Streamlined Approach to Hanford Tank Waste Treatment and Immobilization

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ABSTRACT

Under the Direct-Feed Low-Activity Waste (DFLAW) approach, supernatant and dissolved saltcake from Hanford underground tanks is treated by the Tank Side Cesium Removal (TSCR) System and staged in tank AP-106 for immobilization in the Low-Activity Waste (LAW) Vitrification Facility at the Waste Treatment and Immobilization Plant (WTP). Technical challenges, design problems, escalating costs, and COVID-19 effects have caused startup of the LAW and High-Level Waste (HLW) Vitrification Facilities to be delayed from 2007 to the 2025 and 2036 timeframes, respectively. These delays have raised stakeholder concerns regarding the schedule and escalating costs to immobilize waste and reduce the threat of additional leaks from tanks that are well beyond their design life.

This paper describes a method for using TSCR-treated effluent for the Test Bed Initiative (TBI) Phase II offsite grouting and disposal project and a full scale low-cost streamlined treatment and immobilization approach that could be employed in parallel with WTP-LAW immobilization. This approach provides multiple treatment and disposal pathways that mitigate potential WTP-LAW startup and operational risks and provides low-risk and cost-effective methods that facilitate accelerated tank waste retrieval, treatment, and disposal. The streamlined approach uses two treatment scenarios for grouting TSCR-treated tank waste. Under the first scenario, waste is transferred to an onsite Streamlined Modular Grout (SMG) System. The second scenario entails loading the waste into tanker trucks for transport to offsite grouting facilities. In both scenarios, waste would be disposed outside of Washington state in commercial disposal facilities. Near-term progress and cost savings achieved through the streamlined approach would significantly increase stakeholder confidence in DOE's ability to complete the tank waste mission without further impact to groundwater, the Columbia River, and the Hanford community.

INTRODUCTION

The Office of River Protection (ORP) is responsible for retrieval, treatment, and disposal of 204,400 m³ (54 million gallons) of waste stored in 177 underground tanks at Hanford [1]. Under the DFLAW approach, the   the LAW Vitrification Facility at the WTP. Technical challenges, design problems, escalating costs, and COVID-19 effects have caused the LAW and HLW Vitrification Facilities to be delayed from 2007 to the 2025 and 2036 timeframes, respectively. These delays have raised stakeholder concerns regarding the schedule to immobilize waste and reduce the threat of additional leaks from tanks that are well beyond their design life.

Additional Immobilization

These concerns are now highlighted by the fact that TSCR should have the 3,785 m³ (1 Mgal) LAW feed tank (AP-106) full by the end of this year. As shown in Fig. 1, DFLAW Facilities, there is a bottleneck downstream of AP-106 that won't be resolved until WTP-LAW achieves its operational capacity of approximately 5,900 m³/yr (1.56 Mgal/yr) of LAW feed [2]. Since the WTP-LAW facility won't be operational until or before August 2025 [3], TSCR will be shut down for about 30 months due to lack of downstream treatment capabilities. Losing momentum in treating tank waste further exacerbates stakeholder concerns for timely completion of the cleanup mission and escalating cost estimates. Accordingly, there is a need for parallel immobilization capacity to maintain progress on ORP's tank waste treatment mission with a high degree of confidence, mitigating any startup delays or operational issues associated with WTP-LAW.

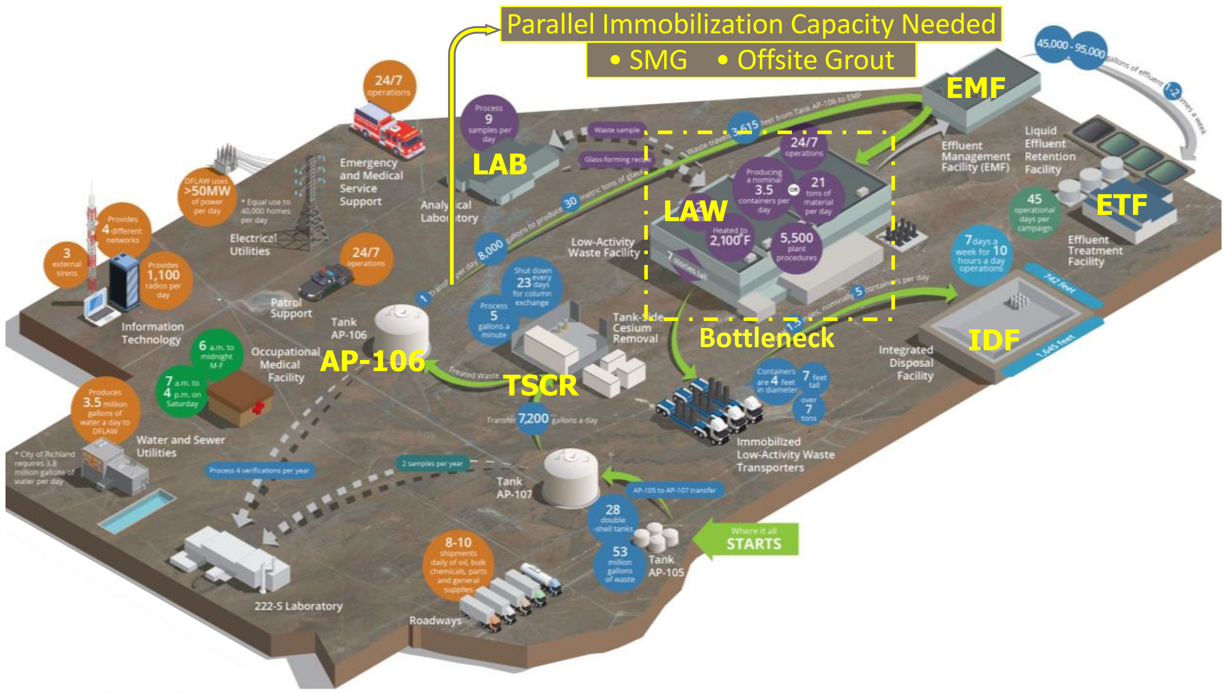

Fig. 1. DFLAW Facilities.

Streamlined Immobilization Approach

The streamlined immobilization approach can be employed in parallel with WTP-LAW to reduce mission risks and accelerate Hanford cleanup. The described approach can treat over 2 million gallons of liquid tank waste per year using TSCR, or TSCR-type units, followed by proven onsite and offsite grout immobilization systems. The streamlined approach uses two treatment scenarios for grouting TSCR treated tank waste. Under the first scenario, waste would be transferred to an onsite SMG System. Under a second scenario, waste would be loaded into tanker trucks and sent to offsite grouting facilities. In both scenarios, grouted waste would be disposed at offsite commercial facilities outside of Washington state.

