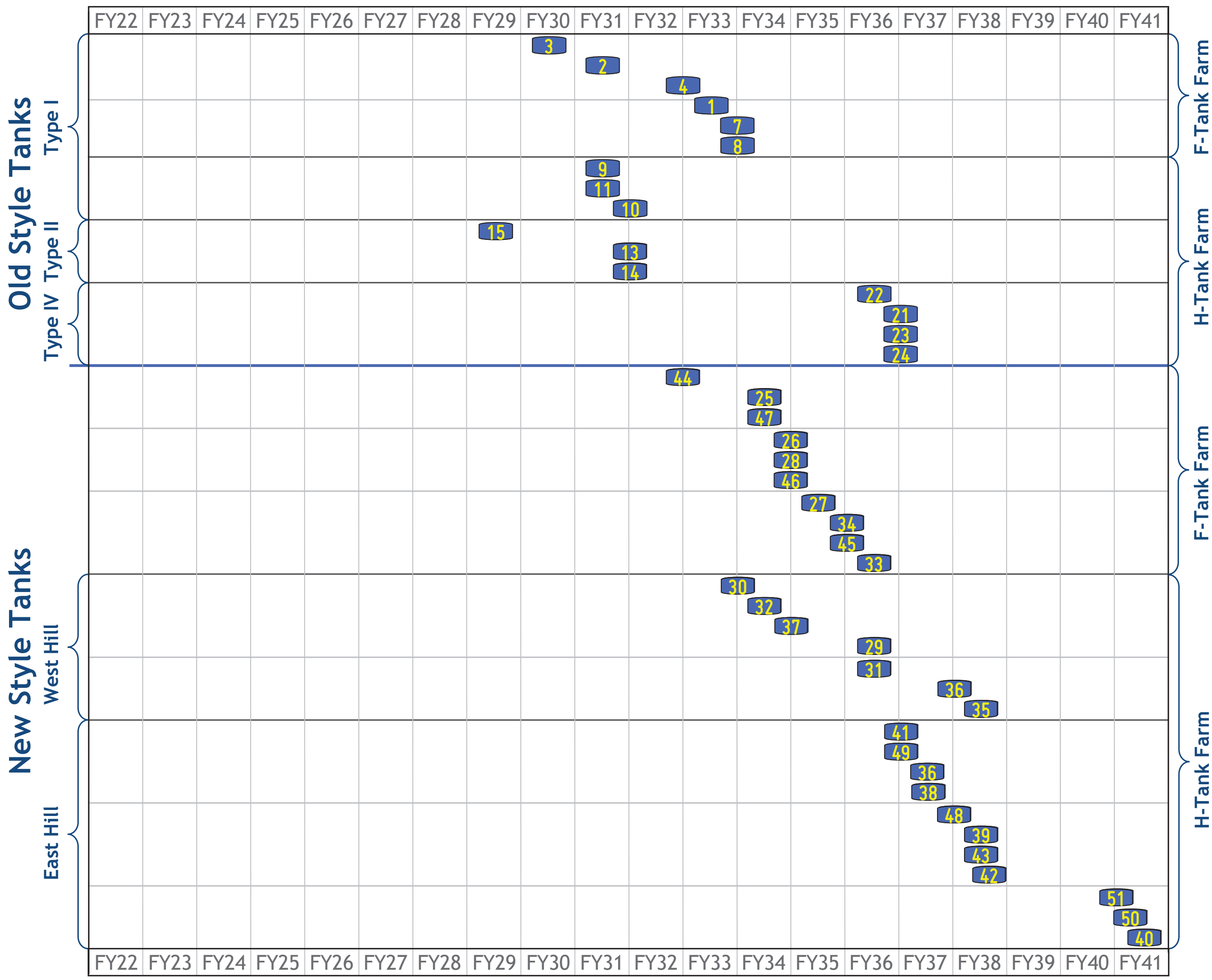
[c] At the end of each year, a certain number of cans are not emplaced in the GWSBs, being retained in the vitrification building. At the end of the program, all canisters will be stored in the GWSBs pending final disposition. The remaining capacity is the number of additional canisters that could be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

Note: These canister estimates are calculated based on the best information available at the time and many assumptions about future waste inventory and processing. The canister numbers are calculated based on all of the assumptions and constraints, but are not intended to be more than a rough discriminator between cases. The number should be expected to change for cases with different assumptions and in general there are no cases that are identical.

