

APPENDIX A

TECHNOLOGY DESCRIPTIONS

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APPENDIX A. TECHNOLOGY DESCRIPTIONS

A.1 Introduction

The Savannah River Site (SRS) currently stores 34 million gallons of aqueous high-level waste (HLW) in F- and H-Area Tank Farms (Figures A-1 and A-2; see also text box on this page). This waste comprises approximately 2.8 million gallons of insoluble sludge, 15.2 million gallons of solid saltcake, and 16 million gallons of supernatant salt, all contained in 49 large underground steel tanks. The U.S. Department of Energy (DOE) is committed to removing this waste material from the HLW tanks and processing it for final disposal to resolve critical safety and regulatory issues.

DOE has developed processes and facilities to convert the aqueous wastes into environmentally safe forms for long-term storage and final disposal (DOE 1994, 1995). Sludge components of the wastes, which contain most of the radioactive strontium and alpha-emitting actinides (such as plutonium and uranium), are washed and treated with sodium hydroxide to reduce the aluminum content, then mixed with glass frit for melting into a glass waste form in the Defense Waste Processing Facility (DWPF). Soluble salt components of the wastes were to be treated in a large waste tank, using a precipitation-sorption process denoted In-Tank Precipitation (ITP), to remove radioactive cesium (principally cesium-137) and other radionuclides for vitrification, along with sludge, in DWPF. The cesium would have been precipitated as an insoluble tetraphenylborate solid, and residual strontium and actinides (such as plutonium and uranium)

would have been sorbed to a particulate solid, monosodium titanate, then both would be filtered from the solution for transfer to the DWPF. The low activity salt solution would then have been fixed in a concrete-like material (saltstone) for onsite disposal in engineered vaults. SRS would provide interim storage of the waste glass in stainless steel canisters until such time as they could be shipped to a monitored geologic repository for final disposal.

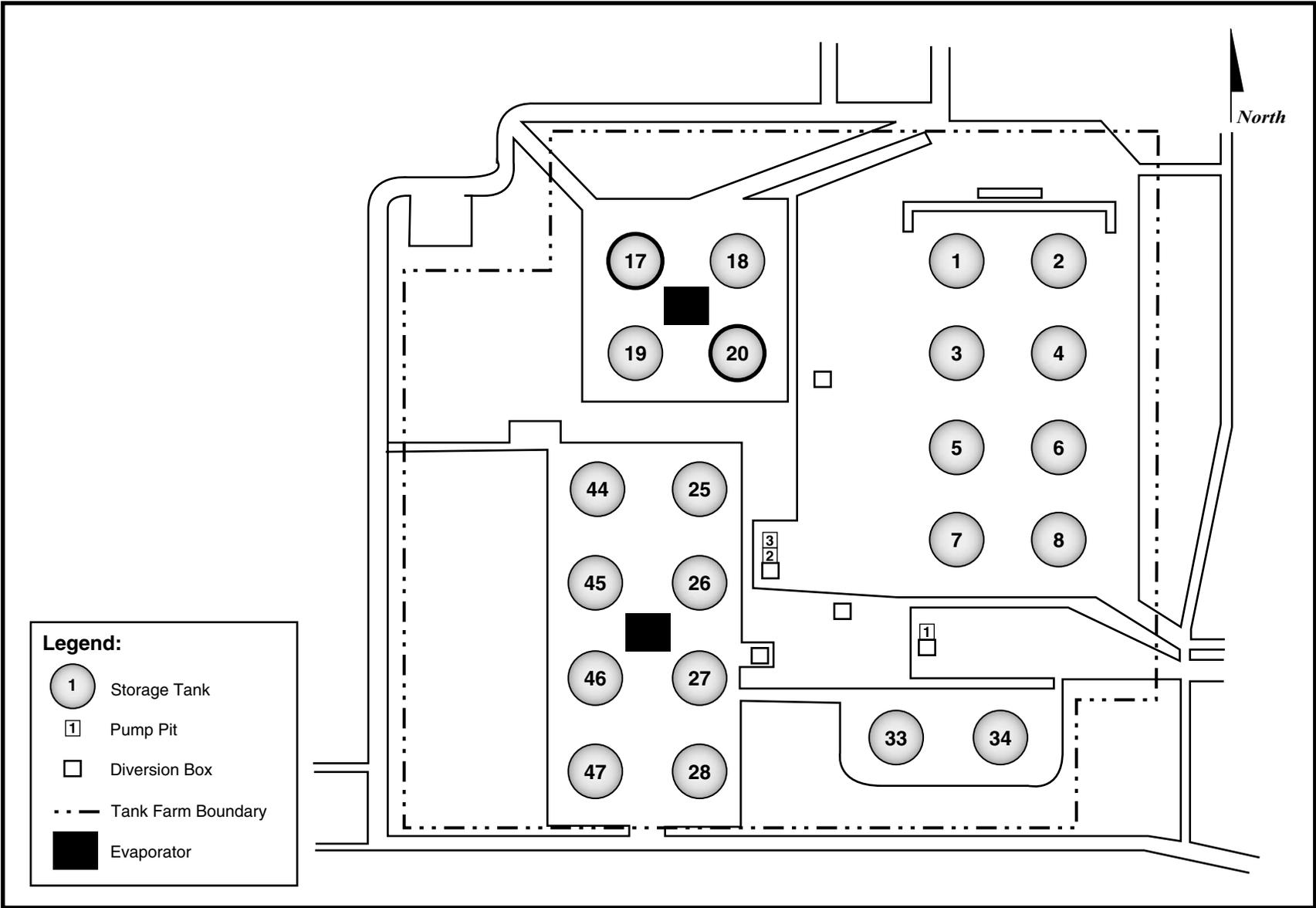
The sludge processing operations were successfully implemented and immobilization of these wastes in glass at DWPF is in progress. During startup of the ITP process, however, it was observed that decomposition of the tetraphenylborate produced benzene in amounts higher than predicted. A comprehensive review of the process concluded that the tetraphenylborate decomposition and benzene release associated with ITP operation could exceed the design capability of the existing facilities, preventing simultaneously meeting safety and production requirements in a cost-effective manner (see text box page A-4).

Evaluation of alternative technologies resulted in the identification of four candidates to replace the ITP process (WSRC 1998a):

- Small Tank Tetraphenylborate Precipitation
- Crystalline Silicotitanate Ion Exchange
- Caustic Side (non-elutable) Solvent Extraction
- Direct Disposal (of cesium) in Grout.

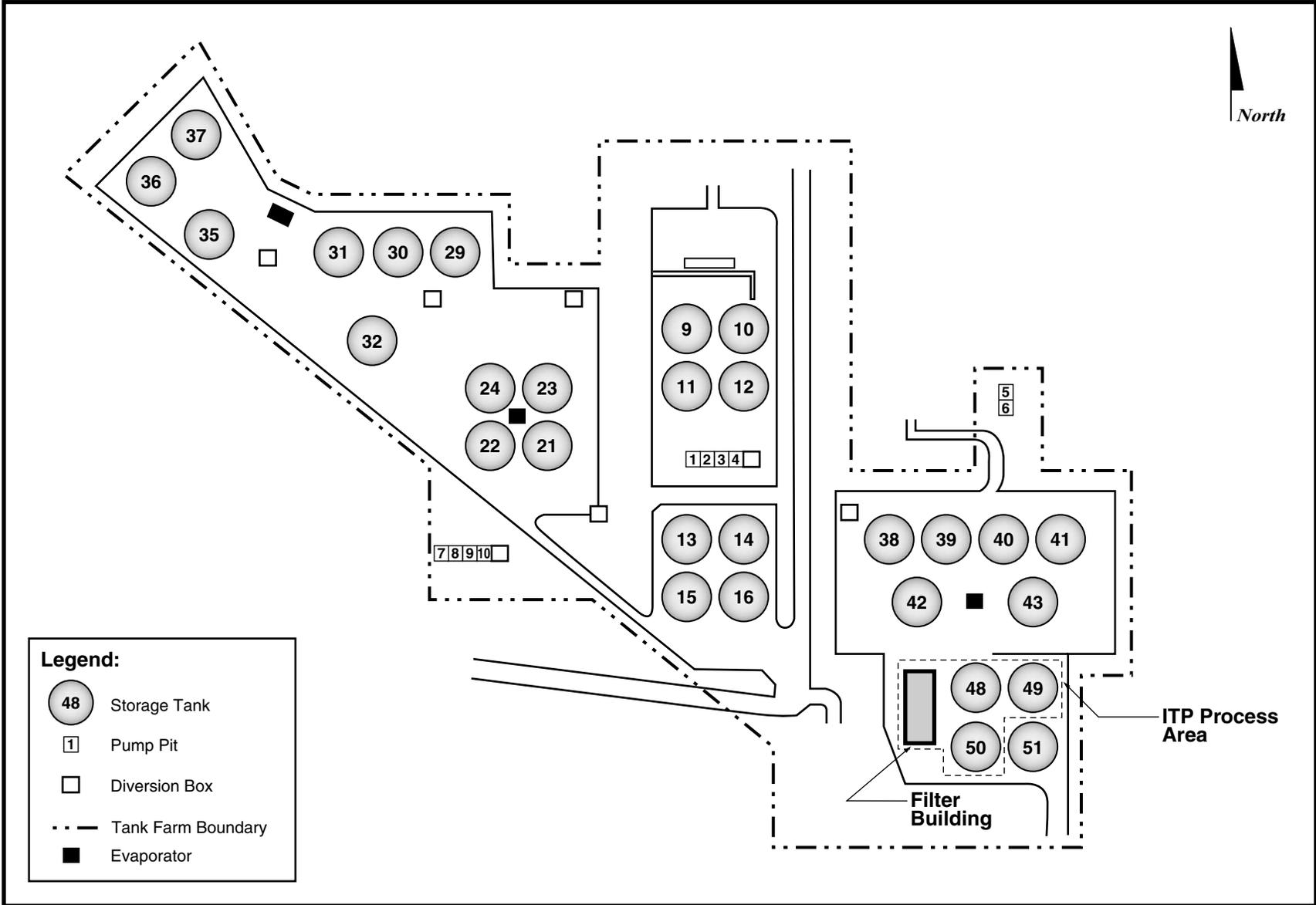
Waste Tank Concerns and Commitments

Two of the original 51 HLW storage tanks (numbers 17 and 20) at SRS had waste removed and have been closed. Of the remaining 49 tanks, 9 (numbers 1, 9, 10, 11, 12, 13, 14, 15, and 16) have leaked observable quantities of liquid waste from primary to secondary containment and one tank (number 16) leaked a few tens of gallons of waste to the environment (WSRC 1998b). One other tank (number 19) has cracks in the tank wall above the level of the waste, although no waste has been observed to leak through these cracks. Tanks 1 through 24 do not meet U.S. Environmental Protection Agency (EPA) secondary containment and leak detection standards for storage of hazardous waste, effective January 12, 1987 (40 CFR 264). Removal of wastes and closure of these tanks by 2022 is required by the Federal Facility Agreement (FFA) for SRS entered into by the DOE, EPA, and the South Carolina Department of Health and Environmental Control (SCDHEC) (EPA 1993). All HLW at SRS is land-disposal-restricted waste, prohibited from long-term storage, and must be removed from the HLW tanks by the year 2028 as a result of FFA (WSRC 2000a).



NW SDA EIS/Grfx/App A/A-1 Lay F Tank.ai

Figure A-1. General layout of F-Area Tank Farm (Tanks 17 and 20 are closed).



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Figure A-2. General layout of H-Area Tank Farm.

The environmental impacts of constructing and operating facilities for these alternative technologies are being identified and evaluated in this *Salt Disposition Alternatives Supplemental Environmental Impact Statement (SEIS)* (DOE 1998a, 1999).

Need for ITP Replacement

Benzene generated during the ITP process results from the decomposition of tetraphenylborate (TPB), which is used to separate soluble radioactive cesium from the HLW salt solution. The cesium is precipitated as an insoluble solid that can be filtered from the waste solution. Under certain conditions the tetraphenylborate is subject to a radiolytic and catalytic decomposition that forms benzene and allows the separated cesium to return to the salt solution. Benzene is a toxic, flammable, and potentially explosive organic substance that must be safely controlled. The redissolution of cesium as a result of tetraphenylborate decomposition must be curtailed to achieve the required decontamination of the salt solution.

Tetraphenylborate decomposition is catalyzed by certain metals in the radioactive waste, notably the fission product palladium. The extent and rate of tetraphenylborate decomposition is affected by the chemical form of the catalyst, and increases with time of exposure to and temperature of the catalyst. Controlled release of benzene from the salt solution, as required to mitigate potential benzene hazards, is promoted by agitation or stirring. Flammability is controlled by maintaining a nitrogen gas cover that excludes oxygen above concentrations that could cause benzene combustion.

The ITP facilities were unsuitable to control tetraphenylborate decomposition and benzene generation because:

- Large volumes and long cycle times allowed excessive tetraphenylborate decomposition before the precipitate could be separated by filtration from the salt solution.
- Adequate temperature control was not possible in the large tank.
- Agitation by slurry pumps produced insufficient mixing.
- Purge of the nitrogen gas cover was inadequate because the large tank was not adaptable to positive pressure or secondary confinement.

These limitations were assessed against requirements for safely processing the large inventory of HLW salt within the time projected for completion of sludge processing in the DWPF. Based on this assessment, DOE concluded that the ITP process could not simultaneously achieve safety and production requirements for the high-level radioactive waste system.

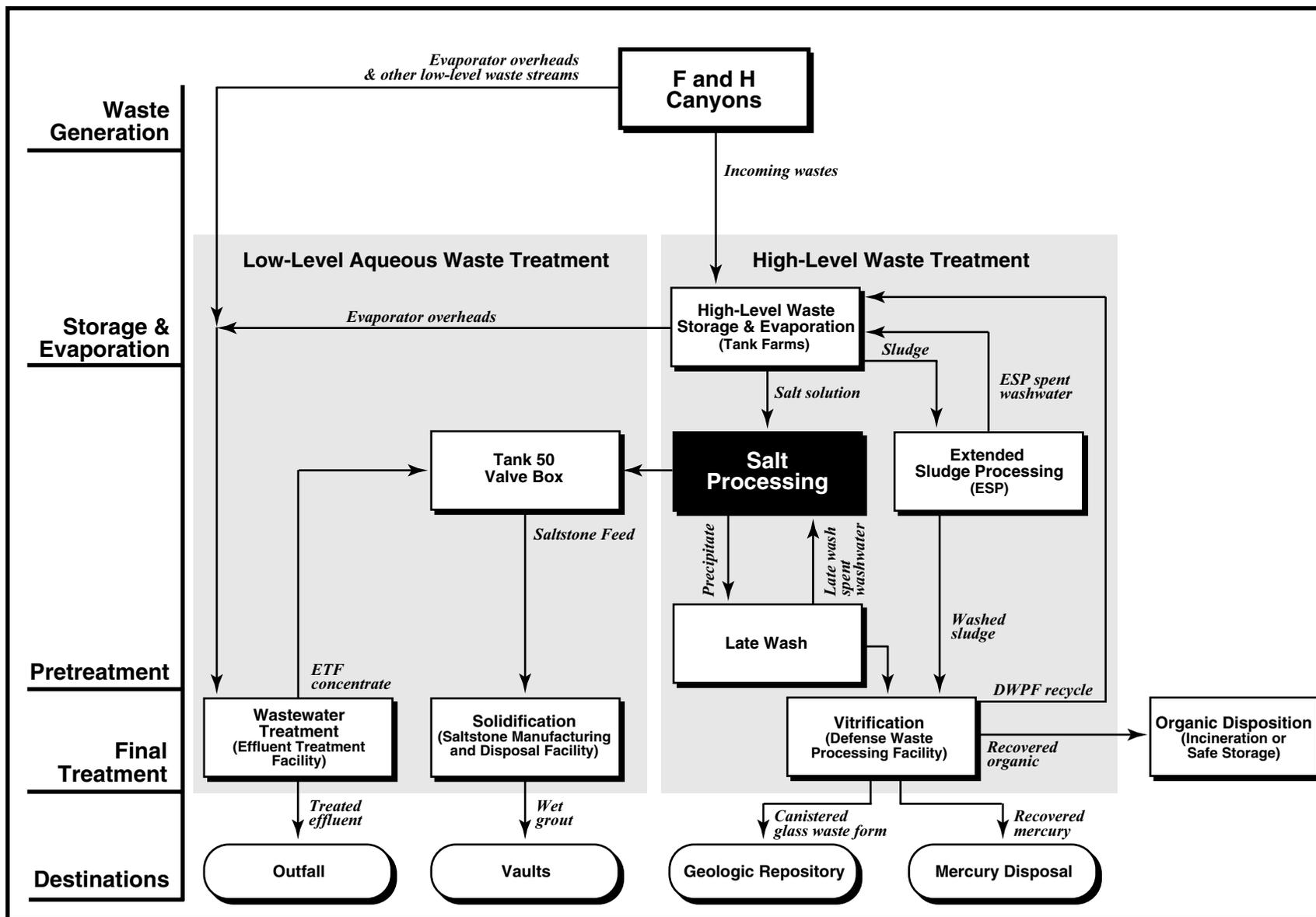
A.2 Current HLW System Configuration

The SRS HLW system was developed to receive and store radioactive wastes in a safe and environmentally sound manner and to convert these wastes into forms suitable for final disposal (DOE 1994). A schematic of the process is shown in Figure A-3 (WSRC 1998b). As planned, sludge components and the highly radioactive soluble constituents recovered from the salt components of the wastes would be immobilized in DWPF as borosilicate glass contained in stainless steel canisters for disposal in a monitored geologic repository. Low activity salt solutions would be immobilized in cementitious form (saltstone) for disposal in onsite vaults. Secondary products from these operations, including mercury derived from sludge processing and benzene released during salt processing operations, would be recovered for appropriate disposition (recycling or destruction). Miscellaneous radioactive and hazardous process wastes would be incorporated into the SRS waste management system for disposal.

A.3 Processes and Facilities

A.3.1 HLW STORAGE AND EVAPORATION

HLW from SRS chemical processing operations is received in the F- and H-Area Tank Farms as an aqueous slurry of insoluble sludge and soluble salts in alkaline solution. The tank farms concentrate (by evaporation of excess water) and store these wastes, pending further processing in other facilities. The sludge component of the alkaline wastes settles to the bottom of the storage tank, and the salt solution is decanted and concentrated by evaporation, leaving a solid saltcake and a concentrated supernatant. Evaporation reduces the volume and mobility of the wastes, enhancing long-term storage. The water driven off by evaporation is processed through the Effluent Treatment Facility (ETF) to decontaminate it before release to an onsite stream. No water is released from ETF to a stream unless it meets all regulatory criteria.



NW SDA EIS/Grix/App A/A-3 SRS HLW.ai

Figure A-3. SRS high-level waste system configuration.

A.3.2 EXTENDED SLUDGE WASHING

The insoluble sludges accumulated in the tanks are hydraulically slurried and transferred to tank farm facilities for washing with inhibited water to remove soluble salts entrained in the sludge. (Inhibited water contains low concentrations of sodium nitrite and sodium hydroxide to inhibit corrosion of the steel waste tanks.) To reduce the quantity of glass waste formed, sludge with high levels of aluminum is treated with caustic (3 to 5 molar sodium hydroxide) to convert aluminum hydroxide to soluble sodium aluminate, which is washed from the sludge along with other soluble salts. The wash solutions are concentrated by evaporation and returned to the waste tanks as salt waste components. The washed sludge is transferred to DWPF for conversion to the borosilicate glass waste form.

A.3.3 SALT PROCESSING

In the salt processing operations, as originally projected, saltcake in the waste tanks would be redissolved and combined with concentrated supernatant, and the resulting salt solution transferred hydraulically to the ITP facilities. ITP was to be conducted in a large waste tank; tetraphenylborate would be added to the salt solution to coprecipitate radioactive cesium (along with essentially nonradioactive potassium) as an insoluble solid, and a slurry of the particulate solid monosodium titanate would be added to react with residual strontium and actinides by a sorption process. The resulting precipitate solids would be concentrated in the tank and separated by cross-flow filtration before being transferred to DWPF for melting into a glass waste form, along with sludge components of the waste. (Cross-flow filtration is a process in which the solid slurry is passed through porous membrane tubes under pressure to force the salt solution into a surrounding vessel and concentrate the solids in the slurry.) The low activity salt solution recovered by filtration would be immobilized in onsite vaults as saltstone.

A.3.4 DWPF GLASS PROCESSING

If the ITP process were operational, sludge and salt precipitate solids would be transferred as

aqueous slurries to DWPF for conversion in a glass melter to the glass waste form. Currently, only sludge is being vitrified at DWPF.

In DWPF, the sludge slurry would be acidified and treated chemically to extract mercury before the sludge was sent to the glass melter. The recovered mercury would be stored for future disposal. The precipitate slurry would be treated in DWPF, using a hydrolysis process to decompose the tetraphenylborate solids. The hydrolysis reaction would produce an aqueous solution of inorganic salts including the radioactive cesium, several organic products (principally benzene), boric acid, and residual titanate solids. The benzene would be distilled from the mixture, washed, and collected for incineration. To avoid potential explosion hazards from benzene, the tetraphenylborate precipitate would be processed in a carbon dioxide atmosphere. The aqueous residues of the precipitate hydrolysis process would be mixed with sludge and glass frit as feed for the DWPF melter. Molten glass would be poured into stainless steel canisters about 2 feet in diameter by 10 feet long, suitable for interim onsite storage and permanent disposal in a monitored geologic repository.