TBI Phase II / Low-Level Waste (LLW) Offsite Disposal Project

The streamlined approach takes advantage of regulatory and permitting information from the TBI Phase II project, which demonstrates offsite grouting and disposal of treated waste. The goal of TBI is to demonstrate and establish the regulatory pathway, including the DOE Manual 435.1-1 Waste Incidental to Reprocessing (WIR) evaluation process [4] to support a non-HLW determination [5] for tank waste that is treated via a process which involves settling, decanting, filtration, and ion exchange. TBI will also demonstrate compliant treatment using grout immobilization/ stabilization and disposal at an out of state commercial facility. TBI Phase II was originally scheduled to take place ahead of TSCR in 2019 [9, 10] using treated liquid waste from an engineering scale in-tank treatment system in Tank SY-101. The start of TSCR operations in January 2022 made use of the TBI in-tank treatment system unnecessary and obsolete. Under the streamlined approach TBI Phase II would use the TSCR treated waste from AP-106, thus eliminating the need for installation, and future decommissioning, of an in-tank treatment system. As shown in Fig. 2, TSCR treated waste would simply be transferred from AP-106 into a tanker or Intermediate Bulk Containers (totes) that have already been purchased for the TBI project. The streamlined approach yields significant advantages for TBI Phase II, including a shortened project schedule and a cost savings of approximately $16 million.

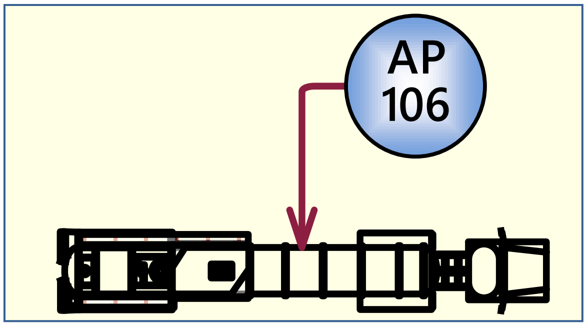

Fig. 2. Tanker or Trailer with Totes

SMG System

SMG uses a two-stage methodology comprised of traditional grouting equipment in a unique configuration that makes efficient use of offsite and onsite resources. The first stage of the process, located offsite near Hanford, would include all the large, non-radioactive equipment necessary for handling raw cementitious grout materials. As shown in Fig. 3, this facility would have silos for receipt and storage of raw grouting materials, a blender for producing grout dry mixes in accordance with prescribed recipes and other ancillary equipment for transferring, weighing, and loading cementitious materials. Dry grout materials would be loaded into lost-paddle grout canisters that are transported to the second stage of the process located on the Hanford site. The grout canisters meet all U.S. Department of Transportation (DOT) Type IP-1 packaging criteria listed in 49 CFR 173.411, "Industrial Packages"; therefore, they facilitate the shipment of Low Specific Activity (LSA) waste without a transportation cask. The unshielded canisters can simply be placed on a truck-trailer or railcar conveyance.

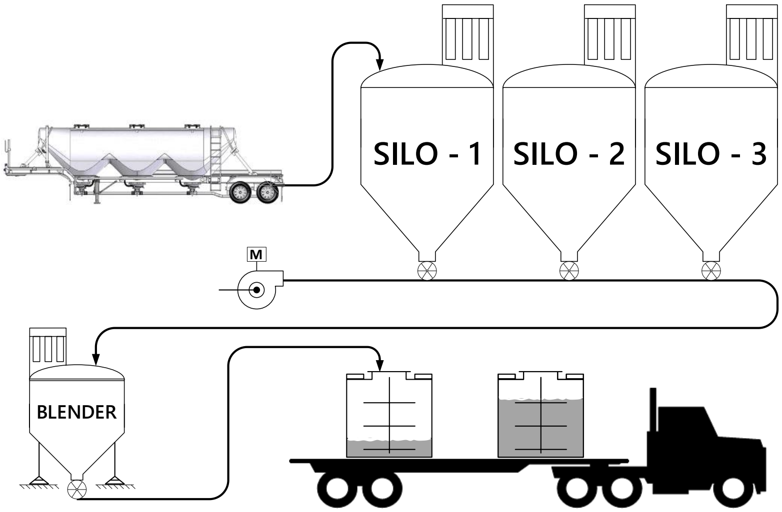

Fig. 3. Offsite Raw Materials Handling (Non-Radiological).

The radiological portion of SMG would be located on the Hanford site downstream of TSCR (Fig. 4). Equipment would be housed in modular enclosures, much like TSCR's (Fig. 5), which would be manufactured and tested offsite, then delivered to Hanford for placement on concrete pads and connected to Tank Farm interfaces. This SMG second stage would include TSCR-treated waste staging tanks and grout process equipment in modular enclosures along with utilities and operator controls.

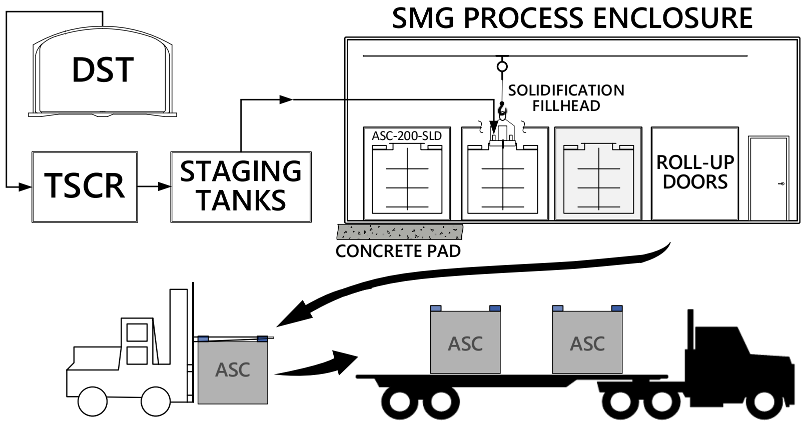

Fig. 4. Onsite Mixed LLW (MLLW) Immobilization (Radiological).