Appendix E2—*Bulk Waste Removal Complete (ABD Case)*



Appendix F2—*Tank Removal from Service (ABD Case)*



Appendix G2—*LW System Plan—Revision 22 Summary (ABD Case DNA)*

(see attached foldout chart)

Appendix H2—*TCCR Columns Interim Safe Storage (ABD Case)*

End of Fiscal Year	TCCR Columns transported to Interim Safe Storage[a]			dispositioned in DWPF[b]	
	Added	Cum.	Remaining	Ground	Cum.
FY19					
FY20					
FY21	4	4	4		
FY22	2	6	6		
FY23	2	8	8		
FY24	2	10	10		
FY25	2	12	12		
FY26	2	14	14		
FY27		14	10	4	4
FY28	2	16	8	4	8
FY29	2	18	7	3	11
FY30	4	22	7	4	15
FY31		22	3	4	19
FY32		22		3	22
FY33	2	24	2		22
FY34	6	30	4	4	26
FY35	6	36	6	4	30
FY36	2	38	4	4	34
FY37		38		4	38

TCCR Ion Exchange Column Assumptions

- TCCR IX column design remains the same (mass of CST is ~515 kg)
- Adsorption kinetics supports a loading of 75,000 Ci of Cs-137 per IX column
- The capacity of CST for cesium adsorption is unaffected by salt solution makeup or UOP manufacturing process
- Temperature of salt solution/columns is maintained constant so CST resin kinetics/capacity is constant
- Resulting decontaminated salt solution meets the Saltstone Waste Acceptance Criteria