Storage of Recycle DWPF Wastes

DWPF operations produce large volumes of recycle wastes, mostly water, returned to the HLW storage tanks. Without a salt processing technology in place, the DWPF sludge-only operation will increase the volume of waste that must be stored in the HLW tanks. Management of existing tank space and equipment would allow DOE to continue sludge-only vitrification in DWPF until about 2010, the projected time for startup of salt processing plant operations (text box page 2-2).

Tank space management would include some or all of the following activities intended to reduce storage requirements in the HLW tanks (WSRC 1999a):

- Continue to evaporate liquid waste
- Use Tank 49 for HLW storage instead of ITP processing

- Return Tank 50 to HLW service
- Implement several activities that gain small incremental volumes
- Near the end of the period, reduce the available emergency space in the tank farm to the minimum required by the Authorization Basis, as necessary.

A.3.5 SALTSTONE PROCESSING

The low activity salt solution from the ITP process would be mixed with a blend of cement, fly-ash, and slag in the Saltstone Manufacturing and Disposal Facility to produce a grout suitable for disposal in onsite vaults. The grout would be poured into the vaults to solidify into large saltstone monoliths.

As originally designed, the saltstone vaults are near-surface concrete containment structures that serve as forms for the cast saltstone and provide a diffusion barrier to the environment (Wilhite 1986; Wilhite et al. 1989). The vaults, 300 feet in length, 200 feet wide, and about 25 feet high, with 1.5-foot-thick sidewalls, a 2.5-foot base and a 2.0-foot cover, are sized to contain approximately 1.4 million cubic feet (40,000 m³) of saltstone within six subdivided cells of the vault. During decommissioning, clay caps would be placed over the vaults, with drainage systems installed between the caps to reduce the volume of rainwater infiltrating the disposal site.

The grout composition and the vault design were specified to minimize the release rate of waste components into the surrounding environment (Langton 1988; Wilhite 1986). Performance criteria imposed on the saltstone vaults required that groundwater quality at the disposal site meet drinking water standards. Performance modeling, validated by field tests, demonstrated the capability of the saltstone vaults to meet these standards (Martin Marietta 1992).

A.4 Salt Processing Alternatives

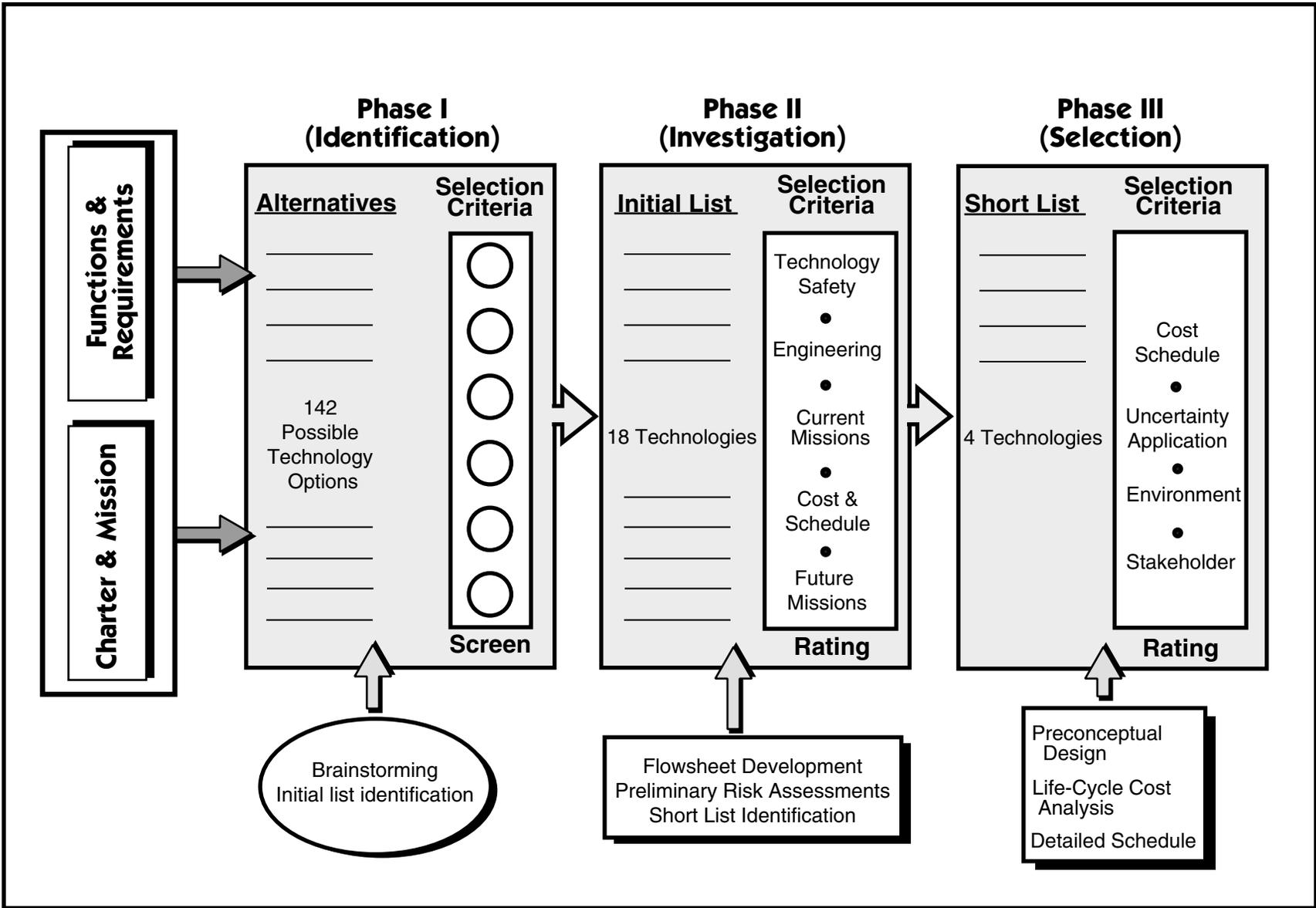
Facility capabilities have been demonstrated and all waste processing operations for the SRS HLW management system are currently opera-

tional, with the exception of ITP processing and related late wash of the precipitate. In December 1995, DOE determined that the ITP process was generating benzene at higher rates than expected and operational testing was suspended in March 1996. Benzene is a flammable product of the decomposition of tetraphenylborate added to precipitate cesium from the salt solution. The excess benzene resulted from the decomposition of tetraphenylborate in the processing tank, allowing redissolution of the precipitate before it could be separated by filtration. In concurrence with a Defense Nuclear Facility Safety Board recommendation, chemical studies were initiated that would better explain the underlying mechanisms for benzene generation and release during the tetraphenylborate precipitation process. These studies demonstrated that the process to remove cesium from the salt solution, as then configured, could not simultaneously achieve production goals and meet safety requirements for processing the salt wastes.

In early 1998, the ITP project was suspended and DOE directed Westinghouse Savannah River Company (WSRC) to initiate a program for evaluation of alternative salt processing technologies. A High-Level Waste Salt Processing Systems Engineering Team (SET) was chartered to identify technologies to replace the ITP process, evaluate the technologies, and recommend a selected technology or technologies to convert the HLW salt solution (supernatant plus dissolved saltcake) to waste forms that could meet regulatory requirements. The SET was composed of WSRC employees with technical support from universities, several national laboratories, independent consultants, and the DOE complex.

A.4.1 SCREENING

The SET employed a phased approach, as summarized in Figure A-4. In Phase I, approximately 140 possible technology options were identified to replace ITP, and meet safety and production requirements. Each option was evaluated against a set of screening criteria that established minimum requirements. This initial



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Figure A-4. Current phased approach to screening and selecting salt processing technologies.

The initial screening of approximately 140 salt processing technologies options identified 18 for further evaluation. The 18 technologies, grouped by general category (WSRC 1998c), were:

Crystallization

Fractional Crystallization – DWPF Vitrification

Electrochemical Separation

Electrochemical Separation and Destruction – DWPF Vitrification

Ion Exchange

Elutable Ion Exchange – DWPF Vitrification
Acid Side Ion Exchange – DWPF Vitrification
Crystalline Silicotitanate Ion Exchange – DWPF Vitrification
Crystalline Silicotitanate Ion Exchange – New Facility Vitrification
Crystalline Silicotitanate Ion Exchange – Ceramic Waste Form
Zeolite Ion Exchange – DWPF Vitrification

Precipitation

Potassium Removal followed by Tetraphenylborate Precipitation – DWPF Vitrification
Reduced Temperature ITP – DWPF Vitrification
Catalyst Removal ITP – DWPF Vitrification
ITP with Enhanced Safety Features – DWPF Vitrification
Small Tank Tetraphenylborate Precipitation – DWPF Vitrification

Solvent Extraction

Caustic Side Solvent Extraction – DWPF Vitrification
Acid Side Solvent Extraction – DWPF Vitrification

Vitrification

Direct Vitrification
Supernatant Separation – DWPF Vitrification
Direct Disposal of Cesium in Grout – DWPF Vitrification

screening reduced the original 140 options to 18 technologies that were selected for further evaluation.

During Phase II of the technology selection process, the SET performed a preliminary technical and programmatic risk assessment for each of the 18 technologies to establish a short list for in-depth analysis. As part of the Phase II analy-

sis, the SET evaluated preliminary material balances, cycle times, and impacts to the HLW system for each of the 18 technologies. A technical document (WSRC 1998d) provides supporting data and the results of this assessment, which narrowed the list of 18 technologies to four:

- Small Tank Tetraphenylborate Precipitation (Small Tank Precipitation)
- Crystalline Silicotitanate (non-elutable) Ion Exchange (Ion Exchange)
- Caustic Side Solvent Extraction (Solvent Extraction)
- Direct Disposal (of cesium) in Grout (Direct Disposal in Grout).

Phase III of the process evaluated the final four technologies in still greater detail, including life-cycle cost estimates and schedule assessments. Some of the uncertainties and assumptions in the Phase II efforts were resolved in Phase III by additional research, literature review, calculations, and experiments. The facility components of the technologies, such as tanks and transport systems, were described in greater detail. Equipment sizing was refined and used to develop pre-conceptual facility layouts and process flow configurations. The layouts were used to develop project schedules and life-cycle cost estimates. This analysis is documented (WSRC 1998e) and forms the basis for the environmental impact analysis presented in this SEIS.

A.4.2 RECOMMENDATION AND REVIEW

On October 29, 1998, following review by the WSRC Review Panel Team, WSRC recommended to DOE the Small Tank Precipitation process as the most reasonable replacement salt processing technology and the Ion Exchange process as a backup technology (WSRC 1998e).

A DOE Savannah River (SR) Review Team evaluated the WSRC recommendation and concluded that the remaining technical uncertainties for each of the alternatives were too significant to justify selection of a preferred technology (DOE 1998b). The DOE-SR Review Team rec-

ommended that additional research and development be conducted to address the key technical uncertainties associated with the two technologies, so that one could be identified as most reasonable. The Review Team agreed with WSRC that one of the four technologies considered in Phase III, Solvent Extraction, should be eliminated from further consideration because of its insufficient technical maturity. The DOE Review Team concluded that the Direct Disposal in Grout alternative should not be eliminated, based on its potential to reduce construction and operating costs and the high confidence in its technology, safety, and feasibility for implementation.

A DOE-Headquarters Independent Review Team concluded that both the Small Tank Precipitation and the Ion Exchange alternatives were technically feasible. This team agreed with the SET that Direct Disposal in Grout should be eliminated from further consideration, because of regulatory issues that had the potential to substantially increase the time required to implement the technology (DOE 1998c), therefore further investigations regarding implementing this alternative will not occur as long as a cesium-separation technology can be proved technically and economically practical.

In January 1999, DOE directed WSRC to conduct additional research and development in the Small Tank Precipitation and Ion Exchange alternatives, while the Department pursued resolution of issues pertaining to Direct Disposal in Grout. These additional studies concluded with WSRC maintaining its recommendation to pursue design and construction for the Small Tank Precipitation process. WSRC further noted that, with additional development to reduce technical and engineering risk factors, the Ion Exchange process could also prove suitable for SRS, as well as a DOE complex-wide application for salt processing.

During this period, the technology for the Solvent Extraction process advanced independent of the SRS alternative evaluations. This information, coupled with recommendations from the National Research Council of the National Academy of Sciences and improved under-

standing of tank farm water management issues, led the Department to reconsider the potential to mature and implement this alternative in time to support HLW salt processing needs.

In February 2000, DOE requested WSRC to initiate further development of the Solvent Extraction alternative, aimed at the timely resolution of previously identified problems (DOE 2000). Consequently, the Solvent Extraction technology is included as a reasonable alternative in the SEIS.

A.4.3 PROCESS DESCRIPTIONS

A.4.3.1 Small Tank Tetraphenylborate Precipitation

In the Small Tank Precipitation technology (WSRC 1998c,e,f), the soluble salt components of the wastes would be processed using precipitation-sorption procedures analogous to the ITP process to separate cesium and other soluble radionuclides from the waste solutions. The process would be conducted as a continuous operation in stirred small tanks (15,000 gallons) with the solution agitated constantly to avoid excessive decomposition of tetraphenylborate and accompanying generation of benzene before separation. In the Small Tank Precipitation technology, tetraphenylborate solution would be added to precipitate cesium and potassium, and a slurry of monosodium titanate would be added to sorb residual strontium and actinides from the salt solution. The resulting solids, along with residual sludge, would be concentrated by filtration and washed to remove soluble salts, then treated chemically to convert the precipitate to a non-flammable form for transfer to DWPF. Catalytic decomposition of the precipitate, with removal of the benzene formed, would generate a product stream containing cesium in aqueous solution and strontium and actinides sorbed onto monosodium titanate for vitrification. The low activity salt solution recovered by filtration would be transferred to the Saltstone Manufacturing and Disposal Facility for processing. The wash water would be recycled into the incoming soluble salt solution.

Small Tank Precipitation would be performed in a new facility to be constructed at Site B in S Area. Process flows for the Small Tank Precipitation alternative are shown in Figure A-5. Salt solution would be collected in an H-Area tank and pumped to the Small Tank Precipitation facility. A section of new interarea transfer line would be required to connect the new facility to the existing transfer line. The precipitation process would be conducted in two Continuous Stirred Tank Reactors. Salt solution mixed with tetraphenylborate, monosodium titanate, process water, and recycled wash water in the first tank reactor would flow to the second tank reactor, providing reaction conditions needed to maximize decontamination factors for the precipitation and sorption processes.

The precipitate slurry, containing about one weight percent tetraphenylborate and monosodium titanate solids, would be transferred continuously from the second tank reactor to a Concentrate Tank, where it would be concentrated to

about 10 weight percent solids by cross-flow filtration. The resulting filtrate would be pumped to a Filtrate Hold Tank for later transfer to the Saltstone Manufacturing and Disposal Facility for immobilization in the saltstone vaults.

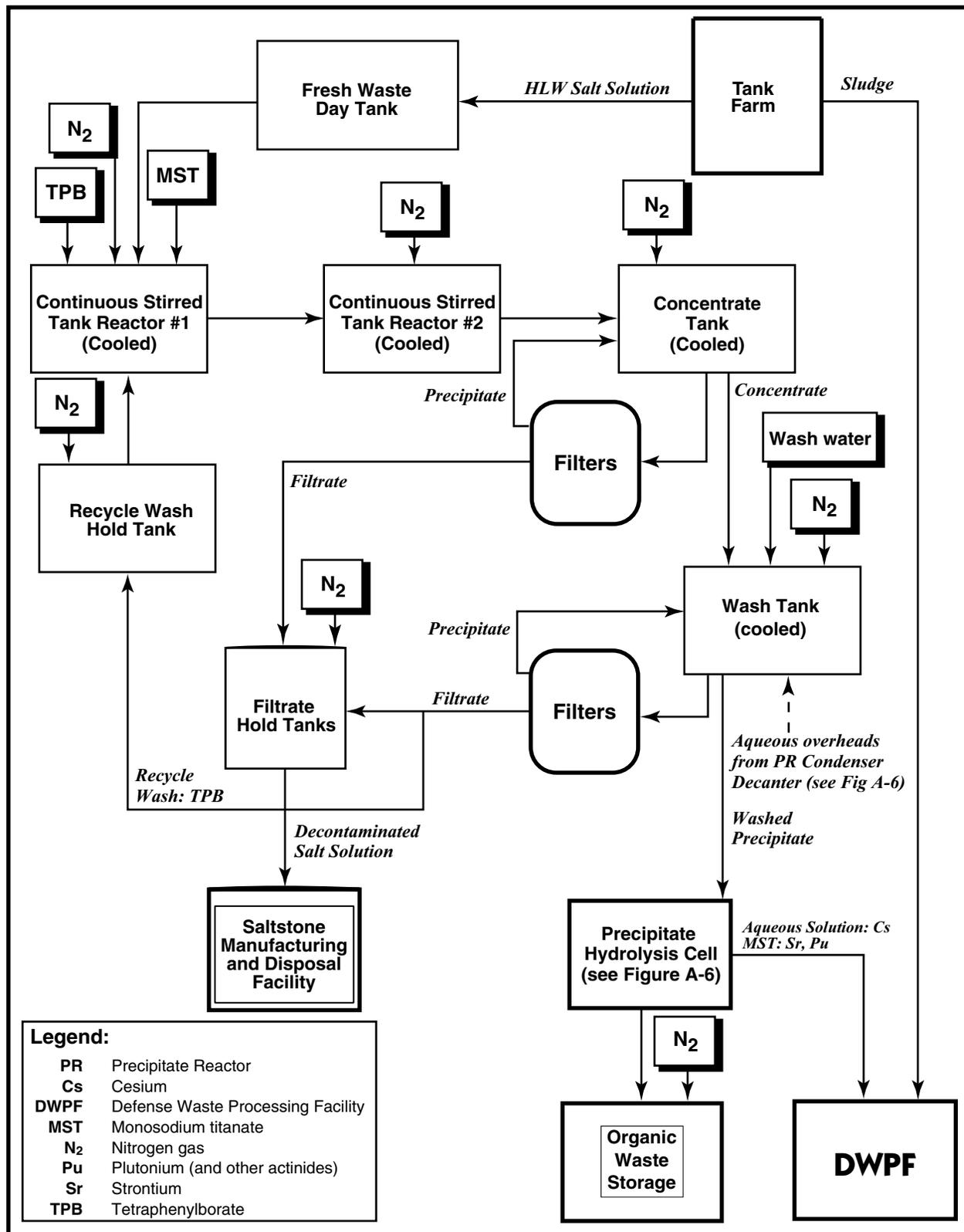
The precipitate slurry accumulated in the Concentrate Tank would be transferred to the Wash Tank for washing in a batch process to remove soluble sodium salts. Spent wash water would be separated from the precipitate by cross-flow filtration. The washed precipitate would be treated in the Precipitate Hydrolysis Cell (PHC) of the facility to eliminate benzene and generate an aqueous product stream termed Precipitate Hydrolysis Aqueous (PHA).

The PHC incorporates process operations formerly assigned to the Salt Processing Cell of DWPF (see text box below). Process flows for the PHC are shown in Figure A-6. In the PHC,

Transfer of DWPF Salt Processing Cell Operations to Small Tank Precipitation Facility

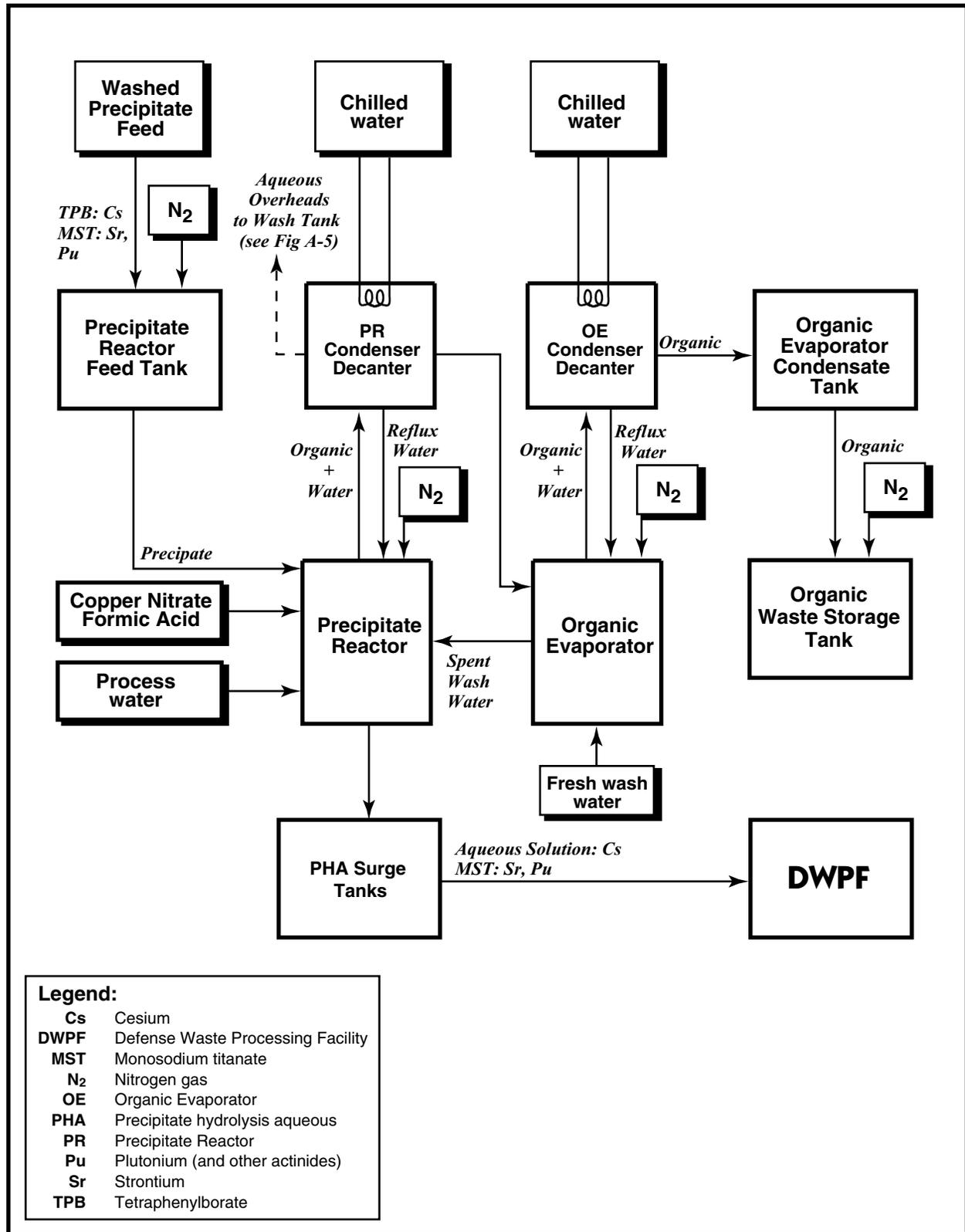
The design basis for the Small Tank Precipitation facility was modified to include the precipitate decomposition operations previously programmed for the DWPF. These operations, to be conducted in a PHC, had been tested during DWPF nonradioactive process runs, but were not employed during radioactive (sludge only) processing because of the unavailability of ITP feed. Major justifications for transferring the PHC operations to the Small Tank Processing facility are as follows:

- **Safety** – Lessons learned in DWPF design would provide PHC equipment with increased safety and control margins. As redesigned, the equipment would operate under slight positive pressure and low purge rates of inert cover gas.
- **Capacity** – Increased throughputs of PHC equipment would provide Small Tank Precipitation processing capacity needed to match required HLW salt removal schedules, with a substantial reduction in life-cycle processing time and significant cost savings.
- **Flexibility** – The vacated cell in the DWPF would become available for other potentially needed operations, including evaporation of DWPF recycle waste streams to conserve Tank Farm space pending startup of salt processing operations.
- **Organic Disposition** – Precipitate Hydrolysis Cell operations in the Small Tank Precipitation facility would confine generation and disposal of flammable organic byproducts to the process facility. This would avoid buildups of high-boiling organics in DWPF process and ventilation systems, and transfer in DWPF recycle streams to the Tank Farm. Lag storage and transfer to DWPF would be provided for the non-flammable aqueous product of the PHC operations, rather than the flammable tetraphenylborate precipitate product.