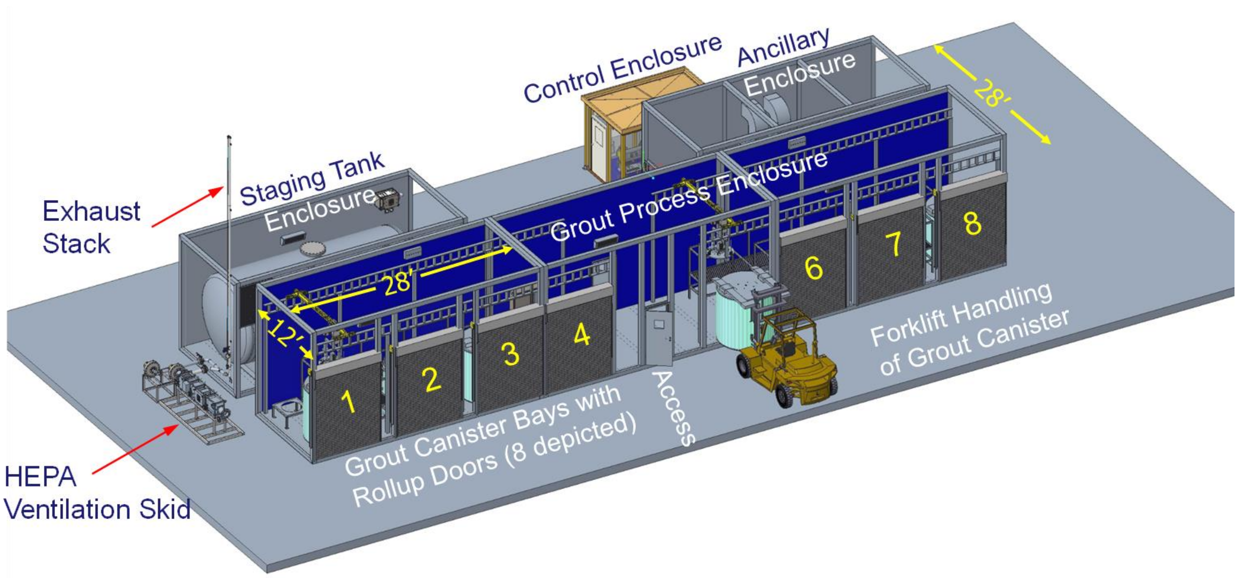

Fig. 5. SMG System Process Enclosure.

The SMG utilizes a forklift to load canisters pre-filled with dry-mix into one of multiple canister bays in the SMG Process Enclosure. Operators would place a self-engaging Fillhead on the canister which contains a liquid transfer line for filling the canister with TSCR treated waste. Grouting is accomplished by energizing/ rotating the mixing impeller with a hydraulic motor and transferring treated liquid into the canister. Mixing continues until all liquid has been added and a uniform grout product is produced. After mixing, the grout is allowed to cure for two days after which the absence of bleed water is confirmed, and a lid is installed on the canister. The lidded canister is removed from the SMG Process Enclosure by forklift and moved to a staging area for shipment. After the disposal site shipping manifest and related documents are completed, two canisters are placed on a truck and transported directly to an out of state disposal site, or to a nearby rail spur where the canisters are transferred to railcars for shipment to an out of state disposal site. The grouted waste from TSCR treatment has an extremely low radioactivity level; therefore, neither a shielded transport cask nor a specialized conveyance with shielding is required for offsite shipment. The SMG canisters have a 5 m^3 (1,320 gallon) grout capacity; two canisters are transported on a truck-trailer and eight canisters on a railcar. The SMG approach leverages design documents and operational experience from commercial nuclear facilities and TSCR to create a simple, rapidly deployable, low-cost system for onsite immobilization of tank waste for out of state disposal.

For illustrative purposes, Fig. 5 depicts a SMG Process Enclosure with eight canister bays; depending on the throughput needs, the number of canister bays can be increased.

Offsite Disposal Facilities

Class A grout produced by the onsite and offsite grouting methods described in this paper can be disposed of outside of Washington state at either the EnergySolutions facility in Utah or the Waste Control Specialists (WCS) facility in Texas [6]. Additional details of these facilities are as follows:

- **EnergySolutions Disposal Facility (Clive, Utah) –** This disposal facility is commercially operated by EnergySolutions and is licensed by the state of Utah (a U.S. Nuclear Regulatory Commission [NRC] Agreement State) and the U.S. Environmental Protection Agency (EPA) to dispose of LLW and MLLW. The Clive facility can accept only Class A LLW and MLLW for disposal.

  The disposal volume available at Clive is 3 million yd^3 or 2,293,665 m^3 (606 million gallons) of waste. This means that EnergySolutions Clive has the capacity to receive all Class A grout produced during the Hanford closure mission.

- **WCS Waste Disposal Facility (Andrews, Texas)** – This disposal facility is commercially operated by WCS and is licensed by the state of Texas (also an NRC Agreement State). The WCS facility can accept Class A, B, and C LLW and MLLW for disposal.

  The Federal Waste Disposal Facility (FWF) at WCS is licensed to dispose up to 736,328 m^3 (26 million ft^3 or 195 million gallons) of waste. WCS has the capacity to receive all grout produced during the Hanford closure mission. In addition, the WCS FWF is licensed to receive up to 5.6 million curies of radioactivity and, as long as the waste meets Class C concentrations, there are no limits on C-14, Tc-99 and I-129 [7].

The Federally Funded Research and Development Center (FFRDC) report [6] provides relevant information regarding disposal of the grouted TSCR effluent; it states the following:

- Based on the existing physical capacities of the Clive and WCS facilities, all Class A grout can be disposed of either at Clive or WCS.
- Based on the existing WCS facility physical capacity, all Class B and C grout can be disposed of at the WCS disposal facility.
- If you assume a Sr-90 and Cs-137 decontamination factor (DF) of 100 (99% removal) for a TSCR-type system, then over 90% of the TSCR treated grout will be Class A per 10 CFR 61.55, "Waste Classification".

It should be noted that the FFRDC DF's are very conservative; the TSCR effluent gamma monitors and Pacific Northwest National Laboratory (PNNL) research with actual waste [8], show that the TSCR DF for Sr-90 and Cs-137 will be well over 1,000. Therefore, the radioactivity of the grouted effluent will be much lower than the FFRDC estimates, resulting in much more than 90% of the grouted TSCR effluent being Class A.

METHODS OF IMPLEMENTATION

Several alternatives exist for straightforward implementation of the streamlined approach in the 200 West and 200 East Areas of Hanford's Central Plateau. Each alternative depends on the use of a TSCR-type system for producing treated effluent for collection in downstream staging/ sample tanks.

