Integrated High-Level Waste System Planning - Utilizing an Integrated Systems Planning Approach to Ensure End-State Definitions are Met and Executed – 13244

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ABSTRACT

The Savannah River Site (SRS) is a Department of Energy site which has produced nuclear materials for national defense, research, space, and medical programs since the 1950's. As a by-product of this activity, approximately 37 million gallons of high-level liquid waste containing approximately 292 million curies of radioactivity is stored on an interim basis in 45 underground storage tanks. Originally, 51 tanks were constructed and utilized to support the mission. Four tanks have been closed and taken out of service and two are currently undergoing the closure process. The Liquid Waste System is a highly integrated operation involving safely storing liquid waste in underground storage tanks; removing, treating, and dispositioning the low-level waste fraction in grout; vitrifying the higher activity waste at the Defense Waste Processing Facility; and storing the vitrified waste in stainless steel canisters until permanent disposition. After waste removal and processing, the storage and processing facilities are decontaminated and closed.

A Liquid Waste System Plan (hereinafter referred to as the Plan) was developed to integrate and document the activities required to disposition legacy and future High-Level Waste and to remove from service radioactive liquid waste tanks and facilities. It establishes and records a planning basis for waste processing in the liquid waste system through the end of the program mission. The integrated Plan which recognizes the challenges of constrained funding provides a path forward to complete the liquid waste mission within all regulatory and legal requirements. The overarching objective of the Plan is to meet all Federal Facility Agreement and Site Treatment Plan regulatory commitments on or ahead of schedule while preserving as much lifecycle acceleration as possible through incorporation of numerous cost savings initiatives, elimination of non-essential scope, and deferral of other scope not on the critical path to compliance.

There is currently a premium on processing and storage space in the radioactive liquid waste tank system. To enable continuation of risk reduction initiatives, the Plan establishes a processing strategy that provides tank space required to meet, or minimizes the impacts to meeting, programmatic objectives. The Plan also addresses perturbations in funding and schedule impacts.

INTRODUCTION

The mission of the Liquid Waste (LW) program at SRS is to provide safe and efficient receipt, storage, and processing of radioactive liquid waste to support both site operations and the Department of Energy-Savannah River (DOE-SR) plans for permanent disposal of radioactive waste and to close the storage, processing, and disposition facilities when they have completed their planned use. This includes Defense Waste Processing Facility (DWPF) operations, Saltstone Production Facility (SPF) operations, Saltstone Disposal Facility (SDF) operations, tank closures, and support for planned separations canyons' missions.

This document provides an overview of the LW System Planning process. It describes the LW program, the planning process, and tools used in the planning process. Plans developed by the LW System Planning process form the basis for developing and modifying the scope, cost, and schedule related to the LW program. The actual project and facility schedules and execution documents implement the conditions of the contract.

The LW System is a large radiochemical-storage, treatment and disposal complex encompassing the processing facilities within LW program (see Figure 1–1 — *Process Flowsheet*). There are ten different facilities interconnected by transfer lines, each of which contains one or more processes. The SRS Liquid Waste contract is managed by Savannah River Remediation LLC (SRR), a team of companies led by URS Corporation with partners Bechtel National, CH2M Hill and B & W. The processes in the ten facilities are listed below with respect to the operational responsibilities:

<u>DWPF / Saltstone Operations</u>

- DWPF – High-Level Waste (HLW) Vitrification
- SPF – Low-Level Waste (LLW) treatment
- SDF – LLW disposition in disposal units
- Actinide Removal Process (ARP) – Salt Processing, Actinide Removal – 512-S Filter Operations

<u>Tank Farm & Effluent Treatment Project (ETP) Operations</u>

- H-Tank Farm (HTF) – Storage and Evaporation, Sludge Removal, Sludge Washing, Salt Dissolution, and closure of tanks and associated facilities