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Figure A-5. Small Tank Precipitation process flow diagram.



NW SDA EIS/Grfx/A-6 Pre Hydro.at

Figure A-6. Precipitate Hydrolysis Cell flow diagram for Small Tank Precipitation process.

the washed precipitate would be combined with a copper nitrate-formic acid solution in the Precipitate Reactor to catalytically decompose the tetraphenylborate precipitate. The Precipitate Reactor would be heated to boiling and the benzene would be removed as it is formed. The benzene and water vaporized during boiling would be condensed in the Precipitate Reactor Condenser, with aqueous and organic condensates separated by decantation for return to the Precipitate Evaporator and Organic Evaporator, respectively. After a period of reflux boiling, the PHA product would be concentrated by distillation, with the aqueous overheads transferred to the Precipitate Wash Tank.

A second evaporation would be conducted in the PHC to ensure that the separated organic was sufficiently decontaminated for transfer outside the containment area. Wash water would be added to the Organic Evaporator and the boiling, evaporation, and decantation cycle would be repeated, with the twice-distilled benzene collected in the Organic Evaporator Condensate Tank for transfer to the Organic Waste Storage Tank.

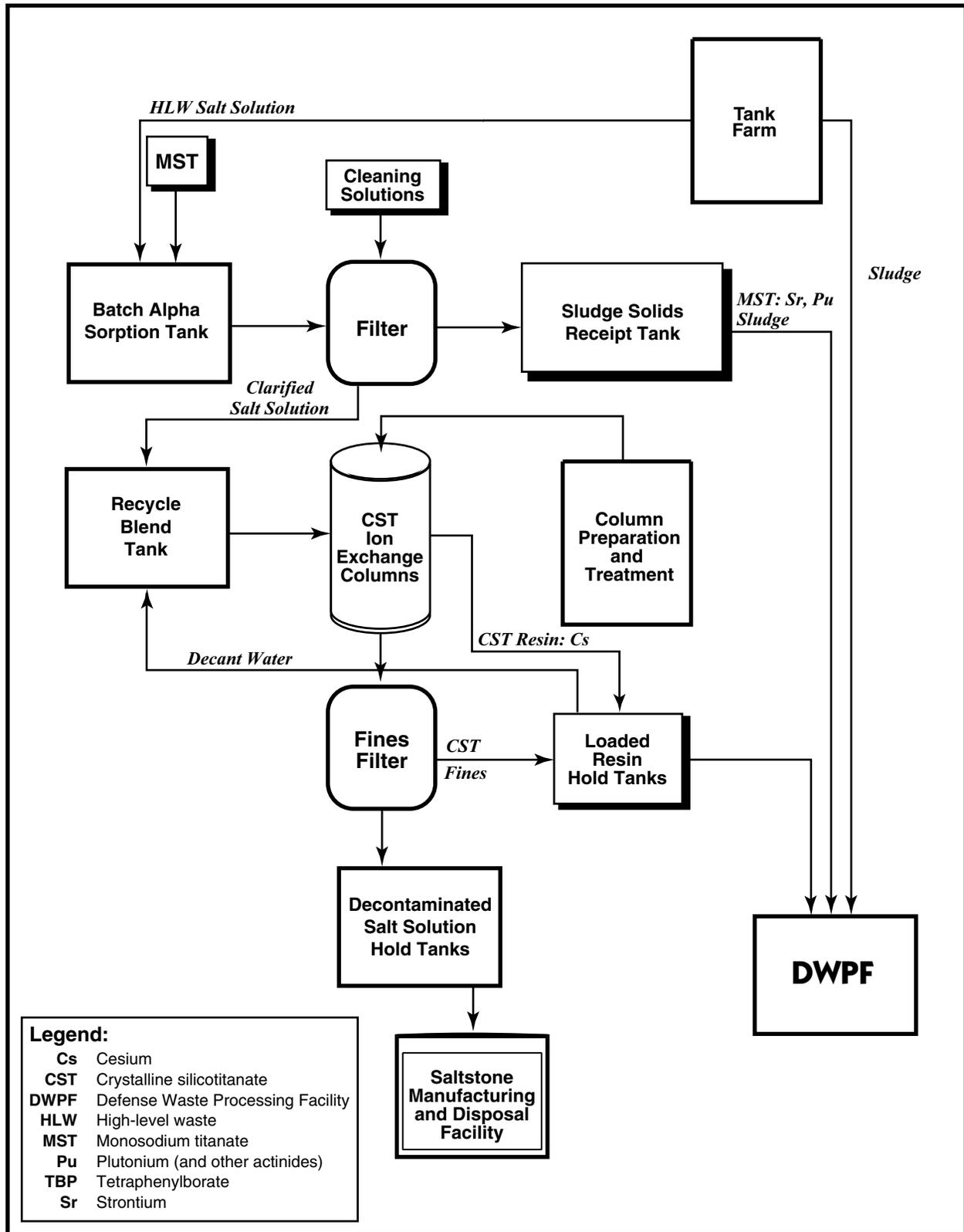
The tetraphenylborate employed in the Small Tank Precipitation process could undergo radiolytic and, under certain conditions, catalytic degradation, producing benzene before the decomposition reactions prescribed in the PHC. The Small Tank Precipitation process would require controlled benzene removal in all steps. Benzene production in the precipitation and washing operations would be limited by the continuous processing of relatively small waste volumes, by a short processing time, and by chilling the process vessels. Accumulation of benzene would be avoided by continuous agitation to prevent retention in the process mixtures and a flowing nitrogen gas blanket to sweep benzene vapors from the system. Benzene formation during precipitate decomposition in the PHC would be controlled by process constraints, with all process vessels purged with nitrogen to maintain oxygen concentrations below combustion limits.

A.4.3.2 Crystalline Silicotitanate Ion Exchange

The Ion Exchange Process (WSRC 1998e,g,h) would employ a crystalline silicotitanate particulate solid (resin) to remove the cesium from the salt solution. In the ion exchange reaction, the radioactive cesium displaces nonradioactive constituents (sodium) of the resin. As in the Small Tank Precipitation process, residual strontium and actinides in the salt solution would be sorbed onto monosodium titanate and, in conjunction with residual sludge, filtered from the salt solution prior to the crystalline silicotitanate ion exchange treatment. The cesium-loaded crystalline silicotitanate resin and the monosodium titanate solids would be transferred to DWPF as slurries to be combined with sludge for incorporation into the glass waste form. Low activity salt solution would be immobilized as saltstone in onsite vaults at the Saltstone Manufacturing and Disposal Facility.

The Ion Exchange process would be performed in a new facility built at Site B in S Area. Process operations are illustrated in the flow diagram in Figure A-7. Salt solution would be pumped from an H-Area tank to the Ion Exchange facility. A new feed line between the existing inter-area transfer line and the Ion Exchange facility would be required for this transfer. In initial feed clarification operations in the batch Alpha Sorption Tank, the salt solution would be mixed with monosodium titanate to sorb soluble strontium and actinides and then filtered by cross-flow filtration to remove monosodium titanate solids and residual sludge. These clarification operations would be necessary to prevent plugging of the ion exchange columns during subsequent processing of the salt solution. The product slurry, washed and concentrated to about 5 weight percent solids, would be pumped through new and existing transfer lines to DWPF as feed for the vitrification process.

After filtration, the clarified salt solution would be transferred to the Recycle Blend Tank in the Ion Exchange facility for dilution with process



NW SDA EIS/Grfx/A-7 CST Ion Flow.ai

Figure A-7. Ion Exchange process flow diagram.

water, and pumped through a series of four ion exchange columns to remove radioactive cesium. Cesium transfer from the salt solution would take place in the first three columns, with the fourth column in reserve for use when the first column in the series reached saturation (> 90 percent maximum capacity) and was taken out of service. Saturated resin in the column would be flushed with water and pumped as slurry to DWPF. The first ion exchange column would then be replenished with fresh resin and held in reserve (as the fourth column) while cesium ion exchange took place in what had been the second, third, and fourth columns. The cycle would continue with the lead column reaching saturation and the reserve column becoming the last in the series of three operating columns. Low activity salt solution recovered as effluent from the third column would be filtered to prevent any cesium-loaded fine particles from recontaminating the salt solution. The low activity salt solution would be sampled in a Product Holdup Tank prior to transfer to the Decontaminated Salt Solution Hold Tanks, to ensure that requirements for disposal as saltstone were met. The low activity salt solution would be transferred to the Saltstone Manufacturing and Disposal Facility for disposal in onsite vaults. All process wastewater would be recycled and re-used.

The Ion Exchange process would result in the accumulation of as much as 15 million curies of cesium within the processing cell. This radioactive loading would necessitate stringent shielding requirements and operational controls because of the generation of hydrogen and other gases.

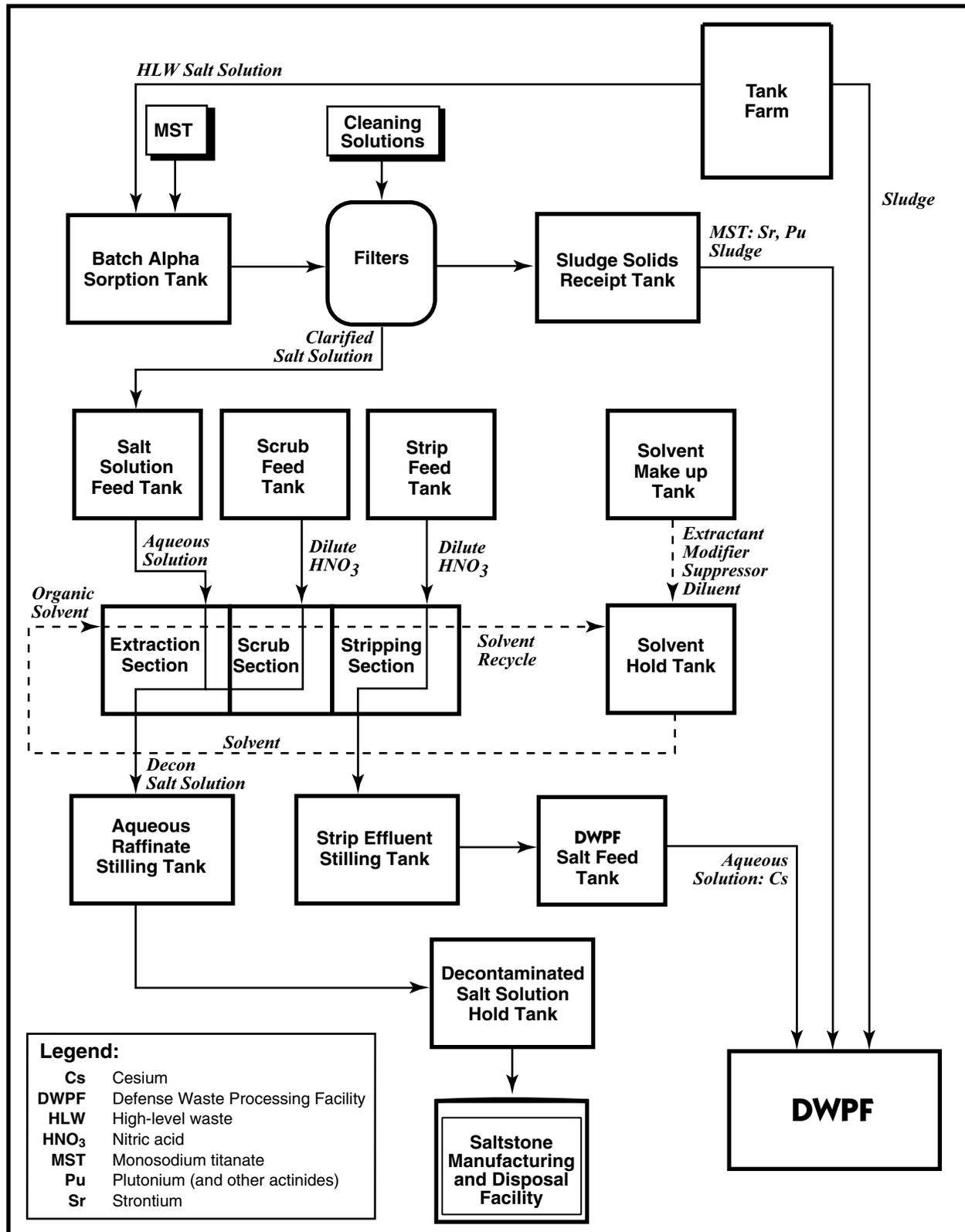
A.4.3.3 Caustic Side Solvent Extraction

In the Solvent Extraction process (WSRC 1999b,c), radioactive cesium would be separated from the caustic HLW salt solution by extracting it from the aqueous phase into an insoluble organic phase, thereby generating a low activity salt solution for immobilization in saltstone. The separated cesium, recovered from the organic phase by back extraction (stripping) into an acidic aqueous solution, would be transferred to DWPF for incorporation, along with HLW

sludge, into the glass waste form. Processing of the HLW salt solution by monosodium titanate to remove soluble strontium and actinides, followed by filtration of monosodium titanate solids and residual sludge, before the solvent extraction process would be necessary to meet saltstone acceptance limits and avoid interference of residual solids in the solvent extraction process.

The organic phase into which the cesium would be extracted is a kerosene-like solvent (diluent) containing an organic extractant (termed BoB-CalixC6) and a diluent modifier (typically Cs-7SBT). The extractant is highly specific for cesium, permitting separation from sodium by a factor of 10^4 (10,000) and from potassium by a factor of 10^2 (100). The diluent modifier increases the cesium extraction capability by increasing extractant solubility in the diluent. The subsequent stripping of separated cesium back into an aqueous solution is promoted by addition of a suppressor constituent, typically trioctylamine (TOA), to the organic phase. The TOA also mitigates the deleterious effects of impurities in the aqueous solution. Chemical structures and concentrations of the additions to the diluent organic phase are specified in the text box on page A-18.

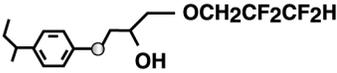
The Solvent Extraction process would be performed in a new facility at Site B in S Area. Process operations are represented by the flow diagram in Figure A-8. In operations similar to that for the Ion Exchange process, initial clarification of the salt solution in the Batch Alpha Sorption Tank would remove strontium and actinides by sorption onto monosodium titanate, followed by filtration of the monosodium titanate solids and any residual sludge, for transfer to DWPF. The separation of radioactive cesium from the salt solution by solvent extraction would take place in a multi-stage countercurrent extraction facility. The facility consists typically of an assembly of centrifugal two-phase contactors for extraction of cesium into the organic phase, scrub contactors for removing non-cesium salt constituents from the organic phase, and strip contactors for back extraction of the cesium into an acidic aqueous stream. The design and operation of the centrifugal contactors is shown in the text box on page A-19.



P:/Government/NW SDA EIS/Grfx_NW_SDAEIS/A-8 CS Flow.ai

Figure A-8. Solvent Extraction process flow diagram.

Components of Organic Phase used in Solvent Extraction Process

Chemical Type	Concentration in Solvent	Function
Diluent Blend of alkane hydrocarbons "Isopar [®] L"	Principal component	Organic phase solvent
Cesium Extractant (with complexed Cs)	0.01 M	Highly specific Cs extraction into organic phase from caustic aqueous solution
 Calix[4]arene-bis(<i>tert</i> -octylbenzo-crown-6) "BoBCalixC6"		
Diluent Modifier	0.5 M	Increases extractant strength for Cs, prevents precipitation and third phase formation
 Aromatic fluoroalcohol "Cs-7SBT"		
Suppressor $N(C_8H_{17})_3$ Trioctylamine "TOA"	0.001 M	Promotes back extraction of Cs from organic to aqueous phase during stripping operation

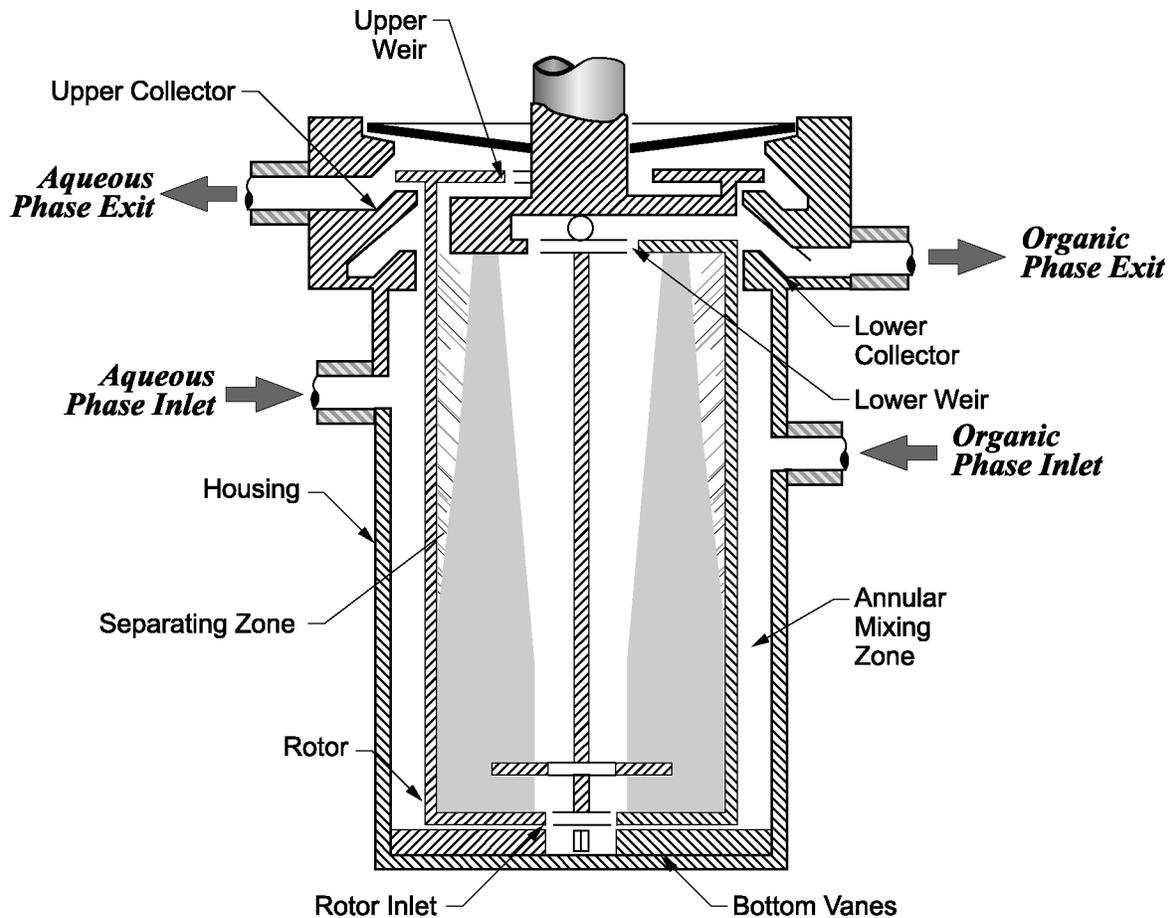
NW SDA EIS/Grfx/App A/Comp organic.ai

The cesium-containing caustic salt solution injected into the contactor assembly at the head end of the extraction section (between extraction and scrub sections) would be progressively depleted of cesium as the aqueous phase moves through the extraction contactors, and would emerge at the back end of the extraction section as a salt solution with very low cesium content. The organic phase (solvent), injected at the back end of the extraction section for countercurrent movement through the contactors, would be progressively concentrated with cesium, scrubbed to remove other salt constituents, then stripped of cesium by contact with a dilute acid aqueous stream. The strip effluent would emerge from the back end of the stripping section as a high-cesium-containing aqueous solu-

tion. The organic solvent recovered from the stripping operation would be washed with dilute acid and caustic to remove degradation products, and recycled through the extraction process, with losses made up by replacement. Occasional purging of degraded solvent during washing would generate a low-volume organic waste stream that would be stored for appropriate disposal.