Configuration in 200 West

A project in the 200 West Area has been initiated which includes a TSCR-type treatment system with an effluent suitable for immobilization in WTP-LAW, using the streamlined approach with SMG, or with offsite grout stabilization. This project, West Area Risk Management (WARM), will replicate the TSCR-type treatment unit from the 200 East Area, provide staging tank capacity, and an IXC storage pad. Currently, the WARM project has not finalized the immobilization pathway, but it provides an excellent location for implementing the streamlined approach. Equipment associated with the streamlined approach would ideally be located near the three 3,785 m³ (1 million gallon) tanks in the SY Tank Farm, which is the only double shell tank farm in the 200 West Area.

The SY Tank Farm is an ideal location for several reasons:

- The SY Farm is uncongested and there is plenty of space for installing new equipment.
- As shown in Fig. 6, a concrete pad that is suitable for holding over 500 TSCR IXC-150 ion exchange columns is already available adjacent to SY Farm and could be repurposed. The pad was built for storing waste from the defunct Demonstration Bulk Vitrification System (DBVS), but never used.

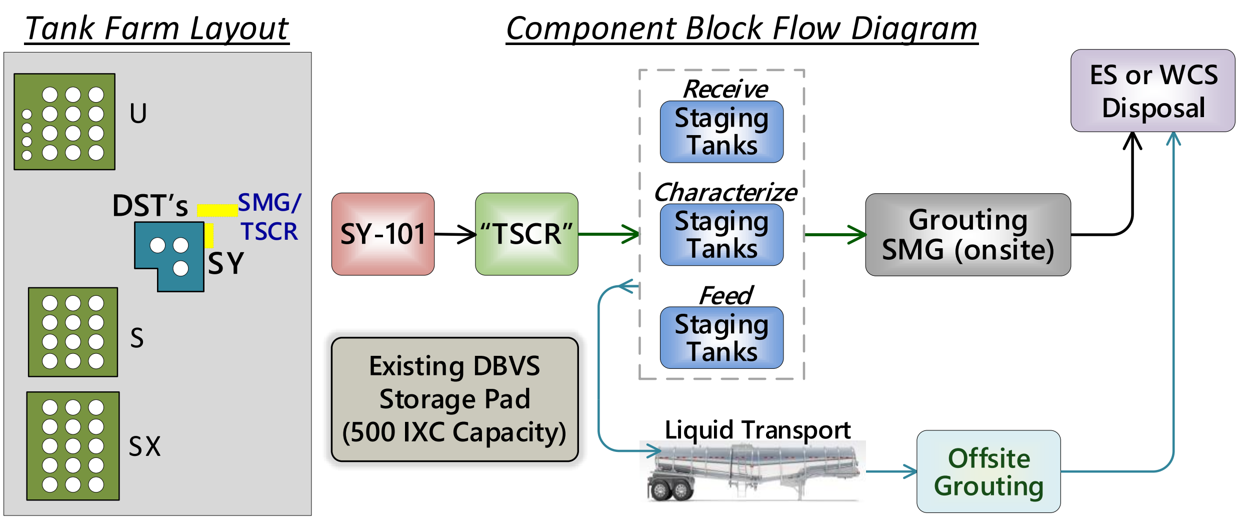

Fig. 6. Location and Configuration of the Streamlined Approach in 200-West.

- The SX, S, and U Tank Farms are very near SY Farm; therefore, there is a large source of liquid and saltcake that could be dissolved and transferred to SY double shell tanks as a feed for the streamlined treatment and immobilization systems.
- SY-101 is a good tank for startup of a new system because it contains almost 3,400 m³ (900,000 gallons) of relatively dilute supernatant with a sodium and Cs-137 concentration of 3 molar [Ref. 9, Table 4-2] and 8.75E-02 Ci/gal [Ref. 10, SY-101 PFD], respectively. These concentrations are about 46% and 86% lower than the respective sodium and Cs-137 concentrations currently being treated by TSCR in the 200 East Area.

As shown in Fig. 6, liquid waste would be prepared in SY-101 and transferred through a TSCR-type system for the removal of solids, cesium, and strontium. Treated liquid waste could be collected in a downstream staging tank for subsequent treatment in an onsite SMG system or sent to tankers that would be used for transporting liquid to an offsite grouting facility. Grouted waste would be disposed of at either the EnergySolutions Clive (UT) facility or at the WCS facility (TX). As processing continues, supernatant from SY-103 could be retrieved into the more dilute SY-101 tank.

SY-102 and SY-103

SY-102 and SY-103 currently contain waste that is somewhat unique. SY-102 is over 20% full of remote handled transuranic (TRU) solids from the Plutonium Finishing Plant (PFP), and SY-103 contains waste with a variety of highly concentrated constituents from 242-S Evaporator campaigns and other sources. The concentrated waste composition and quantities in SY-103 give it the potential for a Buoyant Displacement Gas Release Event (BDGRE), which makes it a Group A tank that imposes increased controls to mitigate the potential for a flammable gas event. As the streamlined approach progresses, portions of waste in SY-103 can be retrieved and transferred into SY-101 where it will be mixed with other retrieved wastes and adjusted with reagents, as necessary, to make it suitable for treatment through a TSCR-type system. Eventually the 1,570 m^3 (414,000 gallons) of saltcake in SY-103 could be dissolved and treated. Once emptied, SY-103 can become a feed staging tank, much like AP-105 in 200 East, that is used for receiving and chemically adjusting liquids from Single Shell Tank (SST) retrievals. Having a feed staging tank improves the efficiency of SST retrievals, for receipt of retrieved liquids and providing feed for the downstream treatment and immobilization systems, thus increasing the annual volume of waste treated and disposed.

Configuration in 200 East

TSCR and the planned Advanced Modular Pretreatment System (AMPS) will operate in a parallel mode to maintain AP-106 in a “topped off” condition with treated and characterized waste. Under the streamlined approach, immobilization will take place using WTP-LAW, as well as onsite grouting and offsite grouting. To ensure that treated waste is always available for WTP-LAW, the grouting options will only be used when AP-106 is above an acceptable level (e.g., 500,000 gallons). For grouting options (Fig. 7), treated liquid waste will be transferred from AP-106 to compliant modular staging tanks, and then to either the onsite SMG system or to a tanker for offsite grouting. In all cases, the grouted waste will be disposed out of state at either EnergySolutions (UT) or WCS (TX).