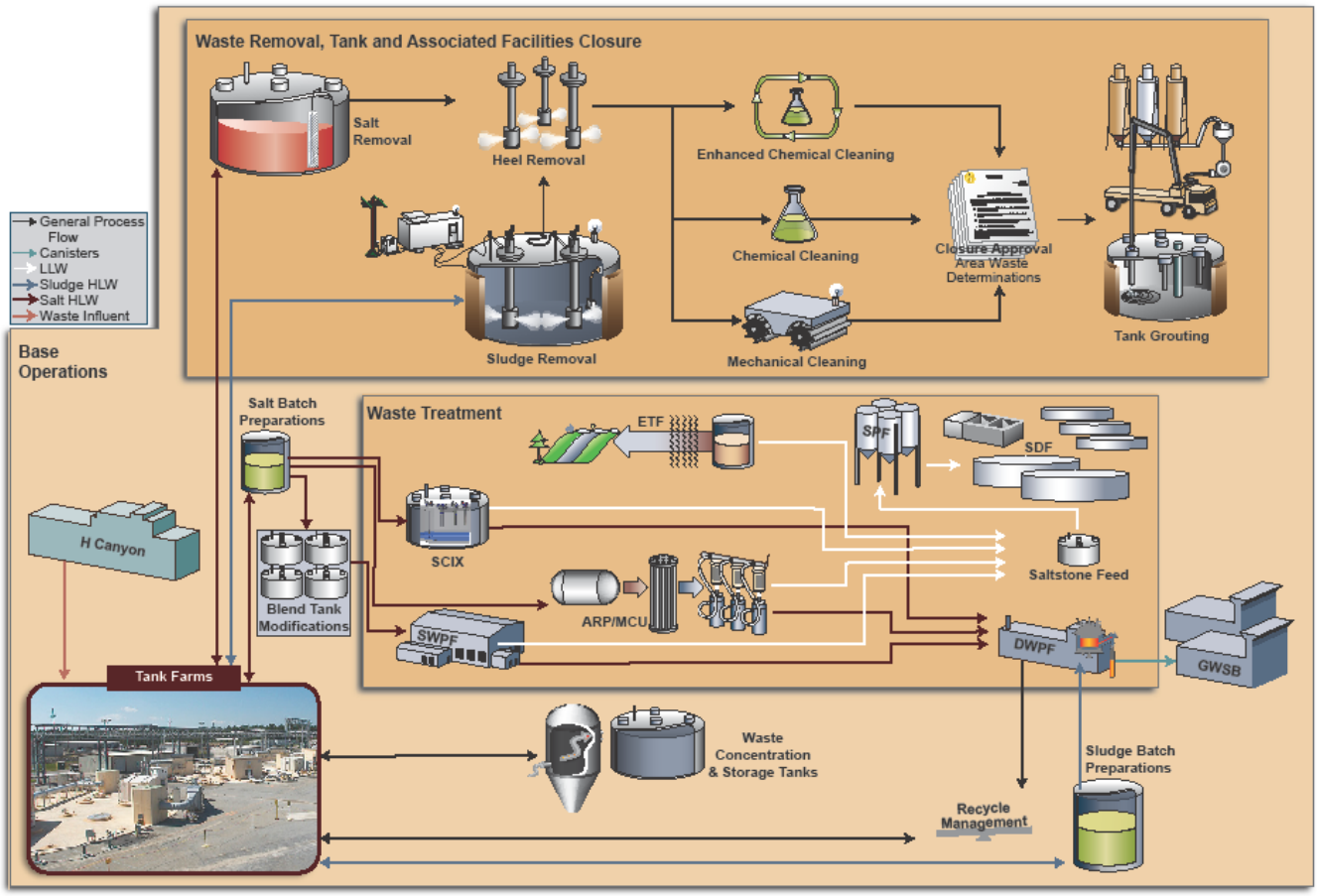
- F-Tank Farm (FTF) – Storage and Evaporation, Sludge Removal, Salt Dissolution, and closure of tanks and associated facilities
- ETP – Wastewater Treatment
- ARP – Salt Processing, Actinide Removal – 241-96H Monosodium Titanate (MST) Strike Tanks
- Modular Caustic Side Solvent Extraction (MCU) – Salt Processing, Cesium Removal