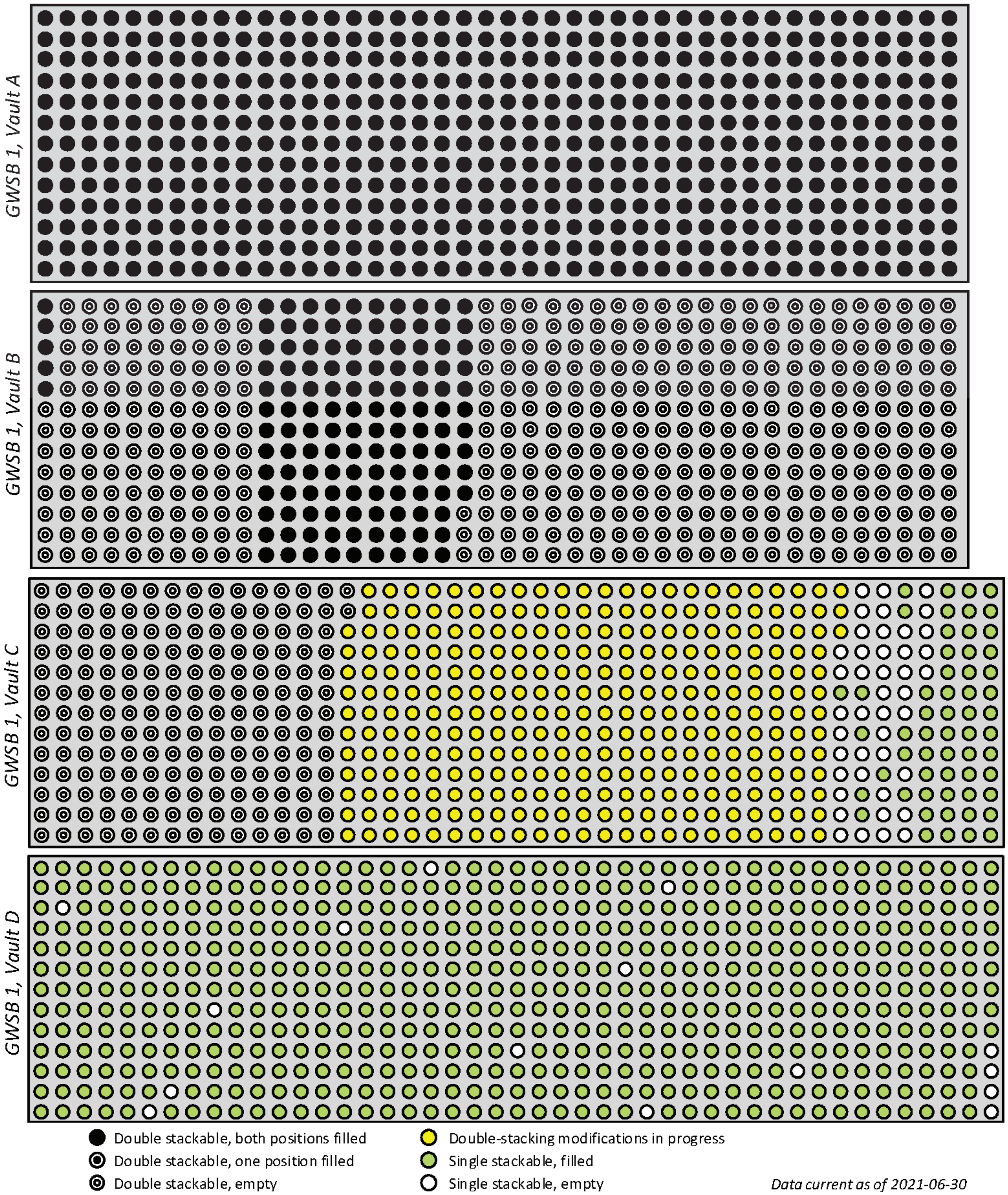
[a] Maximum ISS Capacity: 16 Columns

[b] Grinding cap at DWPF: 12 columns/year

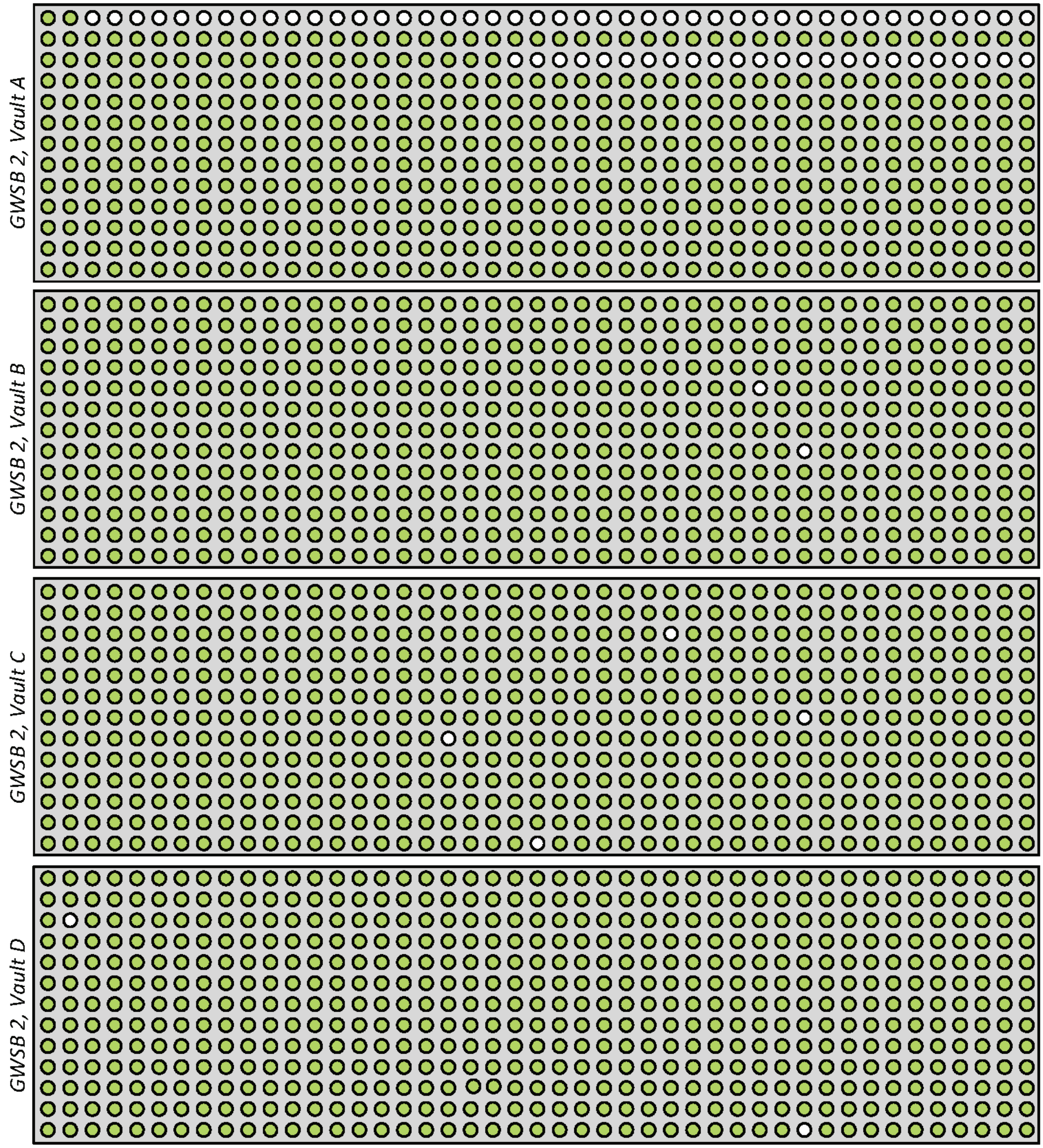
Note: These column estimates are calculated based on the best information available at the time and many assumptions about future waste inventory and processing. They are not intended to provide a bounding analysis of TCCR column production.