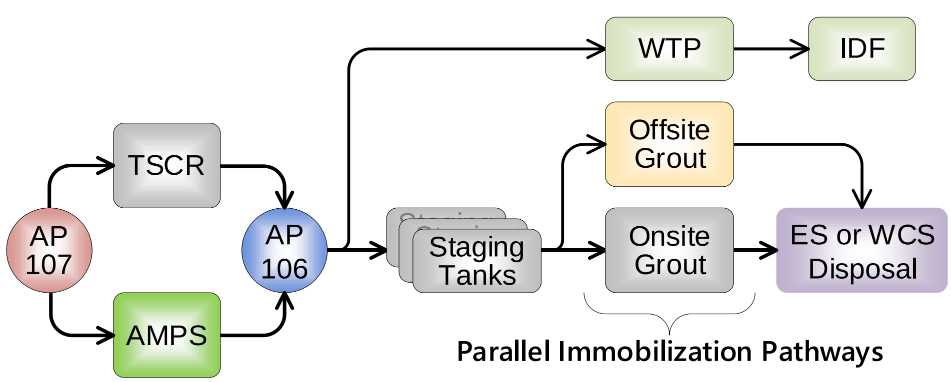

Fig. 7. Streamlined Approach for Immobilization in 200-East.

Location of SMG System in 200 East

The DFLAW program uses multiple interdependent facilities that work together to treat and immobilize liquid tank waste. As illustrated in Fig. 8, DFLAW includes the AP Tank Farm, TSCR-type units and multiple WTP facilities, including the LAW, Laboratory, and Effluent Management Facility (EMF), along with secondary waste treatment and disposal facilities. TSCR treated effluent is collected in AP-106 and then transferred through a 1,067 m (3,500-ft) long pipeline to WTP-LAW. The pipeline passes by two locations that are suitable for the installation of the SMG system as they are near the TSCR treated effluent transfer line as well as good roads and related infrastructure. The first location is near the corner of Canton Ave. and 4th Street and the second location is closer to EMF. It would be prudent for DOE to install diversion boxes with double isolation valves at both these candidate locations. The diversion boxes would greatly simplify connection to these pipelines in the future, especially after treated waste or evaporator concentrates have flowed through them.

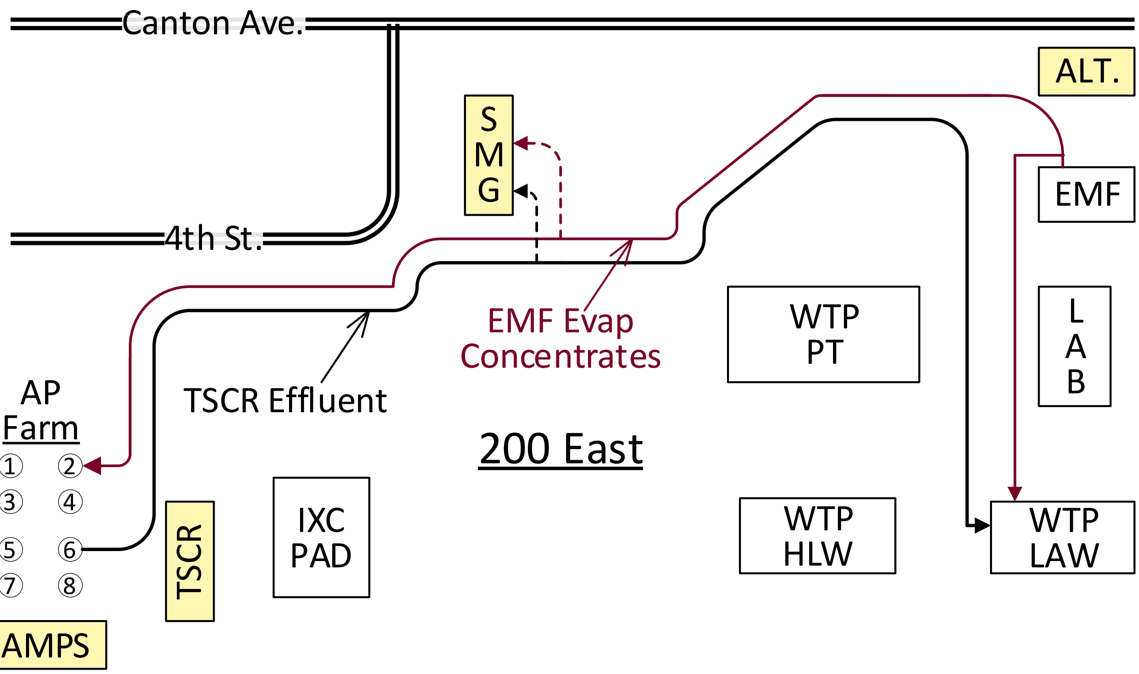

Fig. 8. DFLAW Facilities.

Immobilization of EMF Concentrates in Grout

The WTP-LAW facility mixes TSCR treated effluent with glass-forming reagents at 1150°C; at this temperature a significant fraction of the volatile and semi-volatile constituents (Cl, F, S, Hg, Cr, Tc, I, organics, etc.) are emitted into the melter offgas. WTP-LAW has an extensive offgas treatment system to capture these species before they reach the offgas stack [6]. Volatiles contained in the TSCR effluent plus added water from offgas scrubbing are condensed, collected, and sent to the EMF evaporator as "secondary" liquid waste. The EMF evaporator concentrates the secondary liquid by a factor of approximately 10 [11], and then sends the resulting evaporator concentrates back to the LAW melter or to AP-102. As shown in Fig. 8, the pipeline transferring EMF evaporator concentrate runs parallel to the TSCR treated waste effluent line, thus facilitating transfer to either of the candidate SMG locations. Circulating the EMF concentrates back to the melter creates a "flywheel" that increases the concentration of Tc-99 that is fed to the melters, and to a much lower extent I-129, for incorporation into the glass matrix as shown in Case 1 in Fig. 9. Regardless of whether these species are being vitrified into immobilized LAW or immobilized HLW, they are not easily incorporated into the glass matrix, and a substantial amount is driven into secondary waste streams [6]. Recycling the EMF evaporator concentrate is driven by the goal to immobilize as much of the volatile Tc-99 and I-129 into the glass as possible to minimize potential leaching of these species from Hanford's Integrated Disposal Facility (IDF) into the groundwater.