Salt Waste Processing Facility (SWPF) Operations

- SWPF *Future (currently under construction)* – Salt Processing, Actinide Removal, and Cesium Removal (note: this facility will supersede ARP/MCU operations)

These ten facilities function as one treatment plant that stores and treats waste streams (primarily originating in the F- and H-Area Separations Canyons) and converts them into forms suitable for final disposal. The three major disposal forms are: borosilicate glass, to eventually be dispositioned; Saltstone grout, to be dispositioned on site in the SDF; and treated water effluent, to be released to the environment. In addition, various liquid and vapor effluents and other miscellaneous wastes are generated that must be managed.

Figure 1–1 — *Process Flowsheet*

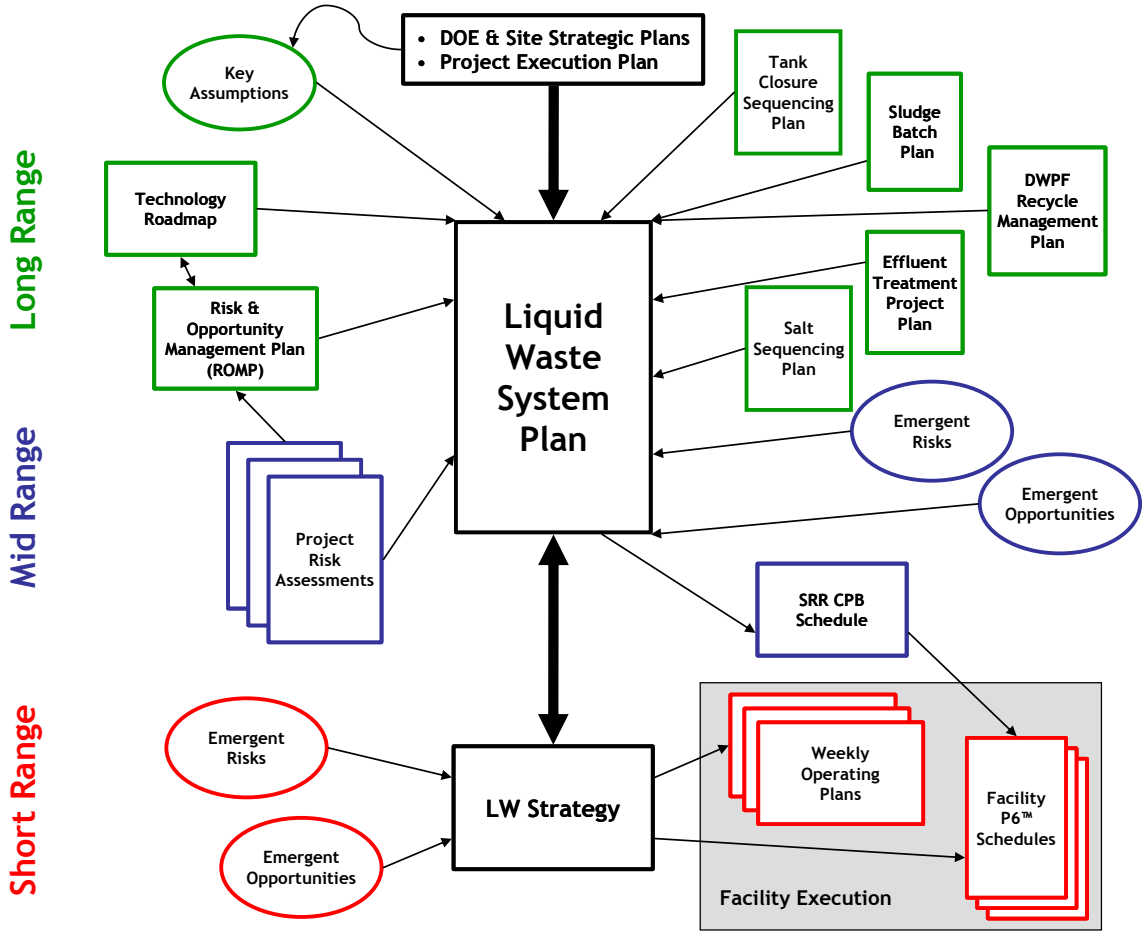


DESCRIPTION

The LW System processing strategy (see Figure 1–2 — *LW System Planning Process*) integrates the plans and schedules developed by the operating facilities and planned projects along with system modeling that forecasts requirements through the end of the program. The LW System planning process results in a family of complementary documents that describe the activities through the end of the program and closure of the facilities and includes:

- the *Liquid Waste System Plan* — an overall comprehensive strategy for disposition of the Liquid Waste stored in F- and H-Tank Farms
- a *LW Strategy*[i] — a short-term overview of the next 12-18 months for change control and tracking, taking into account emergent issues and changes
- various sub-tier program plans (for example, *Sludge Batch Plan*[ii], *Salt Batch Plan*[iii], *Tank Closure Sequencing Plan*[iv], *Effluent Treatment Project Plan*[v], and the *DWPF Recycle Management Plan*[vi]) that describe specific parts of the system in greater detail
- the *Risk & Opportunity Management Plan*[vii] (ROMP) that provides for assessing and managing risks.

Figure 1–2 — *LW System Planning Process*



DISCUSSION

To execute the plans, project and facility schedulers reporting to the Project Owners prepare the detailed implementation documents needed by the facilities. These include:

- project schedules
- facility schedules
- integrated programmatic schedules

The bases for the plans are the definition of objectives and the key assumptions. The definition of objectives consists of directions and agreements, between DOE and the contractor, regarding the major programmatic objectives. This may be a combination of formal and informal agreements. These agreements are then incorporated into Key Assumptions, along with facility conditions, processing parameters, and project assumptions. DOE-SR formally concurs with these Key

Assumptions. These assumptions then guide the development and modeling of the *LW System Plan.*

These plans incorporate the technical and schedule requirements for the disposition of the LW in the F- and H-Tank Farms and the closure of those Tank Farms and the facilities used to process and dispose of the waste. As a whole, they also include historical information, a description of the major processes, and a discussion of the major risks and challenges. The *LW System Plan* includes a summary of the lower tier plans and provides for long-range facility planning, input to budget development, and documentation of plans and concerns to DOE and external stakeholders. These plans are prepared by System Planning and reviewed and approved jointly by the contractor and DOE-SR.

A feature of the utilization of a hierarchical system of plans is the ability to assess different levels of uncertainty. Of necessity, the *LW System Plan* has a higher degree of uncertainty, especially in the out-years, than does, say, the *LW Strategy*. This allows consideration of the contingency appropriate to the uncertainty enabling precise scheduling for near term events while providing a credible assessment of long-range expectations. The facility needs for precise scheduling direction are met with the shorter range plans.

The actual project and facility schedules and execution documents implement the conditions of the contract with DOE-SR. The *LW System Plan* provides input into the development of the key milestones and objectives of the contract and provides a basis for change control when required. The schedules maintain logical integration and detail of the before mentioned plans and strategies to attain key *LW System Plan* milestones and objectives.

Planning Documents

Several plans support, and are supported by, the *LW System Plan.* These include the planning documents:

- *LW Strategy*[i]
- *Sludge Batch Plan*[ii]
- *Salt Batch Plan*[iii]
- *Tank Closure Sequencing Plan*[iv]
- *Effluent Treatment Project Plan*[v]
- *DWPF Recycle Management Plan*[vi]
- *Risk & Opportunity Management Plan*[vii] and the execution documents:

- Facility/Project Schedules

The requirements of the *Sludge Batch Plan,* the *Salt Batch Plan,* and the *Tank Closure Sequencing Plan* are modeled to provide integration of the needs and timeframe for the activities. The results of the integrated modeling are incorporated into the *LW System Plan* for a life-cycle perspective. The process for assessing and managing risks is described in the *Risk & Opportunity Management Plan.* A summary of the requirements, bases, and assumptions for all the activities through the end of the program is included in the *LW System Plan.* The *LW System Plan* is used as input, in an iterative fashion together with emergent information, for subsequent revisions to the *Sludge Batch Plan,* the *Salt Batch Plan,* the *Tank Closure Sequencing Plan,* the *Effluent Treatment Project Plan,* and the *DWPF Recycle Management Plan*.