Appendix I—*GWSB Utilization*

GWSB utilization presents the current conditions, as of June 30, 2021, of the two GWSBs showing which canister storage positions have been converted to double-stack capability and which storage positions are empty, have a single canister, or have two canisters.



Data current as of 2021-06-30


GWSB 2, Vault A
GWSB 2, Vault B
GWSB 2, Vault C
GWSB 2, Vault D

Acronyms

ABD **Accelerated Basin Deinventory**
ARP **Actinide Removal Process** –process that removes actinides and Strontium-90 (Sr-90), both soluble and insoluble, from Tank Farm salt solution using MST and filtration
BFS **Blast Furnace Slag**
Ci/gal **Curies per gallon**
CM **Closure Module**
CSMP **Commercial Submersible Mixing Pumps**
CSSX **Caustic Side Solvent Extraction** – process for removing cesium from a caustic (alkaline) solution. The process is a liquid-liquid extraction process using a crown ether. SRS plans to use this process to remove Cesium-137 (Cs-137) from salt wastes.
D&D **Dismantlement and Decommissioning**
DAR **Drain, Add, Remove**
DDA **Deliquification, Dissolution, and Adjustment**
DNA **Distributed Network Algorithm** – the long fold-out graphic depicting major operational activities of the *Plan*
DNFSB **Defense Nuclear Facilities Safety Board**
DOE **Department of Energy**
DOE-SR The **DOE Savannah River** Operations Office
DQA **Data Quality Assessment**
DSA **Documented Safety Analysis**
DSS **Decontaminated Salt Solution** – the decontaminated stream from any of the salt processes – DDA, ARP/MCU, or SWPF
DWPF **Defense Waste Processing Facility** – SRS facility in which LW is vitrified (turned into glass)
EA **Environmental Assessment**
EIS **Environmental Impact Statement**
ELAWD **Enhanced Low Activity Waste Disposal**
EPA **Environmental Protection Agency**
ETP **Effluent Treatment Project –** SRS facility for treating contaminated wastewaters from F & H Areas
FFA **Federal Facility Agreement** – tri-party agreement between DOE, SCDHEC, and EPA concerning closure of waste sites. The currently approved FFA contains commitment dates for closing specific LW tanks
FESV **Failed Equipment Storage Vault**
FTF **F-Tank Farm**
FY **Fiscal Year**
CGCP **Consolidated General Closure Plan**
GWSB **Glass Waste Storage Building** – SRS facilities with a below-ground concrete vault for storing glass-filled HLW canisters
HLW **High Level Waste**
HM **H Modified** – the modified PUREX process in H-Canyon for separation of special nuclear materials and enriched uranium
HTF **H-Tank Farm**
IPABS **Integrated Planning, Accountability, & Budgeting System**
IAL **Inter-area Line**
ISS **Interim Safe Storage**
IW **inhibited water** – well water to which small quantities of sodium hydroxide and sodium nitrite have been added to prevent corrosion of carbon steel waste tanks
kgal **thousand gallons**
LTAD **Low Temperature Aluminum Dissolution**
LLW **Low Level Waste**
LVMJ **Low Volume Mixing Jet**
LW **Liquid** (Radioactive) **Waste** – broad term that includes the liquid wastes from the canyons, HLW for vitrification in DWPF, LLW for disposition at SDF, and LLW wastes for treatment at ETP
M **Molar**
MAR **Measurement Acceptance Region**
MCi **Million Curies**
MCU **Modular CSSX Unit** – small-scale modular unit that removes cesium from supernate using a CSSX process similar to SWPF
Mgal **million gallons**
MSB **Melter Storage Box**
MST **monosodium titanate**
Na **sodium**
NDAA Ronald W. Reagan **National Defense Authorization Act** for Fiscal Year 2005, Public Law 108-375
NDAA §3116 **Section 3116** – Defense Site Acceleration Completion—of the **NDAA**
NEPA **National Environmental Policy Act**
NGS **Next Generation Solvent**
NPDES **National Pollution Discharge Elimination Systems**
NRC **Nuclear Regulatory Commission**
OA **Oxalic Acid**
OOS **Out of Service**
OYO **One Year Operations** – the first full year of SWPF operations