Following solvent extraction separations, both decontaminated salt (raffinate) and concentrated cesium solutions (strip effluent) would be processed through stilling tanks, to float and decant entrained organic (mostly diluent) before transferring the solutions to final disposition. The decontaminated raffinate solution would be

Centrifugal Contactor Design and Operation



The separation of radioactive cesium from a high-level waste salt solution by solvent extraction utilizes countercurrent centrifugal contactors to provide high surface area interaction between the organic solvent and aqueous solution. These contactors consist of a rapidly rotating inner chamber (rotor) contained within a stationary housing, allowing mixing of organic and aqueous phases as an emulsion in the outer chamber, followed by centrifugal separation of the lesser density organic phase from the greater density aqueous phase in the rotor. The organic and aqueous phases are injected into the housing for transport through an annular mixing zone to an inlet at the bottom of the rotor. Centrifugal separation of the two phases occurs in the rotor as the emulsion flows upward, collected at the top as aqueous phase from the outer circumference and as organic phase from the center of the rotor. For extraction cycles, the cesium is transferred from the caustic aqueous phase to the organic phase and for stripping cycles it is transferred from the organic phase to an acidic aqueous phase during contactor operation.

NW SDA EIS/Grfx/App A/Centrifugal.ai

consigned to a hold tank for processing to saltstone and the strip effluent solution, assuming no concentration by evaporation, would be transferred to a hold tank for vitrification in DWPF. The wash solutions from the organic solvent cleanup would be processed to saltstone.

A.4.3.4 Direct Disposal in Grout

In the Direct Disposal (of cesium) in Grout alternative (WSRC 1998e), the HLW salt solution would be immobilized in saltstone vaults without separation of the radioactive cesium. The saltstone produced would meet acceptance criteria for near-surface disposal of low-level radioactive Class C waste (as defined in 10 CFR 61.55), but would exceed limits for Class A wastes. Treatment of the salt solution to remove strontium and actinides, as well as residual sludge, would still be required to meet restrictions on alpha-emitting radionuclides and HLW constituents in the saltstone.

If saltstone waste containing radioactive cesium was disposed in Z-Area vaults, revision of the existing SCDHEC permit for saltstone disposal would be required. The current SCDHEC permit restricts saltstone vault disposal to wastes containing radioactive constituents within Class A limits, although wastes with higher radionuclide content would be allowed if shown to not produce unacceptable radiation exposure to the public, onsite workers, and inadvertent intruders. A performance assessment to demonstrate acceptability of the high-radioactivity cesium grout in the vaults would be required for the Direct Disposal in Grout alternative.

For the Direct Disposal in Grout alternative, a new facility would be constructed in Z Area, using grout production equipment modified to provide radiation shielding and enable remote operation and maintenance, because of the anticipated radioactive cesium concentrations. Direct Disposal in Grout process operations are illustrated in the flow diagram in Figure A-9. The salt solution would be collected in an H-Area tank and pumped to the Direct Disposal in Grout facility through a new Low Point Drain Tank (LPDT) facility, using the existing inter-area line. The new LPDT would be required to

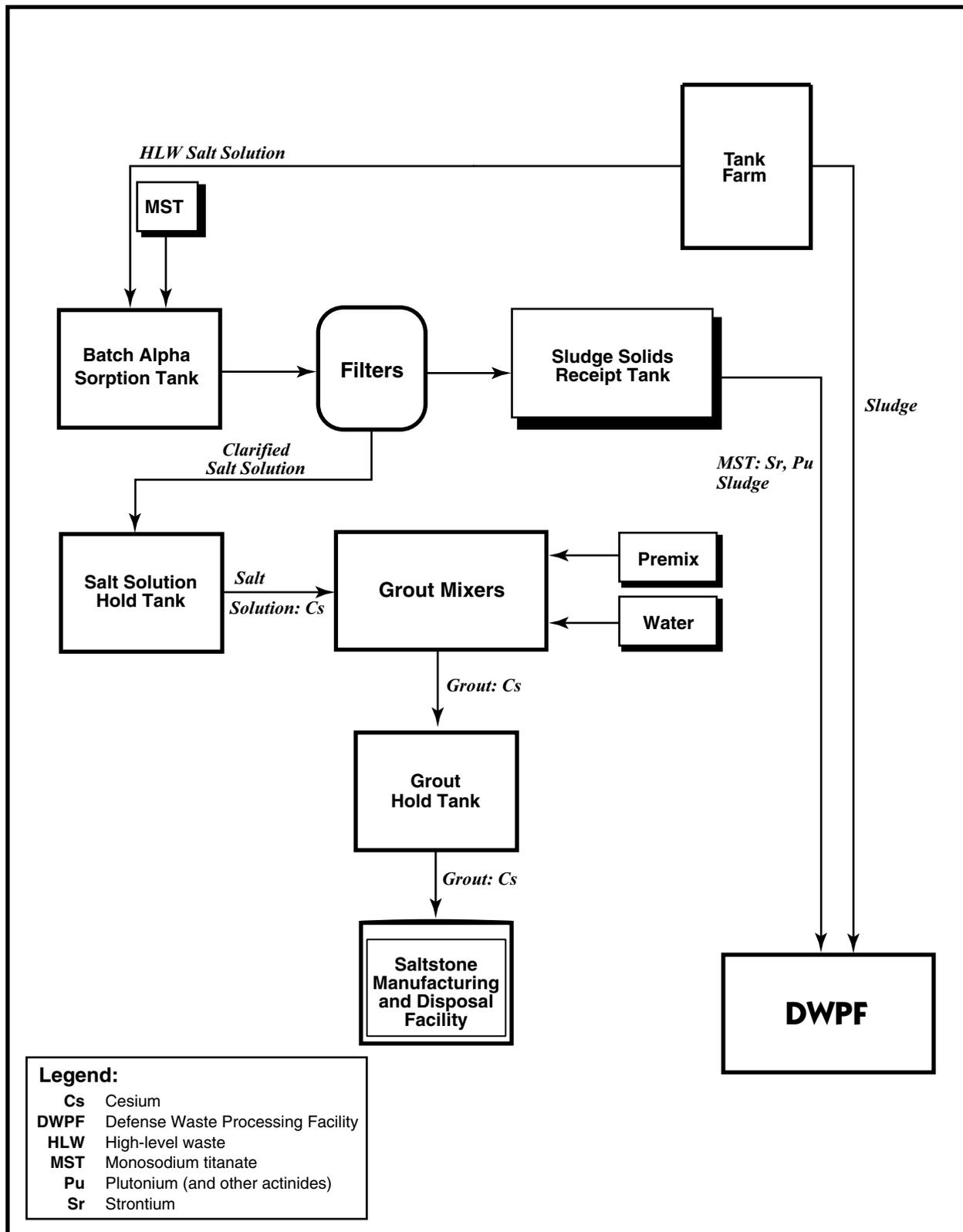
provide adequate shielding for the higher radioactivity in the waste stream than is present in the current feed.

In the new Direct Disposal in Grout facility, salt solution would be fed into a large Batch Alpha Sorption Tank for treatment with monosodium titanate to remove soluble radioactive contaminants other than cesium (strontium and actinides). The monosodium titanate and entrained sludge solids would be separated from the salt solution by cross-flow filtration and washed. The washed solids, collected as slurry in the Sludge Solids Receipt Tank, would be pumped through new and existing transfer lines to the DWPF melter for conversion into the glass waste form. This would be the only Direct Disposal in Grout waste stream incorporated into the DWPF waste glass production operation.

The clarified salt solution resulting from monosodium titanate treatment in the Direct Disposal in Grout facility would be transferred to a Salt Solution Hold Tank to be processed to saltstone.

During saltstone processing, the filtered salt solution would be pumped to a mixer and combined with flyash, cement, and slag to form a batch of grout for disposal in the saltstone vaults. The grout mixture would be pumped to a Grout Hold Tank serving as the feed tank for the Grout Feed Pumps transferring the grout to the saltstone vaults. Thirteen additional vaults would be constructed in Z Area to accommodate Direct Disposal in Grout processing. After each batch of grout was processed and transferred to a vault, the grout transfer lines, Grout Hold Tank, and Grout Feed Pumps would be flushed to remove any residual material for recycle through the process. Direct Disposal in Grout would generate no secondary waste streams.

Chemical composition of the saltstone from the Direct Disposal in Grout process is compared with that from Small Tank Precipitation, Ion Exchange, and Solvent Extraction processes in Table A-1. Expected concentrations of major radionuclides in the saltstone are shown in Table A-2. The values are from an earlier characterization of saltstone, produced during ITP processing of HLW salt solutions (Martin



NW SDA EIS/Grfx/A-9 Dir Disp Flow.ai

Figure A-9. Direct Disposal in Grout process flow diagram.

Table A-1. Chemical composition of saltstone for salt processing alternatives.

Component	Composition, weight percent ^a			
	Small Tank Tetraphenylborate Precipitation	Crystalline Silicotitanate Ion Exchange	Caustic Side Solvent Extraction	Direct Disposal in Grout
H ₂ O	33.70	32.88	34.03	32.57
NaNO ₃	6.60	7.60	6.20	8.00
NaOH	1.90	2.20	1.80	2.40
NaNO ₂	1.60	1.90	1.50	2.00
NaAl (OH) ₄	1.20	1.40	0.94	1.40
NaCO ₃	0.65	0.75	0.61	0.79
Na ₂ SO ₄	0.65	0.75	0.61	0.79
Na ₂ C ₂ O ₄	0.07	0.08	0.07	0.09
NaCl	0.05	0.05	0.05	0.06
Na ₃ PO ₄	0.05	0.05	0.05	0.06
Na ₂ SiO ₃	0.03	0.03	0.03	0.03
NH ₄ NO ₃	0.03	0.04	0.03	0.04
NaB (C ₆ H ₅) ₄	0.03	-	-	-
Na ₂ CrO ₄	0.02	0.02	0.02	0.02
NaF	0.02	0.03	0.02	0.03
CaSO ₄	0.02	0.02	0.02	0.02
NaHgO (OH)	(b)	(b)	(b)	(b)
KNO ₃	(b)	(b)	(b)	(b)
Salt Solution Total	46.61	47.80	45.98	48.30
Dry Blend ^c	53.39	52.20	54.02	51.70
Total	100	100	100	100

- a. The values presented are taken from a previous characterization of saltstone produced during ITP processing of HLW Salt Solution (Martin Marietta 1992), adjusted for dilution in the new salt processing alternatives using sodium concentrations of 4.58 molar for Small Tank Precipitation, 5.31 molar for Ion Exchange, 4.30 molar for Solvent Extraction, and 5.63 molar for Direct Disposal in Grout processing, compared to 4.58 molar for ITP processing.
- b. Expected present; concentration less than 0.01 weight percent.
- c. Dry Blend is cement, flyash, and slag.

Marietta 1992) and adjusted for dilution by the new salt processing alternatives, based on the sodium concentrations of the saltstone feed streams.

A.4.3.5 Process Inputs and Product Streams

A general objective of the salt processing operations is the disposition of about 80 million gallons of HLW salt solution. The capacity throughputs of the process facilities are specified to maintain a long-term average drawdown of salt solution by about 6 million gallons per year, allowing completion of processing of reconstituted salt solution within about 13 years after facility startup. Processing within this time period is necessary to integrate the high-

radioactivity salt waste components into the DWPF vitrification operations for processing with radioactive sludge components of the waste. (See key milestones textbox in Chapter 2).

Process throughput streams for the salt processing alternatives are compared in Table A-3.

The capacity throughputs are somewhat higher than the required long-term average throughputs for Small Tank Precipitation, Ion Exchange, and Solvent Extraction facilities to allow for DWPF outages during melter changeout. The Direct Disposal in Grout facility, not closely coupled to DWPF operation, can operate at capacity throughput equal to the required long-term average throughput (6 million gallons per year).

Table A-2. Radionuclide content of saltstone for salt processing alternatives.

Radionuclide	Concentration (nCi/g)			
	Small Tank Precipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Technetium-99	33	38	31	40
Ruthenium-106+d ^a	17	20	16	21
Cesium-137+d ^a	10	12	9	254,000 ^b
Tritium	10	12	9	12
Antimony-125	3.3	3.8	3.1	4.0
Promethium-147	2.0	2.3	1.9	2.4
Samarium-151	1.0	1.2	0.95	1.2
Strontium-90+d ^a	0.35	0.40	0.33	0.42
Europium-154	0.33	0.38	0.31	0.40
Selenium-79	0.16	0.19	0.15	0.20
Europium-155	0.16	0.19	0.15	0.20
Cobalt-60	0.11	0.12	0.10	0.13
Tellurium-125m	0.10	0.12	0.09	0.12
Tin-126+d ^a	0.07	0.08	0.07	0.08
Cesium-134	0.03	0.04	0.03	440
Tin-121m	0.01	0.02	0.01	0.02
Iodine-129	0.01	0.01	0.01	0.01
Nickel-63	0.01	0.01	0.01	0.01
Antimony-126	0.01	0.01	0.01	0.01
Carbon-14	0.003	0.004	0.003	0.004
Cesium-135	0.00002	0.00002	0.00003	0.26
Other beta gamma	3.3	3.8	3.1	4.0
Plutonium-238	0.03	0.03	0.03	0.03
Plutonium-241	0.02	0.02	0.02	0.02
Americium-241	0.07	0.08	0.07	0.08

nCi/g = nanocuries per gram.

a. +d = with daughter product.

b. Cesium-137+d content of the saltstone for Direct Disposal in Grout alternative corresponds to 225 Ci/m³ of cesium-137 (WSRC 1998b,i).

Table A-3. Salt solution processed.

Alternative	Capacity throughput (million gallons per year)	Long-term average throughput (million gallons per year)	Throughput limitation
Small Tank Precipitation	6.9	6.0	Salt removal rate from waste tanks
Ion Exchange	6.9	6.0	Salt removal rate from waste tanks
Solvent Extraction	6.9	6.0	Salt removal rate from waste tanks
Direct Disposal in Grout	6.0	6.0	Salt removal rate from waste tanks

Source: WSRC (1998d).

The product outputs of the process facilities, including high-radioactivity solids slurry or solution to DWPF, processed salt solution to grout, and saltstone generated by the salt processing alternatives, are compared in Table A-4. The Solvent Extraction process would deliver a greater volume of product to DWPF than the other alternative processes because of the high volume of cesium solution (strip effluent) in the product output of that process. Salt solutions to grout and saltstone produced would be about the same for each alternative, with the ratio of saltstone volume produced to salt solution volume uniform at about 1.8.

In addition to the principal product outputs specified in Table A-4, the Small Tank Precipitation process would generate by-product benzene. About 60,000 gallons (20 metric tons) of liquid benzene would be produced annually by decomposition of the tetraphenylborate salt in the process facilities.

In the Small Tank Precipitation process, gaseous benzene would also be generated in the process facilities, to be dispersed into the atmosphere. Issues associated with gaseous benzene generation have resulted in a number of design features that would reduce or mitigate this problem. Controlled benzene removal, because of flammability concerns, would be accomplished by operating the process vessels with a nitrogen atmosphere. The tank vent systems would be equipped with both primary and backup nitrogen purge systems (WSRC 1998c). The Ion Exchange, Solvent Extraction, and Direct Disposal in Grout processes do not have the same benzene concerns. Rather, the issue for these alternatives is radiolytic decomposition of water into hydrogen and oxygen. Air sweeps of tanks are generally considered sufficient to eliminate the danger of explosions (WSRC 1998g). However, since the consequences of an explosion are unacceptable, due to the high radioactive loading

Table A-4. Product outputs.

Alternative	Annual			Life cycle		
	Solids slurry (and solution) to DWPF (gallons per year)	Salt solution to Grout (million gallons per year)	Grout produced (million gallons per year)	Solids slurry (and solution) to DWPF (million gallons)	Salt solution to Grout (million gallons)	Grout produced (million gallons)
Small Tank Precipitation (13 years) ^a	223,000	8.0	14.5	2.9	104	188
Ion Exchange (13 years) ^b	200,000	6.6	12.0	2.6 ^f	86	156
Solvent Extraction (13 years) ^c	677,000 ^e	7.5	13.5	8.8 ^c	97	175
Direct Disposal in Grout (13 years) ^d	154,000	5.9	10.8	2.0	77	141

a. WSRC (1998j; 2000b).

b. WSRC (1998k).

c. WSRC (1998l; 2000b).

d. WSRC (1998i).

e. Includes 154,000 gal/yr solids slurry and 523,000 gal/yr solution (strip effluent without evaporation) (WSRC 1998e).

f. Includes 2 million gallons monosodium titanate slurry and 600,000 gallons Crystalline Silicotitanate slurry (WSRC 1998e,k).

Note: Material balance estimates are ± 25 percent.

Comparison of Significant Radionuclide Concentrations in Saltstone from Direct Disposal in Grout Process with Limits for Low-Level Waste Disposal Categories (10 CFR 61.55)				
Radionuclide	Concentration in Saltstone (Ci/m ³)	Concentration Limit (Ci/m ³)		
		Class A	Class B	Class C
<u>Long-Lived Activities</u>				
Technetium-99	0.07	0.6	0.6	6.0
Iodine-129	0.00002	0.002	-	0.02
Total alpha	0.0002	0.03	0.03	0.3
<u>Short-Lived Activities</u>				
Tritium	0.02	80	(a)	(a)
Strontium-90	0.0004	0.04	150	7,000
Cesium-137	225	1	44	4,600

a. No limit.
 Ci/m³ = curies per cubic meter.

within the process tanks, the design for Ion Exchange, Solvent Extraction, and Direct Disposal in Grout facilities would include both primary and backup purge systems, comparable to those used in the Small Tank Precipitation facility.

The Solvent Extraction process would also generate a liquid organic waste requiring final disposition (WSRC 2000c). The total solvent inventory for the process, consisting primarily of the diluent Isopar[®]L, is projected to be 1,000 gallons. This inventory is conservatively assumed to be replaced once per year. For an operational time of 13 years, the accumulated total volume of solvent requiring disposition would be 13,000 gallons. Onsite or offsite disposal of this solvent is projected.

A.5 Process Facilities

A.5.1 PROCESS BUILDINGS

New shielded process buildings (WSRC 1998e,m) would be constructed for each salt processing alternative. The process buildings for the Small Tank Precipitation, Ion Exchange, and Solvent Extraction alternatives would be at Site B in S Area and for the Direct Disposal in Grout alternative, they would be in Z Area.

In each case, the process buildings would be constructed of reinforced concrete and include

the shielding required for handling highly radioactive materials. The facilities would be sized to contain large feed, storage, and product hold tanks to ensure an average processing rate of 25,000 gallons per day of salt solution. The size of the tanks would also serve to decouple or buffer the continuous flows of the Small Tank Precipitation, Ion Exchange, and Solvent Extraction processes from the batch flows of the tank farms, and ensure the capability to process the expected average 6 million gallons-per-year of salt solution.

The building specifications would be similar for each of the four salt processing alternatives. Preliminary design dimensions are provided in Table A-5. The buildings would range from 64 to 71 feet above ground level, with crane maintenance bays up to 106 feet high. They would extend down to as much as 45 feet below ground level, allowing shielded, remotely operated, chemical processing cells to be located partially below grade. Site requirements for each alternative process facility are presented in Table A-6.

Adjacent operating areas above grade would extend around the perimeter of the processing cells and contain chemical feed pumps and tanks, radioactive and non-radioactive laboratories for sample testing, electrical and mechanical

Table A-5. Building specifications for each action alternative.

	Process Alternative ^a			
	Small Tank Pre- cipitation	Ion Exchange	Solvent Extraction	Direct Disposal in Grout
Length, ft.	310	280	300	220
Width, ft.	140	140	120	120
Height, ft.	60 (100 ft. bay)	60 (100 ft. bay)	70 (110 ft. bay)	60 (90 ft. bay)
Depth below grade, ft.	40	40	40	20
Floor Area, ft. ²				
including processing cells	66,000	60,000	62,000	54,000
excluding processing cells	50,000	48,000	48,000	43,000
Volume, ft. ³				
including processing cells	4,500,000	4,200,000	4,500,000	1,800,000
excluding processing cells	4,500,000	3,600,000	3,900,000	1,200,000
Processing cell floor area, ft. ²	16,000	12,000	13,000	11,000
Processing cell volume, ft. ³	640,000	550,000	600,000	570,000

Source: WSRC (1998i).

a. Building specifications rounded to two significant figures.

Table A-6. Site requirements for the process building and required support facilities.