The LW System Plan integrates and documents the activities required to disposition LW and close tanks and facilities in the HTF, FTF, DWPF, SWPF, SPF, SDF, and ancillary facilities. The *LW System Plan* consolidates the specific process plans and strategies with milestones, resource needs, planning bases, assumptions, production capabilities, flow-sheet model outputs, technical and programmatic issues, sensitivity cases, and supporting safety and regulatory documentation into one cohesive long-term plan for the accomplishment of the LW program mission. It also includes historical information and a brief description of the major facilities. This plan is updated on an annual basis.

LW Strategy provides a roadmap for FTF and HTF facility planners to develop detailed schedules in order to meet process and project execution commitments of the CPB and the *LW System Plan.* The *LW Strategy* is a graphical representation of the scheduled activities influencing Tank Farm transfers. This strategy covers major tank-to-tank transfers and ensures that available un-concentrated liquid waste is sent to the appropriate evaporator at the appropriate time to support the LWO processing objectives, including handling H-Canyon receipts, preparing sludge batches to ensure continued DWPF operation, allocate feed of salt disposition materials to the SPF, and waste removal and tank cleaning requirements. The strategy integrates transfers, outages, and evaporator operations to highlight potential issues in the support of short and long-term processing commitments. It is used to identify and support change control actions to resolve problems with the transfer schedules as plans or equipment conditions change. Additionally, the plan identifies mid-term transfer procedure and engineering evaluation needs to the facilities to assist in scheduling implementation of the *LW System Plan*. This plan is updated on an as needed basis as conditions change —typically every three months.

The purpose of the ***Sludge Batch Plan*** is to describe the processing of sludge in sufficient detail to establish project objectives and execution schedules for the affected facilities. The *Sludge Batch Plan* provides the recommended sludge batch sequence and timing – including source tanks and anticipated feed make-up of sludge being transferred to DWPF – and estimates of canister production rate, wash water volumes, and concentrations of soluble species. This life-cycle plan

provides input to the DPP and *LW System Plan.* It also provides analysis of planned sludge batches for glass acceptability and DWPF Waste Acceptance Criteria (WAC) compliance to the extent possible given the available data. The requirements of the *Sludge Batch Plan* are conveyed to the *LW Strategy* and the facility schedules via the *LW System Plan* and any associated change control. This plan is subject to an annual review and is updated as needed as conditions change with respect to sludge batch sequencing and configuration.

The ***Salt Batch Plan*** describes the removal and processing of salt waste in sufficient detail to establish project objectives and execution schedules for the affected facilities. The *Salt Batch Plan* provides a comprehensive stand-alone document outlining the requirements for the removal, processing, and disposal of SRS salt waste. This plan includes the assumptions and bases for facility processing rates, data sources, decontamination factors, salt processing activity requirements and durations, transfer information and other pertinent information, as well as summarizing major risks, issues and potential mitigation strategies. The plan provides an overall summary schedule and salt tank priority list for the batching sequences for salt processing. The information provided in this life-cycle plan is used as input to the *LW System Plan.* The requirements of the *Salt Batch Plan* are conveyed to the *LW Strategy* and the facility schedules via the *LW System Plan* and any associated change control. This plan is subject to an annual review and is updated as needed as conditions change with respect to salt sequencing and configuration.

Tank Closure Sequencing Plan describes the waste heel removal process and operational closure of the Liquid Waste tanks in sufficient detail to establish project objectives and execution schedules for the affected facilities. The *Tank Closure Sequencing Plan* provides the recommended tank heel removal, annulus cleaning, operational closure sequence, and timing and estimate of cleaning water volumes to be used as input to the *LW System Plan.* This plan projects tank closure scope to meet the closure date requirements of the Federal Facility Agreement (FFA). The requirements of the *Tank Closure Sequencing Plan* are conveyed to the facility schedules via the *LW System Plan* and any associated change control. This plan is subject to an annual review and is updated as needed as conditions change with respect to tank closure sequencing and configuration.