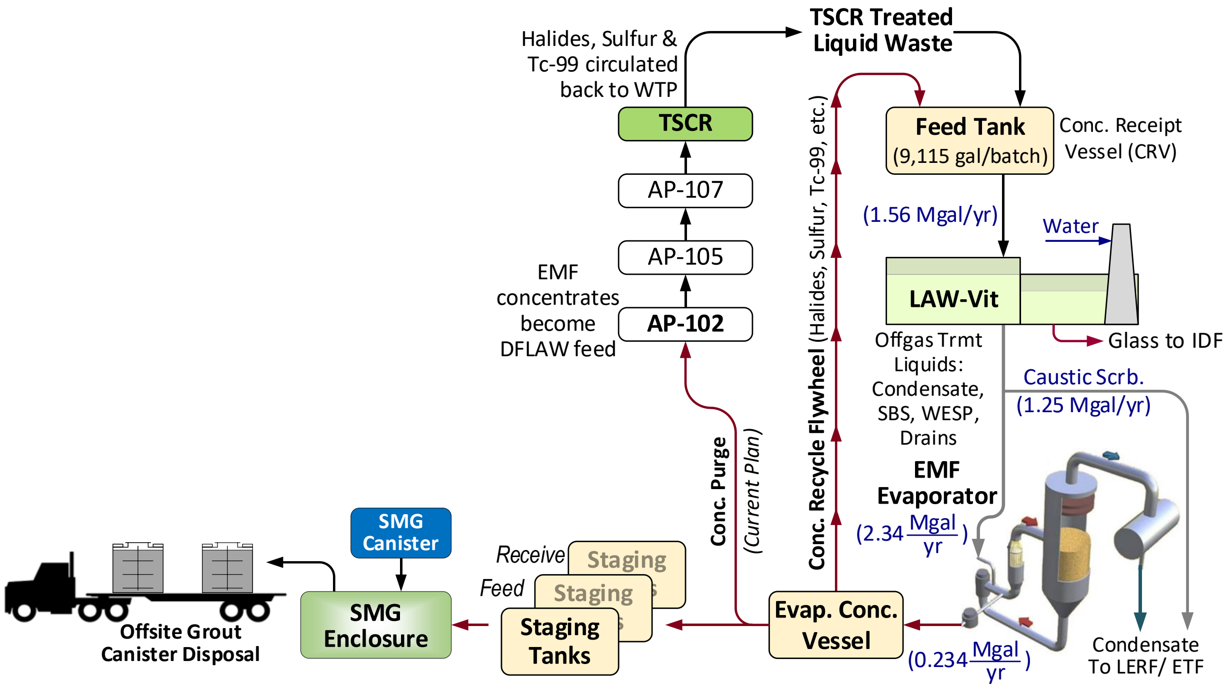

Fig. 9. EMF Concentrate Recycle Flywheel.

However, significant advantages can be realized if the EMF evaporator concentrates are not recycled back to the WTP-LAW melter feed tank but instead are directly immobilized by SMG. These advantages include:

- Grouting breaks the EMF concentrate recycle "flywheel", thus process limiting and problematic constituent like sulfur, chromium and technetium never reach a concentration of concern.
- Enables the WTP-LAW facility to treat at least 18% more tank waste. Grouting EMF concentrates increases the LAW facility tank waste throughput from 1.33 to 1.56 Mgal/yr.
- Creates glass with higher waste (Na_2O) loading, thus reduces the overall quantity of glass canisters needed for the mission by reducing melter corrosion, salt precipitation, etc.
- Long-lived radionuclides (Tc-99/ I-129) are grouted and sent to out of state disposal facilities which have no credible pathway to groundwater and zero potential of contaminating Hanford groundwater, thus providing the best protection of the public and environment.
- Eliminates the buildup of semi-volatiles like Cl, F, S, Hg, Cr, Tc, and I.
- Eliminates melter feed variables and sample requirements stemming from EMF recycle, providing consistent/ characterized feed from AP-106 that simplifies glass forming reagent recipes.
- Reduces melter corrosion and extends melter life due to lower concentrations of halides and sulfur.
- Eliminates return of high halide waste to AP-102, thus reduces tank farm corrosion concerns.

The WTP-LAW Facility is at capacity throughout the WTP mission; therefore, an 18% increase in the rate of waste treatment and a reduction in the number of waste glass canisters could be especially important for timely completion of the mission. (Grouting EMF concentrates shortens the WTP-LAW facility operational life by about a decade or enables it to vitrify a larger portion of tank waste that would otherwise go to a supplemental immobilization system, e.g., grout.)

GROUTED WASTE CHARACTERISTICS

The DFLAW process described in this paper pertains to the upper-most layers of supernatant and dissolved saltcake, which are lower in radioactivity than sludge contained in the bottom of most tanks. DFLAW liquids undergo the following treatment steps prior to immobilization:

- Chemical Adjustment (AP-105)
- Solids Settling and Decanting (AP-105)
- Filtration (TSCR)
- Ion Exchange (TSCR)

Based on the typical tank waste feed characteristics, the TSCR grouted effluent has a total radioactivity concentration of approximately 0.32 Ci/m³ – with the major radionuclides being Ni-63, Zr-93, Nb-93m, Tc-99, I-129, and Cs-137. When compared to the average radioactivity in other types of waste in the DOE Manifest Information Management System (MIMS) database [12], TSCR grouted waste is comparable to medical and academic waste and is 45-times lower in radioactivity than waste produced at commercial nuclear utilities (Fig. 10). Grouted TSCR effluent is approximately 25% of the NRC Class A limit (10 CFR 61.55) – meaning that the radioactivity could increase by 400% and still would be acceptable for disposal at both EnergySolutions (UT) and WCS (TX). Further, grouted TSCR effluent is only 3% of the Class C limit or over 3000% below the waste acceptance criteria for WCS (TX). All classifications are based on the use of the Cast Stone grout recipe [13] with a water to dry mix ratio of 0.5.