Small Tank Precipitation, Ion Exchange, and Solvent Extraction Alternatives	Direct Disposal in Grout Alternative
Clear 23 acres in S Area	Clear 15 acres in Z Area
Construct 5,000 linear feet of access roads	Same
Construct 1,000 linear feet of site roads	Same
Construct a paved parking area for 200 cars (40,000 square feet)	Same
Construct a storm sewer system	Same
Construct site security fence with two vehicle gates	Same
Construct a security fence around the substation	Same
Construct 2,500 feet of sewer line to tie into the existing sewer system	Same
Construct 3,000 feet of water line to tie into the existing potable water system	Construct 2,000 feet of water line
Construct 7,500 feet of power line	Construct 700 feet of power line
Construct a 13.8-kV to 480-V switchyard	Same
Install yard piping for water and sewer distribution systems	Same
Install electrical ductbank distribution system	Same
Install security lighting	Same

Source: WSRC (1998m).

equipment areas, and a truck unloading area. Shielded maintenance areas would be provided for remote equipment laydown, equipment decontamination, and crane maintenance. Figure A-10 presents the floor plan for the Small Tank Precipitation facility, and Figure A-11 presents the elevation for the facility. Figures A-12 and A-13 present the corresponding plans for the Ion Exchange facility, Figures A-14 and A-15 for the Solvent Extraction facility, and Figures A-16 and A-17 for the Direct Disposal in Grout facility.

The process cells would contain equipment required for the respective process alternatives. These include precipitate and sorption reactor tanks; chemical storage, feed, and product hold tanks with associated transfer and sample pumps; pass-through filter assemblages; and grout mixers and transfer equipment. In the case of the Ion Exchange alternative, the ion exchange columns for cesium removal would also be housed in the process cells. In the case of the Solvent Extraction alternative, the centrifugal contactors would be housed in the process cells.

Sumps with leak detection and collection capability would be provided in the cells. The cells would be protected by concrete cell covers and accessible by a remotely-operated crane. The building configurations would allow crane or manipulator access to all shielded process, maintenance, and sampling areas. The cell components would be designed for remote maintenance, replacement, and later decommissioning.

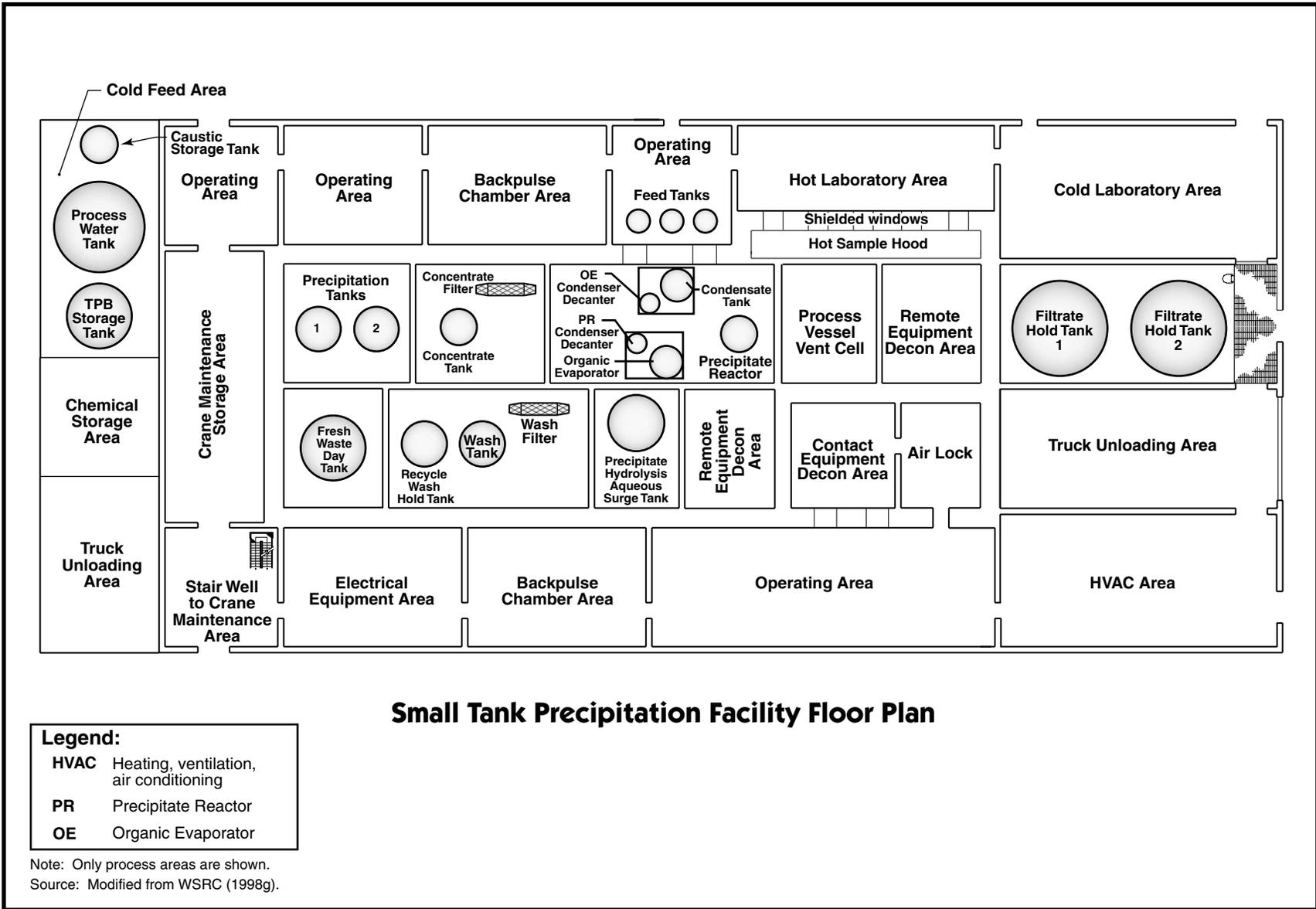
Safety features for each salt processing alternative incorporated into facility design would include:

- Systems to detect leaks in processing piping and vessels
- Structurally strengthened process buildings and process cells to protect process vessels and equipment in case of seismic or other natural phenomena hazard events

- Process vessel vent or purge systems
- Systems to cover process vessels with inert gases, to prevent catastrophic fires
- Leak detection systems and engineered safety features, designed to automatically stop the process before material is released to the environment, if a leak is detected
- Primary confinement of process piping and vessels that could withstand natural phenomena hazard events
- Secondary confinement systems, including ventilation systems, designed to prevent or mitigate unscheduled events and to continue operating, even in the event of a loss of power
- Seismically-qualified equipment, including vessels and piping
- Remote operations
- Adequate shielding
- Temperature monitoring systems to alert operators to any loss of cooling for the Small Tank Precipitation, Ion Exchange, or Solvent Extraction processes
- Radiation and airborne contamination monitors.

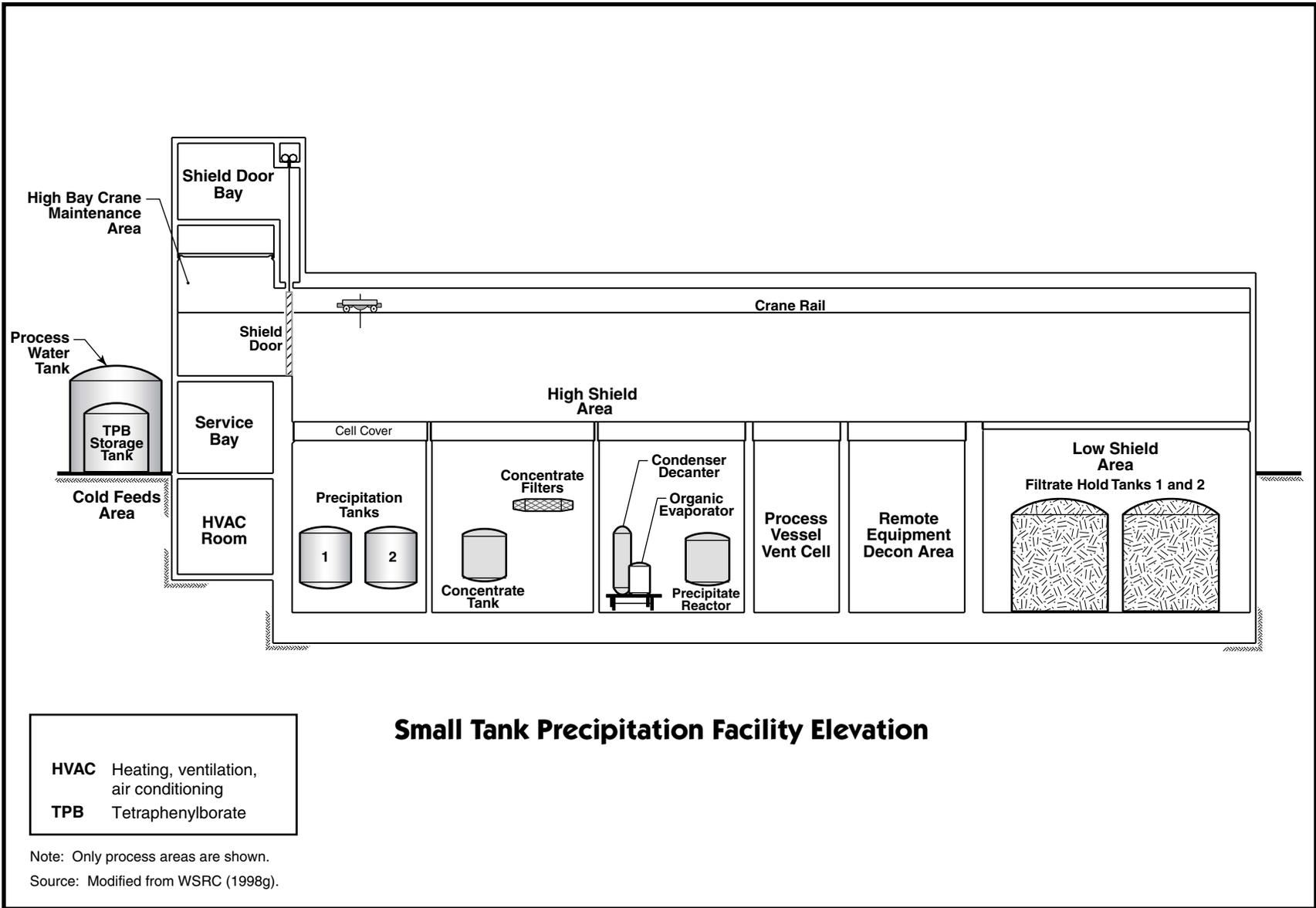
A.5.2 TANK REQUIREMENTS

The types and sizes of process and storage tanks and vessels needed for facility operations would depend on the salt processing alternative utilized. Summary listings of the tanks required for the Small Tank Precipitation, Ion Exchange, Solvent Extraction, and Direct Disposal in Grout processes are given in Tables A-7, A-8, A-9, and A-10, respectively (WSRC 2000d). The characteristics of these tanks form the basis for development of accident scenarios and consequences projected in Appendix B.



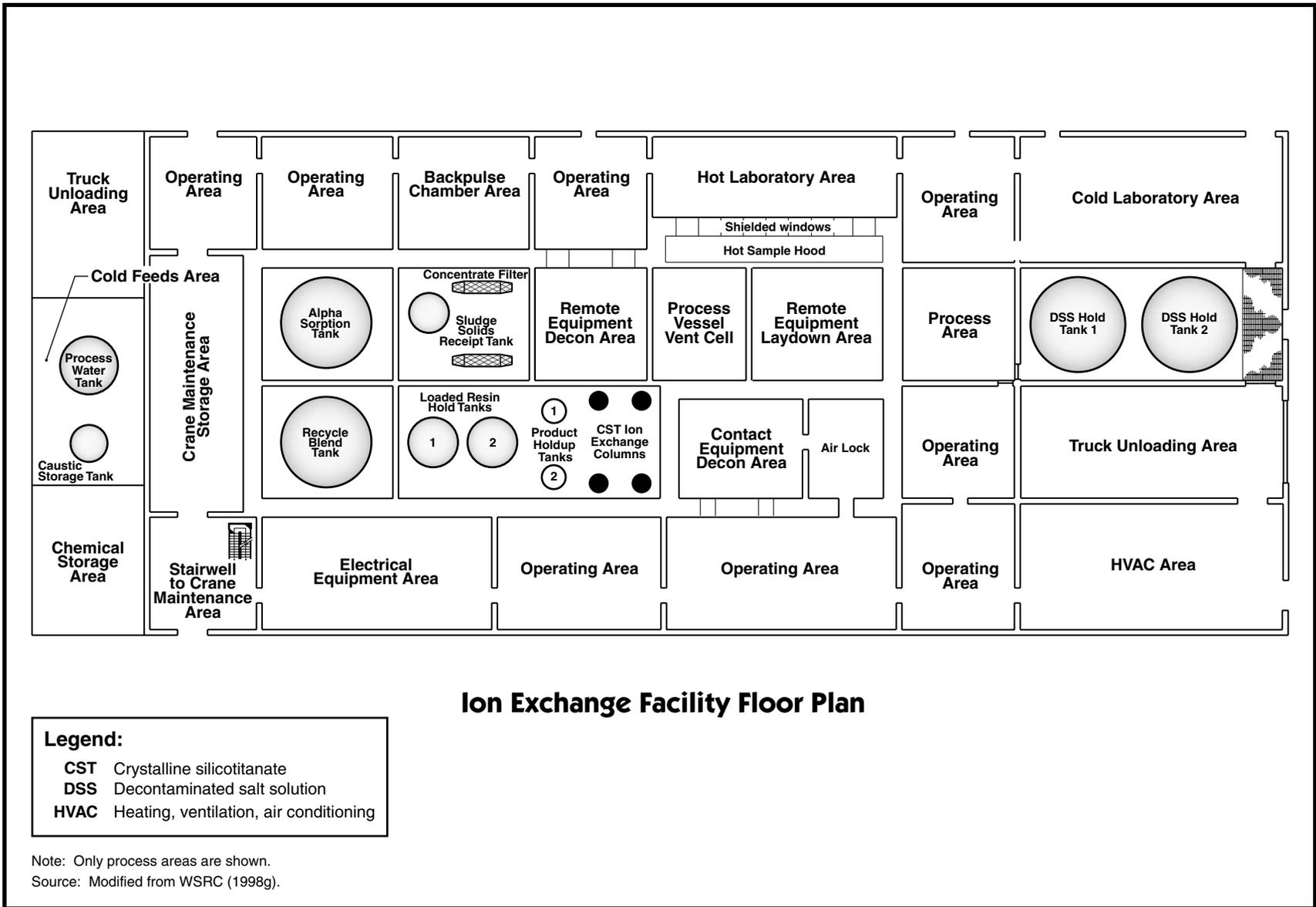
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Figure A-10. Floor plan for Small Tank Precipitation facility.



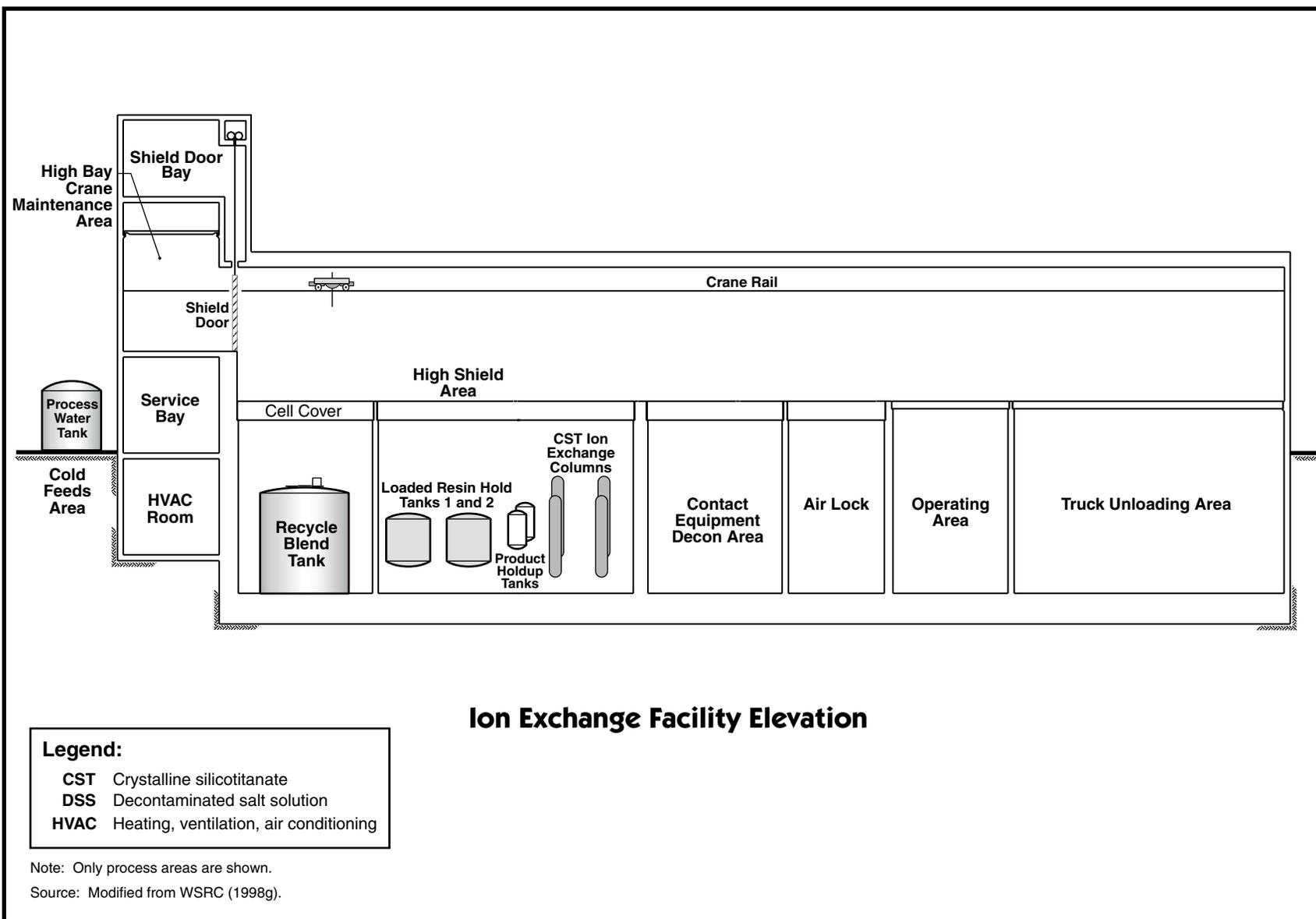
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Figure A-11. Elevation Plan for Small Tank Precipitation facility.



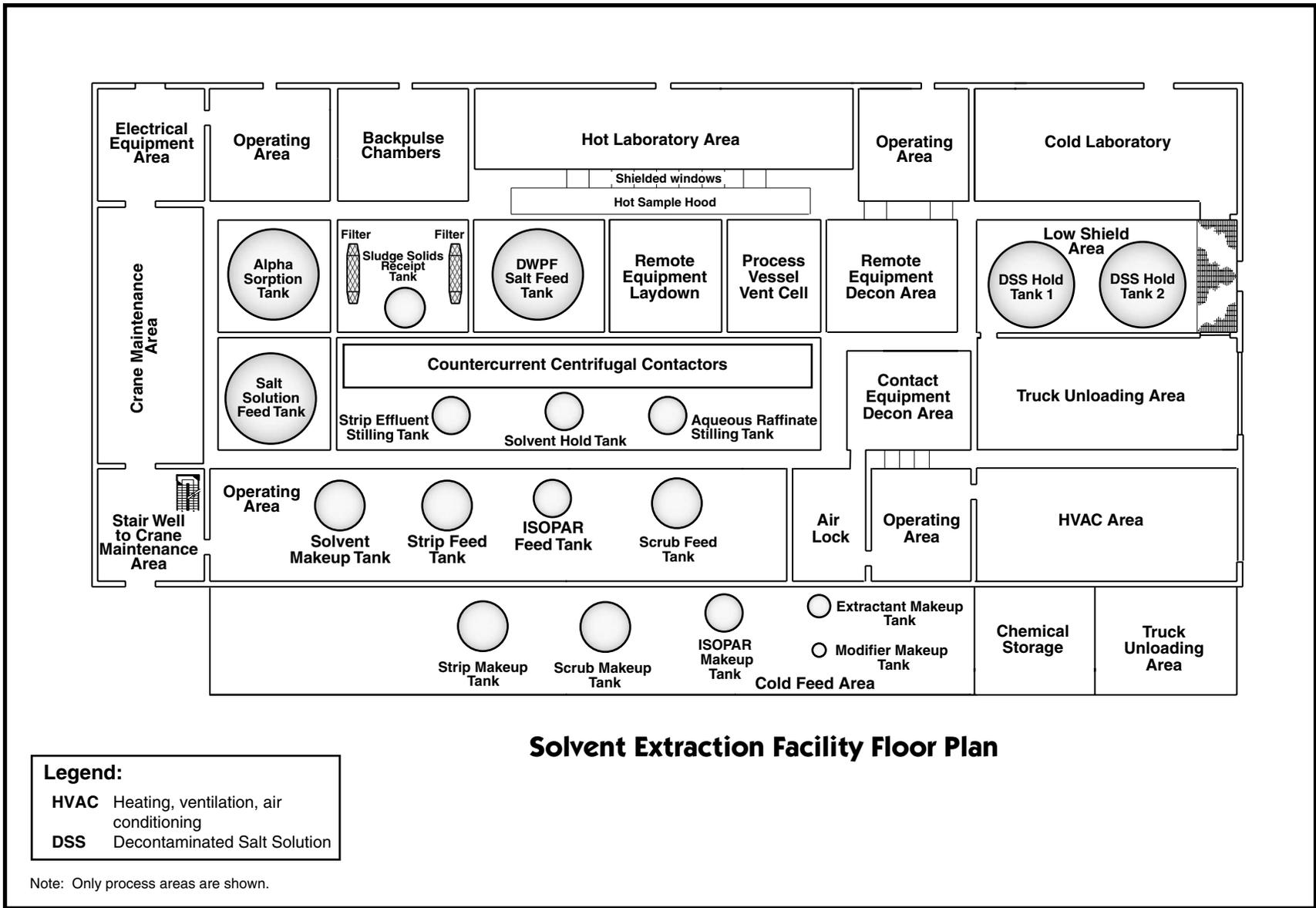
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Figure A-12. Floor plan for Ion Exchange facility.