The ***Effluent Treatment Project Plan*** describes the baseline plan for operation of the ETP. It describes the major activities and assumptions associated with operation of ETP. The *Effluent Treatment Project Plan* provides a brief overview of the process and major generators of feed to the process. It provides forecasts of production rates and effluent rates that feed the SPF for use in the *LW System Plan.* This plan is subject to an annual review and is updated as needed as conditions change with respect to tank closure sequencing and configuration.

The purpose of ***DWPF Recycle Management Plan*** is to describe handling of the DWPF recycle stream, the largest influent stream received by the Tank Farm. The *DWPF Recycle Management Plan* forecasts use of the 2H Evaporator system for volume reduction and the beneficial re-use of

recycle in the Tank Farm through the end of the life cycle. The *DWPF Recycle Management Plan* provides the recommended strategy for volume reducing a portion of the DWPF recycle via evaporation and utilizing the balance of the DWPF recycle to support waste removal and treatment requirements in the H- and F-Tank Farms. When the Tank Farms are no longer able to utilize the DWPF recycle, this plan will propose alternate methods of dispositioning the material. A risk analysis of DWPF recycle handling is also addressed. This plan will provide input for inclusion in the *LW System Plan.* This plan is subject to an annual review and is updated as needed as conditions change with respect to tank closure sequencing and configuration.

The ***Risk & Opportunity Management Plan*** identifies and evaluates risks associated with the LW Program, develops strategies to mitigate the risk consequences. The *LW Program Risk and Opportunity Management Plan* (ROMP) contains the major risks challenging the execution of the LW Program. It identifies ongoing and planned risk handling strategies to manage these risks. It is maintained and updated to ensure program risks are identified and managed and documented. The risks within the LW Program are identified and managed either as part of each individual project (where successful project execution is challenged) or as part of the LW Program risk management (where the LW Program execution is challenged).

The ROMP is reviewed and updated periodically to capture the latest developments that may influence execution of the LW Program. A Risk Register is used to record potential new risks and opportunities within the LW Program and to identify changes to the *LW System Plan* so that potential risks and opportunities associated with these changes can be evaluated. For this reason, the Interim Risk Log is utilized as a "change log" for the *LW System Plan* and the DPP. A joint DOE-SR/SRR Risk Management Board (RMB) is chartered[viii] with a review of Interim Risk Log items to approve, disposition of those entries, and identification of any items requiring immediate action. Thus, risk management is maintained current between annual updates.

Facility/Project Schedules provide for the accomplishment of Project and Facility tasks to support the contractual requirements as expressed in the CPB. They ensure that each authorized Process or Project has an established schedule that provides a logical sequence of activities that lead to the accomplishment of an end state or milestone. Each Process or Project must be properly integrated to limit resource consumption to acceptable levels. These are continually evaluated during implementation phase.

Supplemental Input

Several additional input documents support the *LW System Plan*:

Financial plans are developed during the year for budget and execution planning. These plans include: Annual FY Execution Plan and Schedule, annual FY Contract Performance Baseline, and support to DOE's development of the annual EM Project Execution Plan (PEP). They utilize information from the plans discussed in this document for a technical basis for the required scope.

Individual Project Risk Assessments are used to identify and evaluate risks that may be encountered during the implementation of modifications and operation of projects. Risks are identified that have the potential to adversely affect the execution of design, construction, and operation of the Project. They include:

- Risk Identification — Identify risks associated with projects
- Risk Analysis/Grading — Evaluate identified risks and Grade them as High, Moderate, or Low
- Risk Handling Strategy (RHS) — Select handling strategy for each risk (Mitigate, Avoid, Transfer, or Accept), and for each handling strategy, determine the residual risk impact after execution of the strategy.

Risk assessments also provide input into the assumptions used in preparation of the long-range plans.