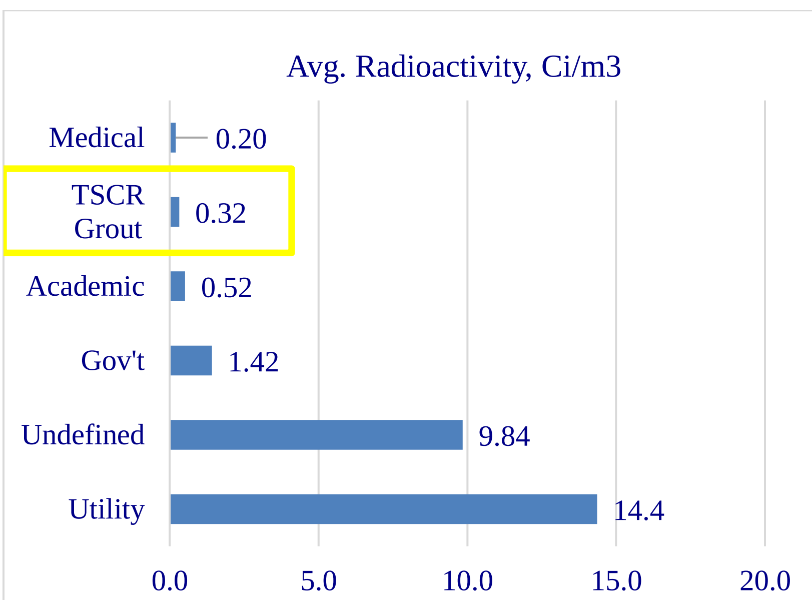

Fig. 10. Average Radioactivity in TSCR LLW [8]

COST SAVINGS FROM STREAMLINED APPROACH

FFRDC Estimated Savings

The FFRDC report [6] provides very detailed information and cost estimates for grout immobilization of approximately 378,500 m^3 (100 Mgal) destined for supplemental treatment. System Plan 9, ORP-11242, states that 200 Mgal of tank waste will be retrieved. Accordingly, both the WTP-LAW facility and the supplemental treatment technology will each need to immobilize approximately 100 Mgal of MLLW – assuming no evaporation takes place prior to immobilization. The FFRDC identified grout immobilization as the lowest cost treatment option with conservative cost estimates, including out of state disposal, that reduce the cost of the tank waste treatment mission by $31 billion (un-escalated) and $95 billion (escalated). This approach also reduces the waste treatment mission duration by 9 years.

Grouting EMF Concentrate Estimated Savings

As identified above, grouting and disposing the EMF concentrates at either the EnergySolutions Clive (UT) facility or at the WCS facility (TX) could provide substantial technical and environmental benefits for the DFLAW vitrification process. In addition, this approach could also provide significant cost and schedule savings.

When applying the cost estimating data and information from the FFRDC report [6] to grouting the EMF concentrates, conservative estimates are very compelling:

- Provides an annual WTP-LAW vitrification savings of **$59.3 million**
- Reduces the WTP-LAW mission duration by approximately **11 years**
- Results in a total mission savings of $**8.74 billion**

The bases for these estimates are shown in Fig. 11.

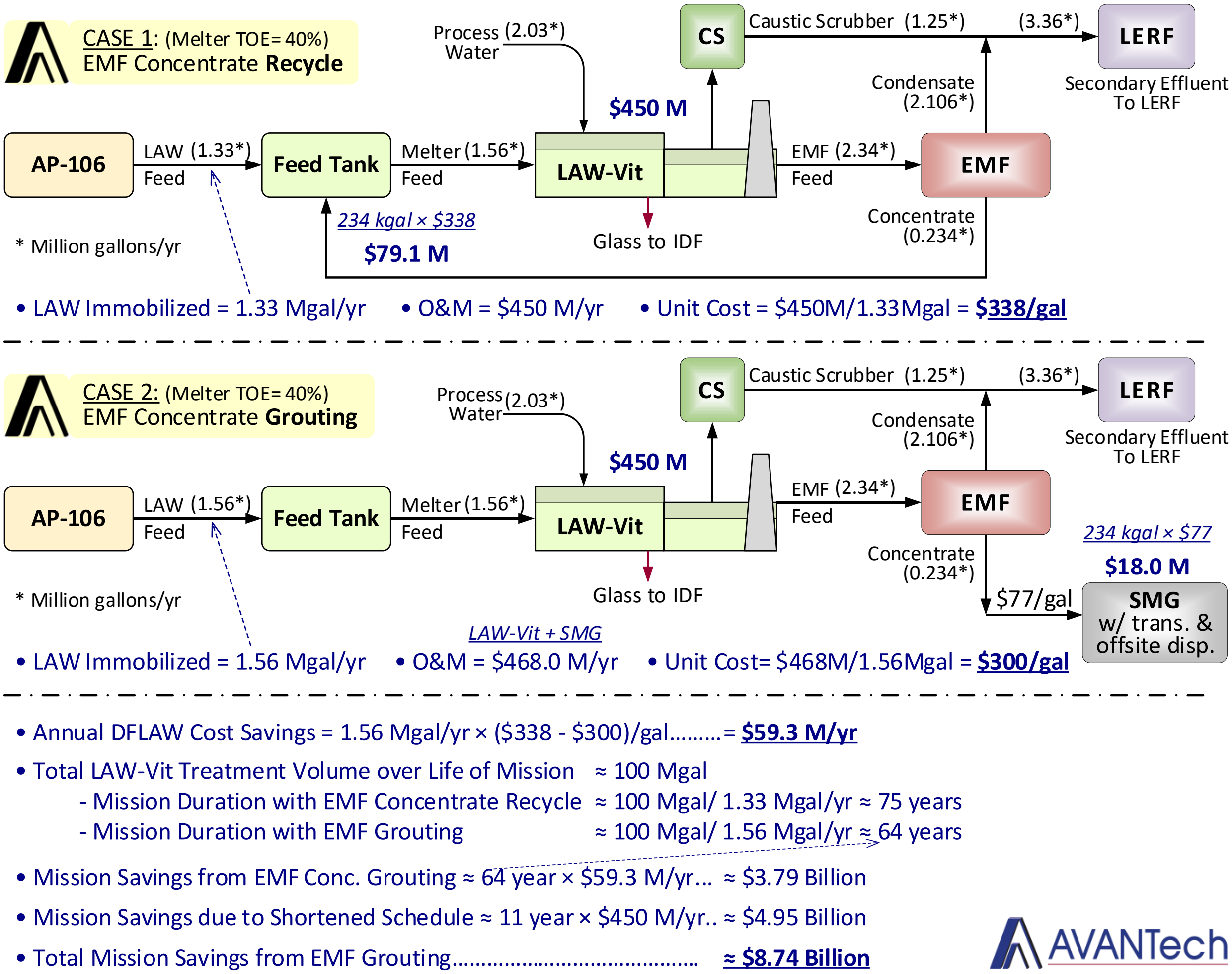

Fig. 11. Savings by Grouting EMF Concentrates

The values and costs noted in Fig. 11 are further described as follows:

a. The amount of liquid treated by the LAW-Vit facility is based on information in [Ref. 2], which correlates to 1.56 Mgal/yr at 40% TOE. (This value is for both LAW melters, i.e., both melters operating.)

b. The correlations between WTP-LAW feed volumes, secondary offgas to the EMF and secondary waste to the caustic scrubber were determined from an input file obtained from WRPS, titled “LAW Vit Feed Vector Crosstab CaseID 9157.xlsx,” which projects monthly liquid flows.

c. The estimated average cost for immobilizing, transporting, and disposing of 1 million gallon of tank waste by the SMG methodology is $77 million. Therefore, the unit cost is $77/gal with the cost allocated as shown in the following table.