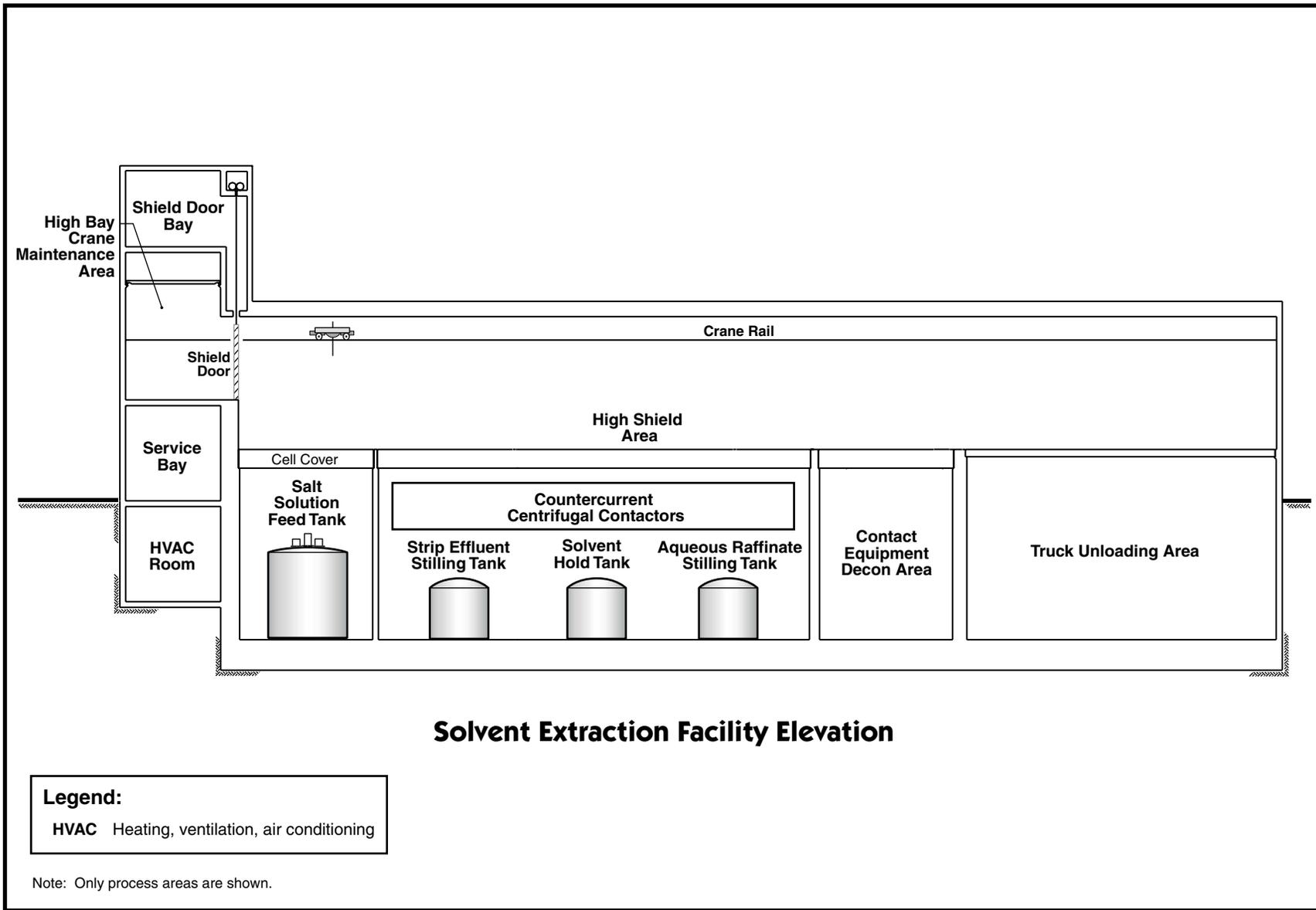
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Figure A-13. Elevation plan for Ion Exchange facility.



Solvent Extraction Facility Floor Plan

Figure A-14. Floor plan for Solvent Extraction facility.



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Figure A-15. Elevation plan for Solvent Extraction facility.

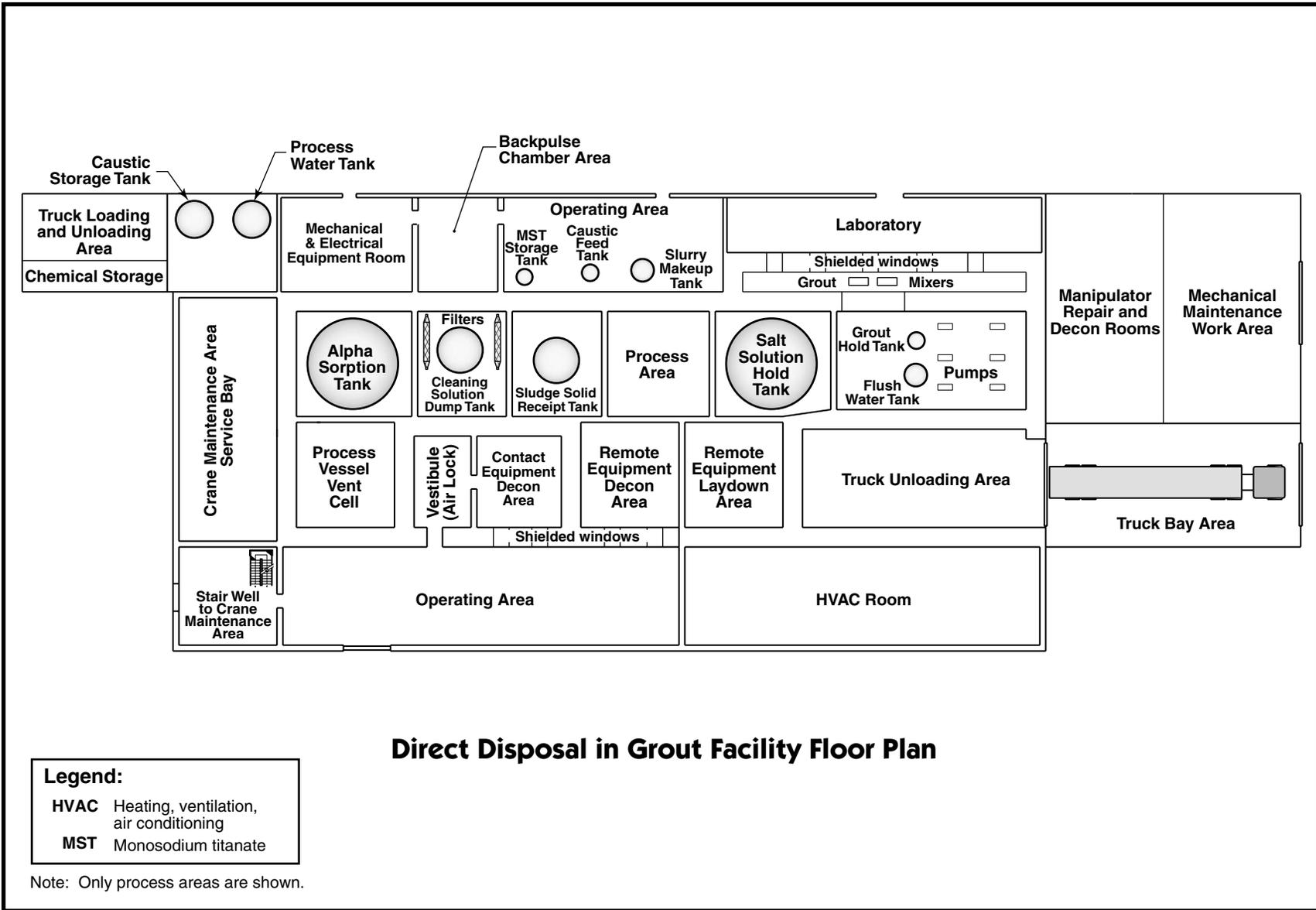
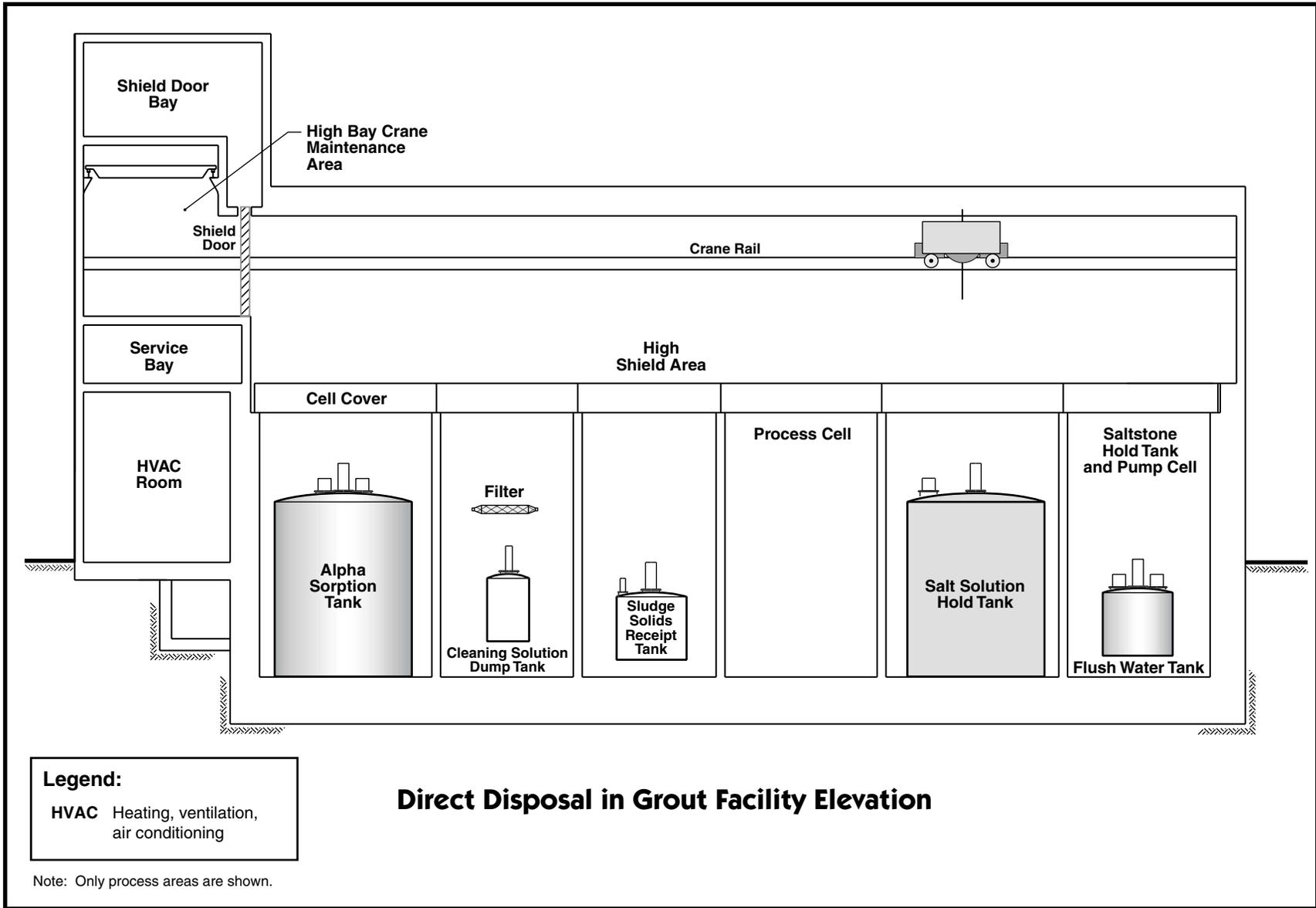


Figure A-16. Floor plan for Direct Disposal in Grout facility.

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NW SDA EIS/Grfx/App_A/A-17 Dir Disp elev.ai

Figure A-17. Elevation plan for Direct Disposal in Grout facility.

Table A-7. Tanks for Small Tank Precipitation Process.

Tank	Tank size (gallons)	Number of tanks	Radioactive	Stream characteristics	Ventilation flow per tank (cfm)
MST Storage Tank	400	1	No	MST	Natural
Process Water Tank	80,000	1	No	Well water	Natural
NaTPB Storage Tank	20,000	1	No	NaTPB solution	100
Copper Nitrate Feed Tank	500	1	No	15 wt% Copper Nitrate	Natural
Formic Acid Feed Tank	500	1	No	90 wt% Formic Acid	Natural
Fresh Waste Day Tank	25,000	1	Yes	Feed	100
Precipitation Tank	15,000	2	Yes	Feed/PPT	10
Concentrate Tank	10,000	1	Yes	PPT	10
Filtrate Hold Tanks	100,000	2	Yes	DSS	10
Wash Tank	10,000	1	Yes	PPT	10
Recycle Wash Hold Tank	10,000	1	Yes	Feed/DSS ^a	10
Precipitate Reactor Feed Tank	10,000	1	Yes	PPT	10
Precipitate Reactor	10,000	1	Yes	PPT/PHA	10
Precipitate Reactor Condenser	610	1	Yes	PHA	(b)
Precipitate Reactor Decanter	610	1	Yes	PHA	(b)
Precipitate Reactor Overheads Tank	7,500	1	Yes	Dilute PHA ^c	10
Precipitate Hydrolysis Aqueous Surge Tank	40,000	1	Yes	PHA	10
Organic Evaporator	1,750	1	Yes	Benzene ^d	10
Organic Evaporator Condenser	610	1	Yes	Benzene ^d	(b)
Organic Evaporator Decanter	610	1	Yes	Benzene ^d	(b)
Organic Evaporator Condensate Tank	1,000	1	Yes	Benzene ^d	(b)
Salt Cell Vent Condenser	310	1	Yes	Benzene ^d	(b)
Organic Waste Storage Tank	40,000	1	Yes	Benzene ^d	10
Cleaning Solution Dump Tanks	1,000	2	Yes	0.01 × PPT ^e	10

DSS = Decontaminated Salt Solution, cfm = cubic feet per minute, PPT = Precipitate slurry, PHA = Precipitate Hydrolysis Aqueous, NaTPB = sodium tetrphenylborate.

- Recycled wash water will hold a diluted DSS but with higher cesium concentration. This stream is conservatively chosen to be feed for radionuclide emissions and DSS for chemical emissions.
- Condensers and decanters do not have independent ventilation. The vapor stream that enters each of these devices includes the nitrogen purge of each of the originating vessels.
- The final processing step in the precipitate reactor concentrates PHA by evaporation. This is the only time the precipitate reactor overheads tank receives any waste. The condensed overheads consists of water and entrained PHA. The amount of entrainment is assumed the same as any other boiling interface, $DF=4.4 \times 10^6$.
- Benzene includes minor quantities of other, heavier organic compounds including biphenyl. The radionuclide concentration in the solution is less than dilute PHA and make an insignificant contribution to radionuclide emissions.
- Cleaning solution is used to clean the cross flow filters and may be contaminated with some dilute mixture of PPT slurry. This stream is conservatively chosen to be 0.01 times the concentrations for PPT slurry.

Table A-8. Tanks for Ion Exchange Process.

Tank	Tank size (gallons)	Number of tanks	Radioactive	Stream characteristics	Ventilation Flow per tank (cfm)
Process Water Tank	20,000	1	No	Well Water	Natural
MST Storage Tank	400	1	No	MST	Natural
Caustic Feed Tank	5,000	1	No	1 M NaOH	100
Resin Make-up Tank/Column Preparation Tank	2,000/ 3,000	1	No	CST	100
Oxalic Acid Feed Tank	200	1	No	2% H ₂ C ₂ O ₄	100
Caustic Feed Tank	500	1	No	1 M NaOH	100
Loaded Resin Hold Tank	15,000	2	Yes	CST	100
Ba-137 Decay Tanks/Product Holdup Tank	2,000/ 5,000	2	Yes	DSS	100
DSS Hold Tanks	100,000	2	Yes	DSS	100
Resin Hold Tank	10,000	1	Yes	CST Slurry	Existing tank in DWPF ^a
Alpha Sorption Tank	100,000	1	Yes	Feed	100
Recycle Blend Tank	100,000	1	Yes	CSS	100
Sludge Solids Receipt Tank	10,000	1	Yes	Feed/MST Slurry	100
Cleaning Solution Dump Tank	1,000	1	Yes	0.01 × MST Slurry ^b	100
Wash Water Hold Tank	25,000	1	Yes	0.25 × CSS ^c	100
CST Ion Exchange Column	3,000	2	Yes	CST Slurry,	10
	3,000	2	Yes	DSS ^d	10

CSS = Clarified Salt Solution; DSS = Decontaminated Salt Solution; MST = Monosodium Titanate; CST = Crystalline Silicotitanate ion exchange resin, cfm = cubic feet per minute.

- This change at DWPF is not expected to impact DWPF stack emissions.
- Cleaning solution is used to clean the cross flow filters may be contaminated with some dilute mixture of MST slurry. This stream is conservatively chosen to be 0.01 time the concentrations for MST slurry.
- The wash water hold tank will hold wash water from the sludge solids receipt tank. The solution washed from the sludge is CSS, which is diluted by the washed water. The dilution is conservatively chosen to be 0.25.
- Two columns are assumed loaded at any one time and the other two are assumed to contain only DSS-resin slurry.

A.5.3 TRANSFER FACILITIES

New transfer facilities would be required to direct the flow of process streams among the various facilities employed in the salt processing alternatives. These include feed lines to the facilities, transfer lines between facilities, and several valve boxes, diversion boxes, and pump pits directing the stream flows (WSRC 1998m, 2000c). Details of the processing-related transport facilities are described in Table A-11. The integration of these new facilities into existing facilities is illustrated in Figures A-18 through A-21 (WSRC 1998e; 2000c).

A.5.4 SUPPORT FACILITIES

Each alternative would require other support facilities including service, office, and substation buildings. The service building would be a single-story, 21,000-23,700-square-foot steel-framed structure with concrete or brick siding. This building would contain electrical and mechanical maintenance shops, control rooms for the process and for the remote crane, a health physics office, conference room, and offices for operations personnel. The structure would also house two 500-kilowatt (kW) diesel generators and associated equipment (WSRC 1998m). The

Table A-9. Tanks for Solvent Extraction Process.

Tank	Tank size (gallons)	Number of tanks	Radioactive	Stream characteristics	Ventilation flow per tank (cfm)
Process Water Tank	20,000	1	No	Well water	Natural
MST Storage Tank	400	1	No	MST	Natural
Caustic Feed Tank	5,000	1	No	1 M NaOH	10
Oxalic Acid Feed Tank	200	1	No	2% H ₂ C ₂ O ₄	10
Caustic Feed Tank	500	1	No	1 M NaOH	10
Caustic Dilution Feed Tank	15,000	1	No	2.0 M caustic	10
Caustic Storage Tank	5,000	1	No	50% caustic	10
Filter Cleaning Caustic Tank	500	1	No	1 M NaOH	10
Caustic Makeup Tank	1,000	1	No	0.5 M NaOH	10
Solvent Wash Solution Makeup Tank	1,000	1	No	0.5 M NaOH	10
Nitrate Acid Feed Tank	1,000	1	No	50% HNO ₃	10
Nitrate Acid Charge Tank	1	1	No	50% HNO ₃	Natural
Strip Feed Tank	4,000	1	No	0.005 M HNO ₃	
Chem Additive Tank	100	1	No	Process water	10
Isopar Makeup Tank	2,000	1	No	Isopar [®] L	10
Isopar Hold Tank	5,000	1	No	Isopar [®] L	10
Isopar Feed Tank	500	1	No	Isopar [®] L	10
Modifier Makeup Tank	500	1	No	1.0 M Cs7SBT in Isopar [®] L	10
Extractant Makeup Tank	50	1	No	0.2 M BobCalix in Isopar [®] L	10
Triethylamine Tank	5	1	No	Triethylamine	10
Solvent Makeup Tank	1,000	1	No	0.01 BobCalix, 0.5 M Cs7SBT, and 0.001 M TOA in Isopar [®] L	10
Alpha Sorption Tank	125,000	1	Yes	Feed	100
Salt Solution Feed Tank	125,000	1	Yes	Clarified salt solution	100
Strip Stages (15)	114	1	Yes	Organic phase	None
Strip Effluent Stilling Tank	500	1	Yes	Strip solution	100
Strip Make-up Tank	25,000	1	Yes	Strip solution	100
Strip Organic Removal Stages (2)	15	1	Yes	Strip solution	100
Wash Water Hold Tank	25,000	1	Yes	~2M Na salt solution, 1/4 dilution of CSS	100
Ba-137 Decay Tanks	2,500	2	Yes	DSS	100
Caustic Solvent Wash Tank	1,000	1	Yes	DSS	100
Solvent Hold Tank	1,000	1	Yes	Organic phase	100
Solvent Wash Tank	1,000	1	Yes	Organic phase	100

Table A-9. (Continued).