Modeling Tools

SRR uses a suite of computer simulations to model the operation of the Liquid Waste System. Each model is designed to address different aspects of long-range production planning. SRR uses these models interactively to guide long-range production planning.

The **COREsim®** model was developed using the Vitech Corporation's COREsim® application package. COREsim® uses discrete-event simulation logic to construct a model and simulate the process. The software analyzes and monitors resource availability to identify bottlenecks, resource contention, and queuing effects on system performance. To date, COREsim® has been applied at SRS to verify the throughput requirements for the MCU, for analyzing resource utilization at DWPF, in the development of the SWPF, and for a time and motion study for the waste transfer line system of the salt processing program. It yields an assessment of the capabilities of various components of the Liquid Waste System as an input to the planning process. Additional process areas have been identified for future COREsim® modeling analysis efforts.

The **Space Management Model (SpaceMan Plus™)**[ix] is a computer model used to forecast out-year LW System conditions. Two input files are needed to run the program. The data file provides the chemistry source data from the Waste Characterization System (WCS). The strategy for controlling LW System activities is provided by a separate management file. This file inputs activities such as external receipts, waste transfers, evaporation, waste removal (including salt dissolution and sludge removal), sludge processing, salt processing via either MCU/ARP or SWPF, blending, tank status (fill limits, jet heights, closure, reuse, etc.), DWPF vitrification, Saltstone processing, and ETP processing. The program automatically steps through each week and tracks available storage space, inventory, and chemistry based on the activity management file

input by the planner. Constituents are tracked depending on their location in the waste forms and tracked through either disposition at the SDF or DWPF. The evaporation simulation (salt space generation and ETP overheads production) is based on current supernate thermodynamic models. The outputs include a graphical display depicting individual tanks grouped by system and major facility processes (*e.g.*, evaporators, ARP, MCU, SWPF, etc.). Data files are used to construct reports and charts.

The **Sludge Batch Planning Toolkit** allows the rapid evaluation of multiple sludge batch processing scenarios and preparation of the sludge batch plan to support system planning. The variables in a given scenario are: sludge oxide loading (SOL) of sludge per canister in a batch; specific frit used per batch; rate of canisters production in DWPF; and number and duration of outages.

The **Sludge Batch Planning Toolkit** consists of four Excel workbooks: SB Plan Input Output; SB4-5 Composition; SB6-17 Composition; Product Composition and Control System (PCCS) Plan.

SB Plan Input-Output allows input of the desired values for the four variables for a given scenario. It uses information from the other three workbooks to calculate the number of canisters of glass produced in each batch and the overall batch duration. It also determines conformance with glass processing and glass quality constraints.

The **SB4-5 Composition** and **SB6-17 Composition** workbooks are used to calculate the sludge oxide mass in each sludge batch and the individual batch compositions from the Waste Characterization System (WCS) Database. They additionally provide information for the sludge batch calculations compositions of Tank 51 (batch) and Tank 40 (blend) for use in SRNL qualification studies conversion between the Element A-Z format and the Oxides and Hydroxides Format receipt of sample information and conversion of the results to a mass basis apportioning MST from ARP/MCU and MST from SWPF.

The **PCCS Plan** workbook uses a stand-alone version of the DWPF process constraint program to evaluate each batch for compliance with the criteria established for each constraint.

The movement of sludge from one tank to another, aluminum dissolution, and washing are all inputs to the toolkit. The information comes from spreadsheets that model the preparation of the batches. The batch composition workbooks typically link directly to a version of the wash model.

This program mainly calculates the DWPF acceptance criteria related to glass acceptability. Complete qualification of a given sludge batch requires sampling, chemical analysis, and DWPF feed preparation testing.

Conclusion

The Liquid Waste System at SRS is complex and dependent on the performance of 10 different and distinct operations and is subject to perturbations in funding and regulatory uncertainties. The Liquid Waste System Plan has proven to be an effective and valuable management tool since 1992. It provides realistic near term goals and objectives through the life-cycle of the Liquid Waste Program. In cooperation with DOE-SR, SRR is preparing to develop Revision 18 to the Liquid Waste System Plan.

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