PA **Performance Assessment**
PCCS **Product Composition Control System**
PEIS **Programmatic Environmental Impact Statement**
PUREX **Plutonium Uranium Reduction Extraction**
RCRA **Resource Conservation and Recovery Act**
ROMP **Risk** and **Opportunity Management Plan**
SAR **Sample Analysis Report**
SAS **Steam Atomized Scrubber**
SB **Sludge Batch**
SC **Safety Class**
SCD **semi-continuous dissolution**
SCDHEC **South Carolina Department of Health and Environmental Control** – state agency that regulates hazardous wastes at SRS
SDF **Saltstone Disposal Facility** – SRS facility containing Saltstone Disposal Units
SDU **Saltstone Disposal Units** – Disposal Units that receive wet grout from SPF, where it cures into a solid, non-hazardous Saltstone
SE **Strip Effluent**
SEIS **Supplemental Environmental Impact Statement**
SME **Slurry Mix Evaporator**
SOL **Solids Oxide Loading**
SPF **Saltstone Production Facility** – SRS facility that mixes decontaminated salt solution and other low-level wastes with dry materials to form a grout that is pumped to SDF
SRNL **Savannah River National Laboratory**
SRNS **Savannah River Nuclear Solutions**
SRR **Savannah River Remediation** LLC
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** –facility that will remove Cs-137 from Tank Farm salt solutions by the CSSX process and Sr-90 and actinides by treatment with MST and filtration
T&PRA **Technical and Programmatic Risk Assessment**
TCCR **Tank Closure Cesium Removal** –process that will remove Cs-137 from Tank Farm salt solutions by the ion exchange process
WAC **Waste Acceptance Criteria**
WCS **Waste Characterization System** – system for estimating the inventories of radionuclides and chemicals in SRS Tank Farm tanks using a combination of process knowledge and samples
WD **Waste Determination**
wt% **weight percent**

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M. T. Sautman, 703-41A

File
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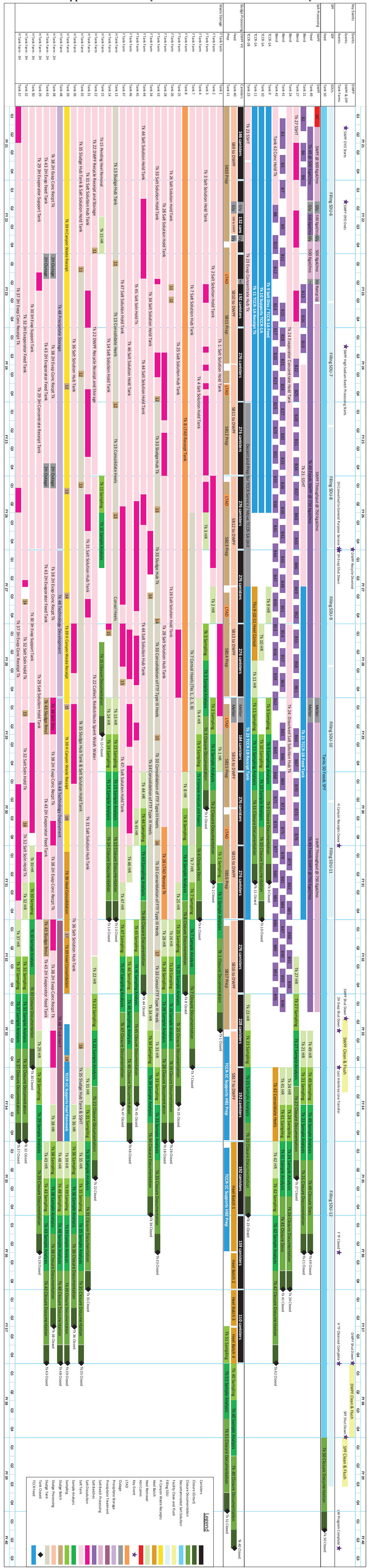
D. P. Chew (300), 766-H
Records Administration, 773-52A

Appendix G1—LW System Plan—Rev 22 No ABD Summary



Appendix G2—System Plan—Rev 22 with ABD Summary