Tank	Tank size (gallons)	Number of tanks	Radioactive	Stream characteristics	Ventilation flow per tank (cfm)
Kerosene Still	1,000	1	Yes	Organic phase	None
Kerosene Condensate Tank	1,000	1	Yes	Organic phase	None
Re-alkaline Stages (2)	15	1	Yes	Organic phase	None
Solvent Acid Wash Stages (2)	15	1	Yes	Organic phase	None
Scrub Stages (2)	15	1	Yes	Organic phase	None
Raffinate Organic Removal Stages (2)	15	1	Yes	DSS	None
Extraction Stages (15)	114	1	Yes	Clarified salt solution	None
DWPF Salt Feed Tank	100,000	1	Yes	Strip solution	100
Aqueous Raffinate Stilling Tank	500	1	Yes	DSS	100
DSS Hold Tanks	100,000	2	Yes	DSS	100
Sludge Solids Receipt Tank	10,000	1	Yes	Feed/MST slurry	100
Cleaning Solution Dump Tank	1,000	1	Yes	0.01 × MST slurry ^a	100

CSS = Clarified Salt Solution; DSS = Decontaminated Salt Solution; MST = Monosodium Titanate.

- a. Cleaning solution is used to clean the cross flow filters and may be contaminated with some dilute mixture of MST slurry. This stream is conservatively chosen to be 0.01 times the concentrations for MST slurry.

Table A-10. Tanks for Direct Disposal in Grout Process.

Tank	Tank Size (gallons)	Number of Tanks	Radioactive	Stream Characteristics	Ventilation Flow (cfm)
MST Storage Tank (non-rad)	400	1	No	MST	natural
Process Water Tank (non-rad)	5,000	1	No	Well Water	natural
Oxalic Acid Feed Tank (non-rad)	200	1	No	2% H ₂ C ₂ O ₄	natural
Caustic Feed Tank (non-rad)	500	1	No	1M NaOH	100
Caustic Storage Tank (non-rad)	500	1	No	50% NaOH	natural
Alpha Sorption Tank	100,000	1	Yes	Feed	100
Sludge Solids Receipt Tank	10,000	1	Yes	MST Slurry	100
Cleaning Solution Dump Tank	1,000	1	Yes	(a)	100
Salt Solution Hold Tank	100,000	1	Yes	CSS	100
Flush Water Receipt Tank	10,000	1	Yes	CSS ^b	100
Saltstone Hold Tank	500	1	Yes	CSS with gout	100

CSS = Clarified Salt Solution; MST = Monosodium Titanate; cfm = cubic feet per minute.

- a. Cleaning solution used to clear cross flow filters may be contaminated with MST slurry. Stream chosen to be 0.01 times concentration for MST slurry.
- b. Flush water receipt tank holds water used to flush process lines at the mixer and saltstone hold tank, thus, will contain a diluted form of CSS. This stream is conservatively chosen to be 0.01 times the concentrations for CSS.

Table A-11. New transfer facilities.

Facility	Small Tank Tetraphenylborate Precipitation	Crystalline Silicotitanate Ion Exchange	Caustic Side Solvent Extraction	Direct Disposal in Grout
	Processing facility at Site B ^a	Processing facility at Site B ^a	Processing facility at Site B ^a	Processing facility in Z Area ^a
Interarea feed line from H-Area Tank Farm to new processing facility	Extension of interarea feed line from the H-Area Tank Farm to the processing facility, consisting of a 150-foot-long double-walled pipe ^b , installed 6 feet underground	Same as Small Tank Tetraphenylborate Precipitation Alternative	Same as Small Tank Tetraphenylborate Precipitation Alternative	A feed line from the interarea feed line to the processing facility, consisting of a double-walled pipe ^b , approximately 500 feet long, installed 6 feet underground
Saltstone feed line	A pipe line from the processing facility to the feed line from H-Area Tank Farm to Saltstone Manufacturing and Disposal Facility, connecting at a valve box. Line is a double-walled pipe ^b , approximately 150 feet long, installed 6 feet underground	Same as Small Tank Tetraphenylborate Precipitation Alternative	Same as Small Tank Tetraphenylborate Precipitation Alternative	NA
Vault feed line	A feed line from the Saltstone Manufacturing and Disposal Facility to the vaults consisting of a galvanized carbon steel pipe, 300 feet long, laid in a concrete trench 5 feet deep, 3 feet wide, with 1.5-foot-thick sides and top	Same as Small Tank Tetraphenylborate Precipitation Alternative	Same as Small Tank Tetraphenylborate Precipitation Alternative	A feed line identical in specifications to the Small Tank Tetraphenylborate Precipitation vault feed line that would run from the new grout processing facility to the saltstone vaults
ETF Bottoms Holding Tank	A 50,000-gallon ETF Bottoms Holding Tank constructed between ETF and the Saltstone Manufacturing and Disposal Facility	Same as Small Tank Tetraphenylborate Precipitation Alternative	Same as Small Tank Tetraphenylborate Precipitation Alternative	A 50,000-gallon Bottoms Holding Tank constructed between ETF and the H-Area Tank Farm
Precipitate Hydrolysis Aqueous transfer line	A pipe line from the processing facility to the existing Low Point Pump Pit, connecting with existing feed line to DWPF. Line is a double-walled pipe 2,300 feet long, buried 6 feet below grade	NA	NA	NA

Table A-11. (Continued).

Facility	Small Tank Tetraphenylborate Precipitation	Crystalline Silicotitanate Ion Exchange	Caustic Side Solvent Extraction	Direct Disposal in Grout
Valve box	A valve box constructed between the processing facility and the Saltstone Manufacturing and Disposal Facility, providing tie-in for feed lines from processing facility and ETF	Same as Small Tank Tetraphenylborate Precipitation Alternative	Same as Small Tank Tetraphenylborate Precipitation Alternative	NA
Feed line from ETF to valve box	A feed line from the ETF Bottoms Holding Tank to the new valve box, consisting of a double-walled pipe ^b , approximately 1 mile long, installed 6 feet underground	Same as Small Tank Tetraphenylborate Precipitation Alternative	Same as Small Tank Tetraphenylborate Precipitation Alternative	NA
Low Point Pump Pit	NA	A new Low Point Pump Pit to transfer resin between the processing facility and DWPF	A new Low Point Pump Pit between the processing facility and DWPF to transfer monosodium titanate/sludge slurry	NA
Resin transfer line	NA	A feed line from the processing facility through the new Low Point Pump Pit to the DWPF, consisting of a double-walled pipe ^b , 2,300 feet long, installed 6 feet underground	NA	NA
Monosodium Titanate/Sludge Slurry transfer line	NA	A pipe line from the processing facility to the existing Low Point Pump Pit, connecting with existing feed line to DWPF. Line is a double-walled pipe 2,300 feet long, buried 6 feet below grade	A pipeline from the processing facility through the new Low Point Pump Pit to the DWPF Line is a double-walled pipe, 2,300 feet long, buried 6 feet below grade	NA

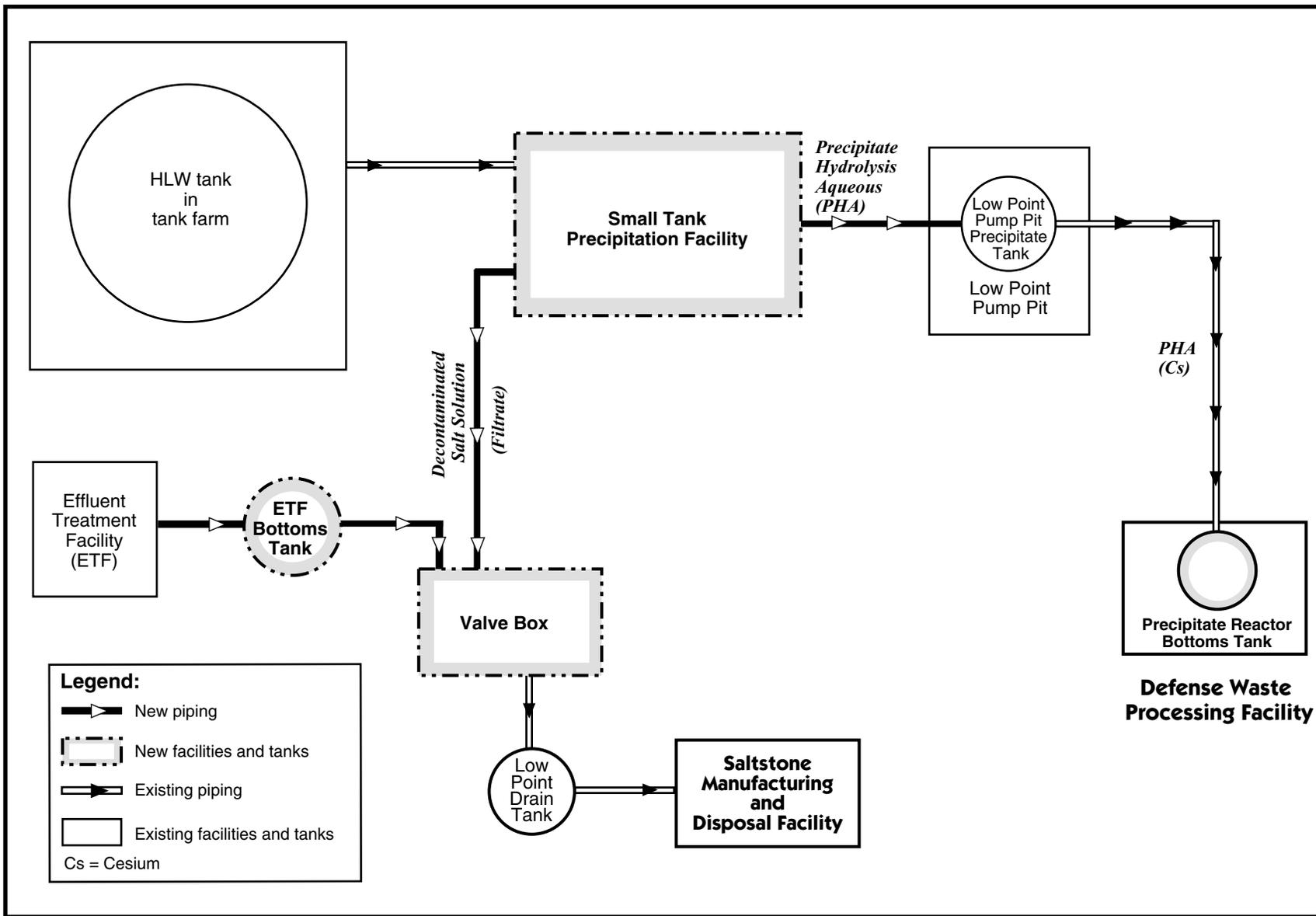
Table A-11. (Continued).

Facility	Small Tank Tetraphenylborate Precipitation	Crystalline Silicotitanate Ion Exchange	Caustic Side Solvent Extraction	Direct Disposal in Grout
Monosodium Titanate/Sludge Receipt Tank in DWPF	NA	A 15,000-gallon tank installed in the DWPF	Same as Crystalline Silicotitanate Ion Exchange	Same as Crystalline Silicotitanate Ion Exchange
Resin Hold tank in DWPF	NA	A 10,000-gallon tank installed in the DWPF	NA	NA
Cesium Strip Effluent transfer line	NA	NA	A pipe line from the processing facility to the existing Low Point Pump Pit connecting with the existing feed line to the DWPF	NA
Cesium Strip Effluent Hold Tank in DWPF	NA	NA	A 10,000-gallon tank installed in the DWPF	NA
Low Point Drain Tank facility	NA	NA	NA	A Low Point Drain Tank Facility to serve transfer lines between the H-Area Tank Farm and the processing facility and between the processing facility and DWPF. It would be used to transfer salt solution to the grout facility and monosodium titanate/sludge slurry to DWPF
Monosodium Titanate/Slurry feed line to DWPF	NA	NA	NA	A feed line from the processing facility through the Low Point Drain Tank Facility to DWPF, consisting of a doubled-walled pipe 1 mile long, installed 6 feet underground

a. See text for description of the proposed facilities.

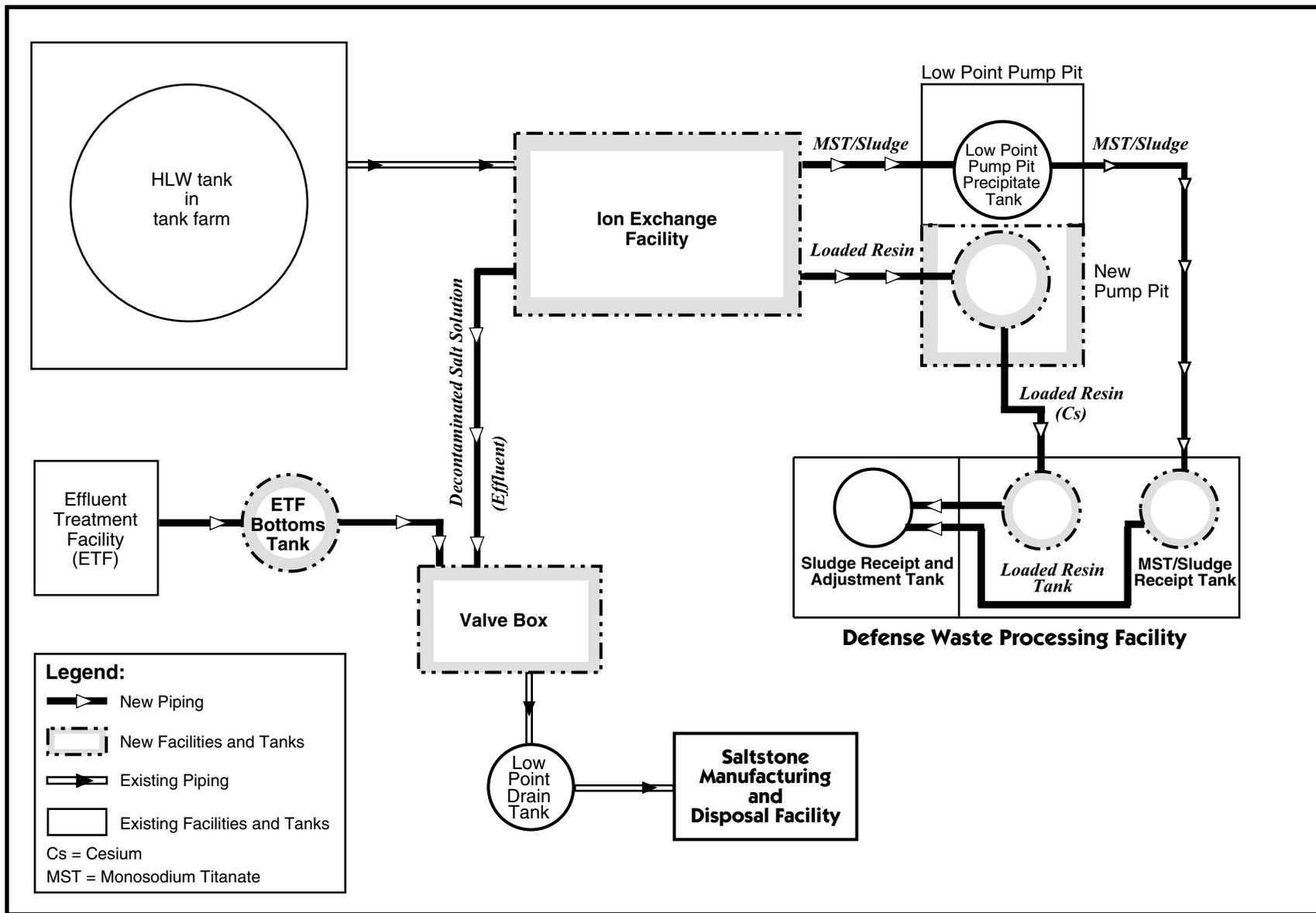
b. All double-walled transfer lines, comprised of 3-in.-diameter, schedule 40 (or 80), Type 304L stainless steel inner pipe and 6-in.-diameter, schedule 40, carbon steel outer pipe.

NA = not applicable.



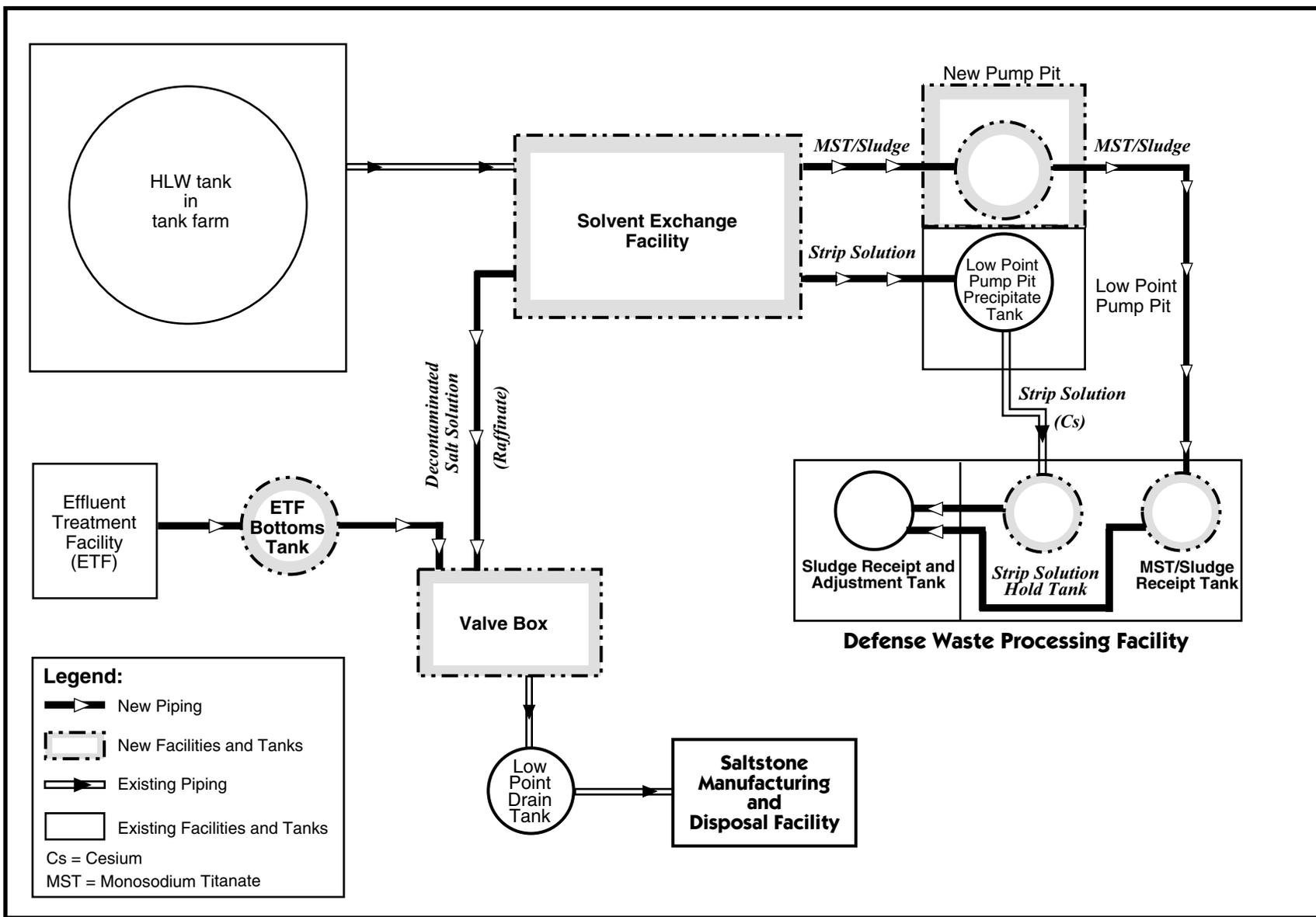
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Figure A-18. Transfer facilities for Small Tank Precipitation alternative.