SMG Treatment, Transport & Disposal Cost	Units	Cost
Offsite Commercial Disposal - Average	$/Mgal	$13,750,000
Transportation for Offsite Disposal - Average	$/Mgal	$4,250,000
Grout Process Consumables	$/Mgal	$37,500,000
Operations and Maintenance Onsite	$/Mgal	$21,500,000
Total Treatment, Transport, & Disposal Cost	$/Mgal	$77,000,000
Total Unit Rate - Treatment, Transport, & Disposal Cost	$/gal	**$77.00**

a. The benchmark operation and maintenance budget for the WTP-LAW facility is $450 million per year.

b. In "Case 1", the WTP-LAW facility treats 1.33 Mgal of tank waste plus 0.234 Mgal EMF concentrate recycle, thus the cost per gallon for tank waste immobilization is $338/gal ($450 M/ 1.33 Mgal).

c. In "Case 2", the WTP-LAW facility will incur an annual operating and maintenance cost of $450 million, plus another $18 million for grout immobilization, transport, and disposal of 0.234 Mgal of EMF concentrates, thus the total budget for Case 2 is $468 million.

d. For "Case 2", even though the total cost is slightly greater ($468 vs. $450 million), the unit cost for vitrification is lower ($300 vs. $338/gal) due to the 18% increased throughput achieved by elimination of the 0.234 Mgal "Recycle Flywheel". ($468 M/1.56 Mgal = $300/gal).

e. System Plan 9, ORP-11242, Figure 5-7, states that 200 Mgal of liquid waste will be retrieved from the DSTs, it is assumed that 100 Mgal (50%) of this waste will be treated by the WTP-LAW facility and that 100 Mgal will be treated by Supplemental LAW.

f. The annual cost savings associated with Case 2, EMF Concentrate Grouting, is estimated to be $59.3 million and is calculated as follows:

- 1.56 Mgal/yr × ($338 - $300)/gal = **$59.3 million per year**

g. As previously noted, the LAW facility will immobilize about 100 Mgal of tank waste over the life of its mission. As shown below, the LAW mission life will be about 75 years and 64 years for "Case 1" and "Case 2", respectively.

- Case 1: 100 Mgal / 1.33 Mgal/yr = **75 yr**
- Case 2: 100 Mgal / 1.56 Mgal/yr = **64 yr**
- NOTE: The FFRDC Report [6], Figure 1.3-3 shows the LAW facility mission extending to the 2085 timeframe; therefore, the 64 yr mission is reasonable.

h. In Case 2, grouting the EMF concentrates saves $3.79 billion over the life of the LAW facility.

- Case 2: 64 yr × $59.3 million per year = **$3.79 billion**

i. In Case 2, savings associated with shortening the LAW facility schedule by 11 years is $4.95 billion.

- Case 2: 11 yr × $450 million per year = **$4.95 billion**

Thus, the total mission saving from grouting EMF concentrates is **$8.74 billion**. ($3.79 + $4.95 = $8.74)

The estimated savings are very conservative as they only account for the operations and maintenance cost of the WTP-LAW facility. The actual savings should be greater when considering other benefits, such as:

- Increased waste (Na_2O) loading
- Reduced volume of waste to IDF
- Reduced quantity of Tc-99 & I-129 to IDF
- Extended melter life / reduced corrosion
- Reduced WTP-LAW sampling needs
- Overall reduction in Hanford cleanup mission

SUMMARY

The FFRDC report [6] provides a strong recommendation that DOE should expeditiously secure and implement multiple pathways for grout immobilization and disposal in parallel with the DFLAW vitrification process. The streamlined approach presented in this paper directly accomplishes the FFRDC recommendation and identifies additional measures to improve the efficiency of the vitrification process to realize even greater cost and schedule benefits. A streamlined grouting approach that uses multiple pathways for liquid tank waste treatment, grouting, and offsite disposal in parallel with DFLAW vitrification could be implemented for a comparatively minimal cost while not impacting WTP startup and operations. There are many benefits to implementing the streamlined approaches presented in this paper, including: Use of the revised TBI Phase II approach via AP-106 and grout stabilization of TSCR-treated waste and EMF concentrates, and the onsite and offsite waste grouting pathways will:

- Save $16 million on TBI Phase II implementation.
- Increase WTP-LAW facility tank waste treatment throughput by 18% (from 1.33 to 1.56 Mgal/yr) and shorten the mission schedule by 11 years by SMG stabilization of EMF concentrates.
- Accelerate the treatment and disposal of liquid waste in DSTs; freeing up much-needed space.
- Diminish concerns of I-129 and Tc-99 disposal at Hanford's IDF.
- Provide grouting and offsite disposal experience that can inform future Supplemental LAW decisions.
- Demonstrate a waste treatment and stabilization approach that could be applied to remotely located Tank Farms.
- Improve the WTP-LAW vitrification efficacy.
- Significantly reduce Hanford's mission cost and schedule.

Further, near-term progress achieved through the streamlined approach would significantly increase stakeholder confidence in DOE's ability to complete the tank waste mission without further impact to groundwater, the Columbia River, and the Hanford community.

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LAW Design Cap.		Na2O in Glass		Sodium in Na2O		Waste Na Conc.		Conversion		Conversion		Operating Eff.			LAW Facility Nominal Capacity							
30.0	MTG	23	MT-Na2O	46	MT-Na	1	L	1	Mole Na	1.0E+06	g Na	40%	TOE	=	16,188	L	=	4,277	gal	=	**1.56**	**Mgal**
1	Day	100	MTG	62	MT-Na2O	5.5	Mole Na	23	g Na	1	MT-Na					day			day			**yr**

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