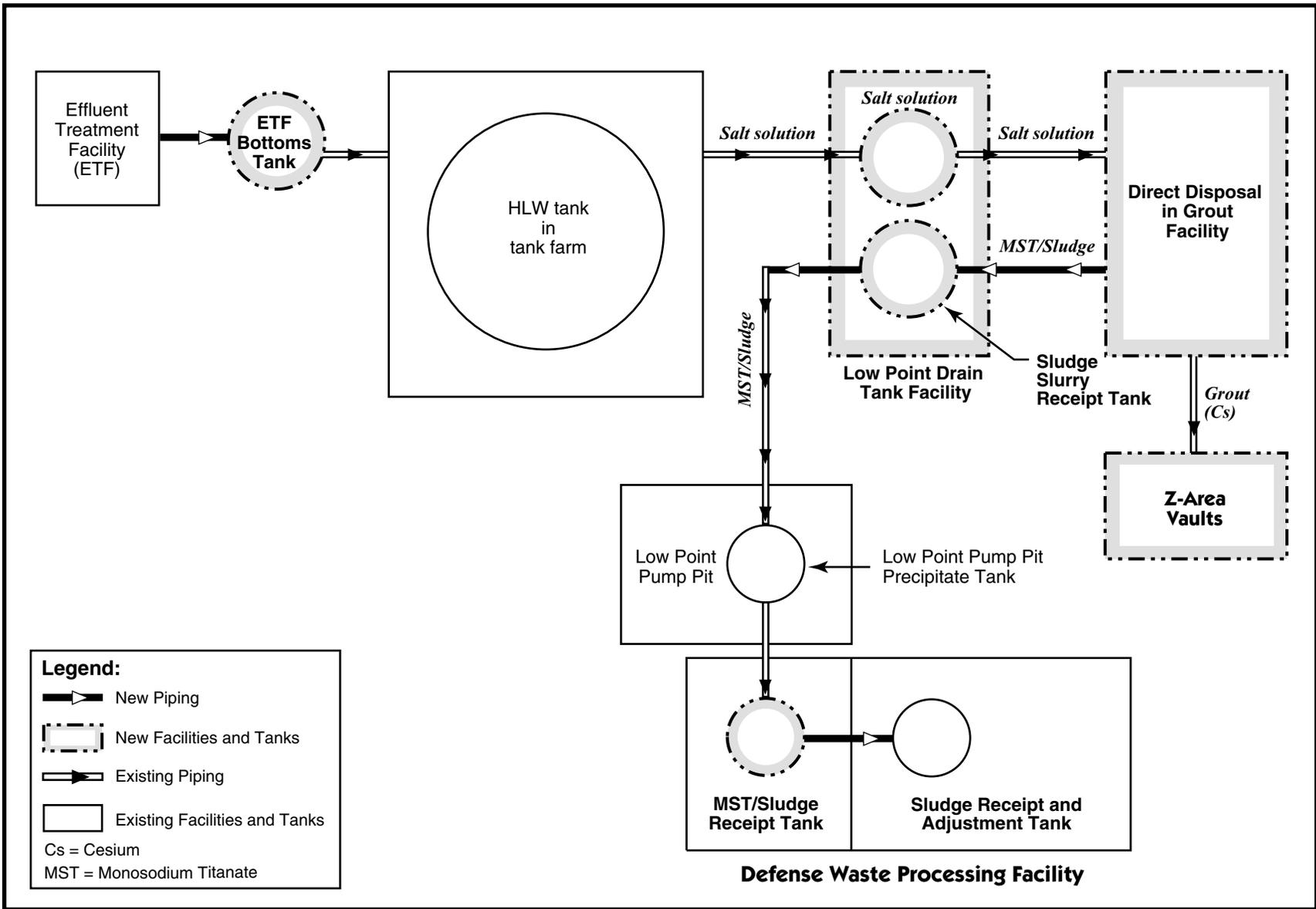
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Figure A-19. Transfer facilities for Ion Exchange alternative.



NW SDA EIS/Grfx/App A/A-20 Trans CST Solv.ai

Figure A-20. Transfer facilities for Solvent Extraction alternative.



NW SDA EIS/Grfx/App A/A-21 Trans Dir Disp.ai

Figure A-21. Transfer facilities for Direct Disposal in Grout alternative.

office building would typically be a 22,500-square-foot single-story structure capable of providing personnel emergency shelter protection. It would house offices, a conference area, cafeteria, and restroom facilities for support personnel (e.g., engineering support, facility management, and clerical staff). The support facilities for each technology would include a process simulator building.

An electrical substation building, encompassing 600 square feet, would be needed for each alternative. A chemical storage area would be located on a concrete slab adjacent to the process building and add approximately 30 feet to the length of the process building. The area would be protected from the elements and contain storage tanks for chemicals used in the process. Dikes would be located around the tanks to contain any potential spills and to prevent inadvertent mixing of chemicals.

A.5.5 SALTSTONE VAULTS

As many as 16 saltstone disposal vaults beyond the currently existing two vaults would be constructed in Z Area to support the salt disposal alternatives (Figure A-22). Nominal dimensions of the additional vaults would be 300 feet long by 200 feet wide by 25 feet high. Each vault would consist of six cells, 100 feet long by 100 feet wide, to contain about 6,600 cubic meters of saltstone grout per cell. Interior and exterior walls would be 18 inches thick and the base slab would be 30 inches thick. The roof slab would be 24 inches thick. The interior floor and walls for each cell would be painted with epoxy to inhibit infiltration of moisture during grout curing. Any voids left in the grout in a cell would be filled with nonradioactive grout prior to final vault closure to help ensure structural integrity. All vaults would be equipped with cameras and lights to monitor filling, and thermocouple assemblies to monitor heat generation during the curing process. As with the existing saltstone vaults, the additional vaults would be considered near-surface containment structures and covered with soil after vault closure for additional shielding.

The six-cell configuration of the additional vaults would facilitate a pouring rotation that would meet grout-cooling requirements. A 500-cubic-foot-per-minute ventilation system would be equipped with a pre-filter, high-efficiency particulate air (HEPA) filter and fan, and connected ductwork to control contamination during vault filling operations. Radiation monitors and dampers would be included (WSRC 1998m).

A.5.6 PILOT PLANT

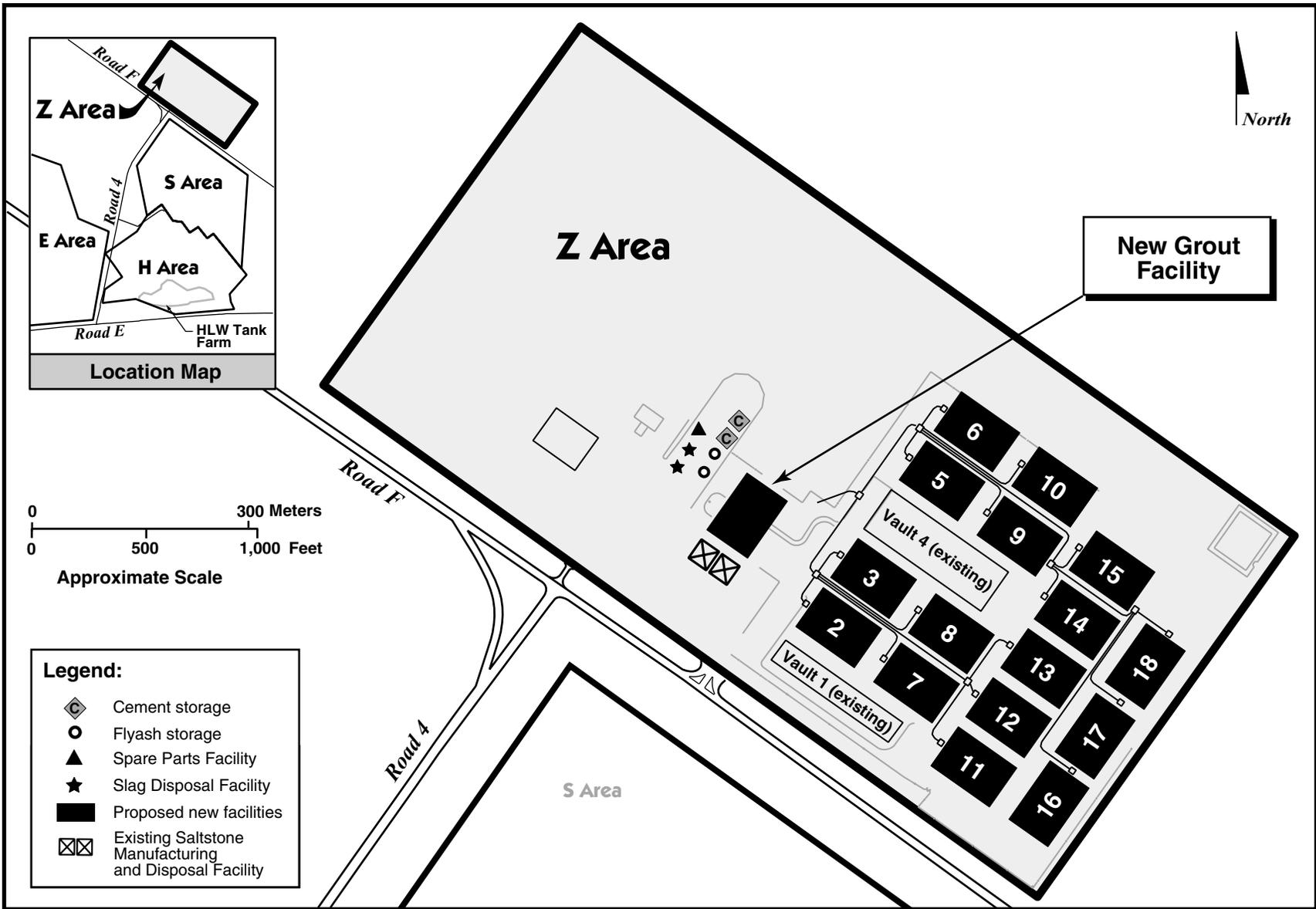
To achieve pilot scale testing of the selected salt processing process before operation of the full-scale facility, a pilot plant would be needed, as defined in Chapter 2 (Section 2.7.5). The pilot plant would provide scaled process data, utilizing equipment ranging from 1/100 to 1/10 the size of the full-scale facility (WSRC 2000e). Process streams would consist of real radioactive waste from various HLW tanks to demonstrate required decontamination factors (DF), as follows:

Cs-137 DF 40,000
Sr-90 DF 100 or greater
Pu-238 DF 10 or greater

The capability for appropriate waste disposal would be required in the pilot plant.

Installation of pilot plant process equipment in the existing Late Wash Facility provided for ITP is projected. The Late Wash Facility has three highly shielded cells designed to contain up to 5,000 gallons of concentrated precipitate slurry, into which salt processing equipment mounted in frames could be installed. If additional shielded space was required, the filter cell previously provided to support ITP operations would be considered.

Test runs designed to demonstrate the process flowsheet for the selected salt processing alternative would be conducted in the pilot plant. Functional process flows would parallel those for the full-scale facility. Major equipment would be tested to confirm vessel sizing and de-



NW SDA EIS/Grfx/App_A/A-22 Loc Z Area.ai

Figure A-22. Proposed location of new Grout Facility and saltstone disposal vaults in Z Area.

sign constraints, and process parameters would be evaluated to ensure satisfactory resolution of problems encountered during process development.

Process demonstrations would be designed to meet the following objectives:

Small Tank Precipitation – Validity design parameters, as determined by kinetics of cesium precipitation by tetraphenylborate, and strontium and actinide sorption on monosodium titanate; feed stream mixing rates; and excess tetraphenylborate recovery. Resolve processing uncertainties related to the activation of tetraphenylborate decomposition catalysts at operating temperatures, and foam formation.

Major equipment would include:

- Process Feed Tank
- Precipitation Tanks (Continuous Stirred Tank Reactors 1 and 2)
- Concentrate Tanks
- Concentrate Filter and Cleaning System
- Filtrate Hold Tank
- Wash Tank
- Wash Filter and Cleaning System
- Precipitate Surge Tank
- Recycle Wash Hold Tank
- Cold Feeds and Facilities
- Laboratory Facilities

Ion Exchange – Resolve key issues, including the kinetics of strontium and actinide sorption onto monosodium titanate; filtration of monosodium titanate solids; the kinetics of cesium removal on crystalline silicotitanate as function of temperature and waste composition; and design parameters for the ion-exchange columns. Resolve processing uncertainties relating to hydrogen generation in the ion-exchange columns at high cesium loadings; desorption of cesium from the crystalline silicotitanate ion exchange resin; resin stability; and extraneous solids formation.

Major equipment would include:

- Alpha Sorption Tank
- Alpha/Sludge Filter and Cleaning System
- Sludge Solids Receipt Tank
- Recycle Blend Tank
- Crystalline Silicotitanate Columns in series (1 ft diam × 16 ft length)
- Loaded Resin Hold Tank
- Decontaminated Salt Solution Hold Tank
- Cold Feeds and Facilities
- Laboratory Facilities

Solvent Extraction – Demonstrate or confirm the kinetics of strontium and actinide sorption onto monosodium titanate with removal by filtration; cesium separation and concentration in centrifugal contactor operation with minimal long-term chemical and radiolytic degradation of solvent; solvent cleanup and recycle capabilities, including self purification by back extraction to aqueous phase; and final separation of organics from aqueous raffinate and strip effluent product streams.

Major equipment would include:

- Alpha Sorption Tank
- Alpha/Sludge Filter and Cleaning System
- Sludge Solids Receipt Tank
- Salt Solution Feed Tank
- Solvent Extraction Contactors in Series
- Solvent Hold Tank and Cleaning System
- Raffinate Stilling Tank
- Strip Effluent Stilling Tank
- Decontaminated Salt Solution Hold Tank

Direct Disposal in Grout – A requirement for the demonstration of the Direct Disposal in Grout alternative has not been confirmed. Because this technology is better developed than the other alternatives and has been thoroughly demonstrated by the existing Saltstone Manufacturing and Disposal Facility, it is not anticipated that any further demonstration of this technology will be necessary.

A.5.7 DECONTAMINATION AND DECOMMISSIONING

Any new facility would be designed and constructed to limit the generation and dispersion of radioactive and hazardous materials and to facilitate its ultimate decontamination and decommissioning or reuse. Areas of the facility that might become contaminated with radioactive or other hazardous materials under normal or off-normal operating conditions would incorporate design features to simplify their decontamination. Items such as service piping, conduits, and ductwork would be minimized in these areas and arranged to facilitate decontamination. Facility design would include a dedicated area for decontamination of tools and some equipment. Design features that would be incorporated into any of the facilities are described below.

- Modular confinement would be used for radioactive and hazardous materials to pre-

clude contamination of fixed portions of the structure.

- Long runs of buried piping that would carry radioactive or hazardous materials would be minimized to the extent possible, and provisions would be included in the design to allow the inspection of the integrity of joints in buried pipelines. The facility would be designed to facilitate dismantlement, removal, and packaging of contaminated equipment.
- Modular shielding would be used in interior areas to permit modification to larger shielded areas for future use.
- Lifting lugs would be used on equipment to facilitate remote removal from the contaminated process cells.
- The piping systems that would carry hazardous products would be fully drainable.

References

- DOE (U.S. Department of Energy), 1994, *Final Supplemental Environmental Impact Statement, Defense Waste Processing Facility*, DOE/EIS-0082-S, Savannah River Operations Office, Savannah River Site, Aiken, South Carolina.
- DOE (U.S. Department of Energy), 1995, *Final Environmental Impact Statement Savannah River Site Waste Management*, DOE/EIS-0217, Savannah River Operations Office, Aiken, South Carolina.
- DOE (U.S. Department of Energy), 1998a, *Supplement Analysis, Defense Waste Processing Facility Salt Disposition Technology Options at the Savannah River Site*, DOE/EIS-0082-SA-03, Savannah River Operations Office, Aiken, South Carolina, November.
- DOE (U.S. Department of Energy), 1998b, *Review Team Final Report on the High-Level Waste Salt Disposition Alternatives Evaluation*, Savannah River Site, Aiken, South Carolina.
- DOE (U.S. Department of Energy), 1998c, *Independent Assessment of Savannah River Site High-Level Waste Salt Disposition Alternatives Evaluation*, DOE-ID-101672, Washington, D.C.
- DOE (U.S. Department of Energy), 1999, *Notice of Intent to Prepare a Supplemental Environmental Impact Statement for Alternatives to the In-Tank Precipitation Process at the Savannah River Site, Aiken, South Carolina*, Federal Register 64 (34): 8558-8560, February 22.
- DOE (U.S. Department of Energy), 2000, "Additional Research and Development (R&D) of Caustic Side Solvent Extraction (CSEX) Alternative." Letter to W. G. Poulson, Westinghouse Savannah River Company, February 15.
- EPA (U.S. Environmental Protection Agency), 1993, Federal Facility Agreement between the U.S. Environmental Protection Agency, Region IV, the U.S. Department of Energy, and the South Carolina Department of Health and Environmental Control, Docket No. 89-05-FF, August 16.
- Langton, C. A., 1988, "Slag-Based Saltstone Formations," *Ninth Annual DOE Low-Level Waste Management Forum*, CONF-87059-Session I, U.S. Department of Energy, Denver, Colorado.
- Martin Marietta (Martin Marietta Energy Systems, Inc.), 1992, *Radiological Performance Assessment for the Z-Area Saltstone Disposal Facility*, WSRC-RP-92-1360, prepared for Westinghouse Savannah River Company, Aiken, South Carolina, by Martin Marietta Energy Systems, Inc.
- Wilhite, E. L., 1986, "Waste Salt Disposal at the Savannah River Plant," *SPECTRUM '86 – Waste Management, Decontamination, and Decommissioning*, American Nuclear Society.
- Wilhite, E. L., C. A. Langton, H. F. Sturm, R. L. Hooker, and E. S. Occhipinti, 1989, "Saltstone Processing Startup at the Savannah River Plant," *SPECTRUM '88 Nuclear and Hazardous Waste Management International Topical Meeting*, American Nuclear Society, Pasco, Washington.
- WSRC (Westinghouse Savannah River Company), 1998a, *High-Level Waste Salt Disposition Systems Engineering Team Final Report (U)* WSRC-RP-98-00170, Rev. 0, Savannah River Site, Aiken, South Carolina.
- WSRC (Westinghouse Savannah River Company), 1998b, *High-Level Waste Salt Disposition Interface Requirements*, WSRC-RP-98-00164, Rev. 0, Savannah River Site, Aiken, South Carolina, June 25.

- WSRC (Westinghouse Savannah River Company), 1998c, *Preconceptual Design Package for the Small Tank TPB Precipitation Facility* (U), G-CDP-H-00003, Savannah River Site, Aiken, South Carolina.
- WSRC (Westinghouse Savannah River Company), 1998d, *WSRC Review Panel Report on the Selection of High-Level Waste Salt Disposition Alternatives*, Savannah River Site, Aiken, South Carolina, November.
- WSRC (Westinghouse Savannah River Company), 1998e, *Bases, Assumptions, and Results of Flowsheet Calculations for the Short List Salt Disposition Alternatives*, WSRC-RP-98-00168, Rev. 1, Savannah River Site, Aiken, South Carolina.
- WSRC (Westinghouse Savannah River Company), 1998f, *Facility Design Description-Chapter One for High Level Waste Management Division – Small Tank TPB Precipitation Facility*, G-FDD-H-00014, Rev. B, Savannah River Site, Aiken, South Carolina.
- WSRC (Westinghouse Savannah River Company), 1998g, *Preconceptual Design Package for the CST Non-Elutable Ion Exchange Facility* (U), G-CDP-H-0004, Savannah River Site, Aiken, South Carolina, October 29.
- WSRC (Westinghouse Savannah River Company), 1998h, *Facility Design Description for High-Level Waste Management Division CST Non-Elutable Ion Exchange Facility*, G-FDD-H-00013, Rev. A, Savannah River Site, Aiken, South Carolina.
- WSRC (Westinghouse Savannah River Company), 1998i, *High-Level Waste Salt Processing Alternatives – Life Cycle Analysis Details – Cesium Encapsulation in Grout*, WSRC-RP-98-00123, Rev. 1, Savannah River Site High-Level Waste Disposition Systems Engineering Team, Aiken, South Carolina.
- WSRC (Westinghouse Savannah River Company), 1998j, *High-Level Waste Salt Processing Alternatives – Life Cycle Analysis Details – Small Tank TPB Precipitation*, WSRC-RP-98-00126, Rev. 1, Savannah River Site High-Level Waste Disposition Systems Engineering Team, Aiken, South Carolina.
- WSRC (Westinghouse Savannah River Company), 1998k, *High-Level Waste Salt Processing Alternatives – Life Cycle Analysis Details – CST Ion Exchange*, WSRC-RP-98-00125, Rev. 1, Savannah River Site High-Level Waste Disposition Systems Engineering Team, Aiken, South Carolina.
- WSRC (Westinghouse Savannah River Company), 1998l, *High-Level Waste Salt Processing Alternatives – Life Cycle Analysis Details - Caustic Side Solvent Extraction*, WSRC-RP-98-001234, Rev. 1, Savannah River Site High-Level Waste Disposition Systems Engineering Team, Aiken, South Carolina.
- WSRC (Westinghouse Savannah River Company), 1998m, *Life Cycle Cost Estimate Bases, Assumptions, and Results, Rev. 1*, WSRC-RP-98-00167, Savannah River Site, Aiken, South Carolina.
- WSRC (Westinghouse Savannah River Company), 1999a, *Savannah River Site High-Level Waste Tank Space Management Team Final Report*, WSRC-RP-99-0005, Rev. 0, Aiken, South Carolina.
- WSRC (Westinghouse Savannah River Company), 1999b, *High-Level Waste Salt Disposition Systems Engineering Team Decision Phase Final Report (U)*, WSRC-RP-99-00007, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 1999c, A Robust Alkaline Side CSEX Solvent High-Level Waste - P. V. Bonnesen, L. H. Delmau, B. A. Mayer (Oak Ridge National Laboratory), and R. A. Leonard (Argonne National Laboratory). Draft Manuscript HLW-SDT-99-0283, September 13-14, 1999.

WSRC (Westinghouse Savannah River Company), 2000a, *High-Level Waste System Plan, Revision 11 (U)*, HLW-2000-00019, Savannah River Site, Aiken, South Carolina.

WSRC (Westinghouse Savannah River Company), 2000b, *WSRC Response to Needed Information for Inclusion of Caustic Side Solvent Extraction and Small Tank TPB Precipitation with Saltcell in Salt Disposition Alternatives SEIS*. HLW-SDT-2000-00136, Rev. 0, June 6, 2000.

WSRC (Westinghouse Savannah River Company), 2000c, *WSRC Response to TtNUS Supplemental Data Call*, HLW-SDT-2000-00263, Rev. 0, July 17, 2000.

WSRC (Westinghouse Savannah River Company), 2000d, *Preliminary Source Term and Emissions Data for Salt Processing Environmental Impact Statement*, HLW-SDT-99-0161, Rev. 5, August 22, 2000.

WSRC (Westinghouse Savannah River Company), 2000e, *Technical Demonstration Unit*, HLW-SDT-2000-00169, May 16, 2000; *Position Paper on Salt Disposition Pilot Facilities Approach*, HLW-SDT-99-0225, Rev. 0, July 22, 1999.