EVALUATION OF WEST VALLEY HIGH-LEVEL WASTE TANK LAY-UP STRATEGIES

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ABSTRACT

The primary objective of the task summarized in this paper was to demonstrate a methodology for evaluating alternative strategies for preclosure lay-up of the two high-level waste (HLW) storage tanks at the West Valley Demonstration Project (WVDP). Lay-up is defined as the period between operational use of tanks for waste storage and final closure.

The U.S. Department of Energy (DOE) is planning to separate the environmental impact statement (EIS) for completion of closure of the WVDP into two separate EISs. The first EIS will cover only waste management and decontamination. DOE expects to complete this EIS in about 18 months. The second EIS will cover final decommissioning and closure and may take up to five years to complete.
This approach has been proposed to expedite continued management of the waste and decontamination activities in advance of the final EIS and its associated Record of Decision on final site closure.
Final closure of the WVDP site may take 10 to 15 years; therefore, the tanks need to be placed in a safe, stable condition with minimum surveillance during an extended lay-up period.

The methodology developed for ranking the potential strategies for lay-up of the WVDP tanks can be used to provide a basis for a decision on the preferred path forward. The methodology is also applicable to determining preferred lay-up approaches at other DOE sites. Some of the alternative strategies identified for the WVDP should also be considered for implementation at the other DOE sites. Each site has unique characteristics that would require unique considerations for lay-up.

INTRODUCTION

The WVDP is located about 50 km south of Buffalo, New York, on the site of a former commercial spent fuel reprocessing facility, which operated from 1966 to 1972. Approximately 640 metric tons of commercial and defense fuels were reprocessed at the site using the plutonium-uranium extraction and the thorium extraction processes. In 1980, the *West Valley Demonstration Project Act* was signed, directing DOE to (a) solidify and develop suitable containers for the site's high-level radioactive waste, (b) transport the solidified waste to a federal repository, and (c) dispose of the low-level radioactive and transuranic wastes created during reprocessing operations.

Approximately 2 million L of neutralized high-level plutonium-uranium extraction radioactive waste remained on the site in an underground carbon steel storage tank designated as 8D-2 in 1982. This waste consisted of insoluble hydroxides and other salts that precipitated out of the solution to form a bottom sludge layer, and a liquid top layer (supernate) rich in sodium nitrate and sodium nitrite. Most of this waste has been vitrified for final disposal.

HIGH-LEVEL WASTE STORAGE TANKS AND VAULTS

Underground waste storage tanks 8D-1 and 8D-2 are identical 2.8 million L capacity, carbon steel storage tanks each contained within a secondary containment pan and a concrete vault. Figure 1 is a schematic of the tank and vault configuration. Each tank is 21 m in diameter and 8.2 m high with wall thicknesses ranging from 1.3 to 1.7 cm. The bottom floor plates are 1.7 cm thick and the tank roof plates are 1.1 cm thick. These tanks have a complex internal gridwork comprised of a network of wide flange beams supported underneath by vertical plates of varying lengths and widths. These girders attach to the tank bottom by rods held on with reinforcing disks. Forty-five 22 cm diameter pipe columns in each tank connect the beams to the tank top and provide support to the roof. Various air circulators, thermowells, and level/density probes also reside within the tanks.

There is an annular air space of 76 cm between the tank and vault wall. Each tank rests directly on a 30 cm layer of perlite blocks and the perlite blocks rest on a 7.5 cm layer of pea gravel within the carbon steel secondary containment pan. The secondary containment pan is approximately 1.5 m deep. There is another 7.5 cm layer of pea gravel between the pan and the vault floor. The bottom of the vault is 70 cm thick except for a thicker ring under the columns that support the vault roof. There are six 1.2 m diameter columns that pass through each tank to support the vault roof. These columns pass through carbon steel tubes constructed of 1 cm plate welded to the top plate and floor plate.

Long-shafted centrifugal mobilization pumps are installed in tanks 8D-1 and 8D-2 to mix settled solids with the liquid supernate. These pumps are each 15 m in length with a single impeller to draw the slurry up into the pump suction and a strainer device to keep out larger debris. The suction is positioned from 2.5 to 3.8 cm from the tank bottom with discharge jets approximately 13 cm above the tank bottom. Two tangential nozzles are used to discharge liquid from the volute above the suction. One long-shafted vertical turbine transfer pump is also installed in each tank. Each pump is approximately 12 m long with a radial inlet suction and two concentric strainers about 2.5 to 3.8 cm above the tank bottom and is equipped with instrumentation to allow remote operation and performance monitoring and with vibration sensors to monitor pump wear.

Figure 2 shows the pump support superstructure, the vault and tank roof support columns, the bottom gridwork and the gravel base below the tanks.

A 70 m long seismically designed concrete transfer trench connects the tanks to the vitrification facility. Transfer piping within the trench is 6.4 cm diameter stainless steel inside a 10 cm diameter stainless steel secondary containment pipe. The trench is equipped with leak detectors, radiation probe penetrations, high-point vents, and exterior valving for monitoring and safety control functions.

A dewatering well between the tanks is used for periodic pumping of water from outside the vaults. The water outside the vaults is never completely removed. The hydraulic pressure of the water is considered secondary containment for any potential leaks into the vault. Liquid can also be pumped from the secondary containment pans (see Figure 1). Water is currently pumped from outside the vaults on a weekly basis and pumping from the containment pans is necessary only one to four times per year. There is currently very little ingress of water into the vaults, but the humidity is always at or near 100%.

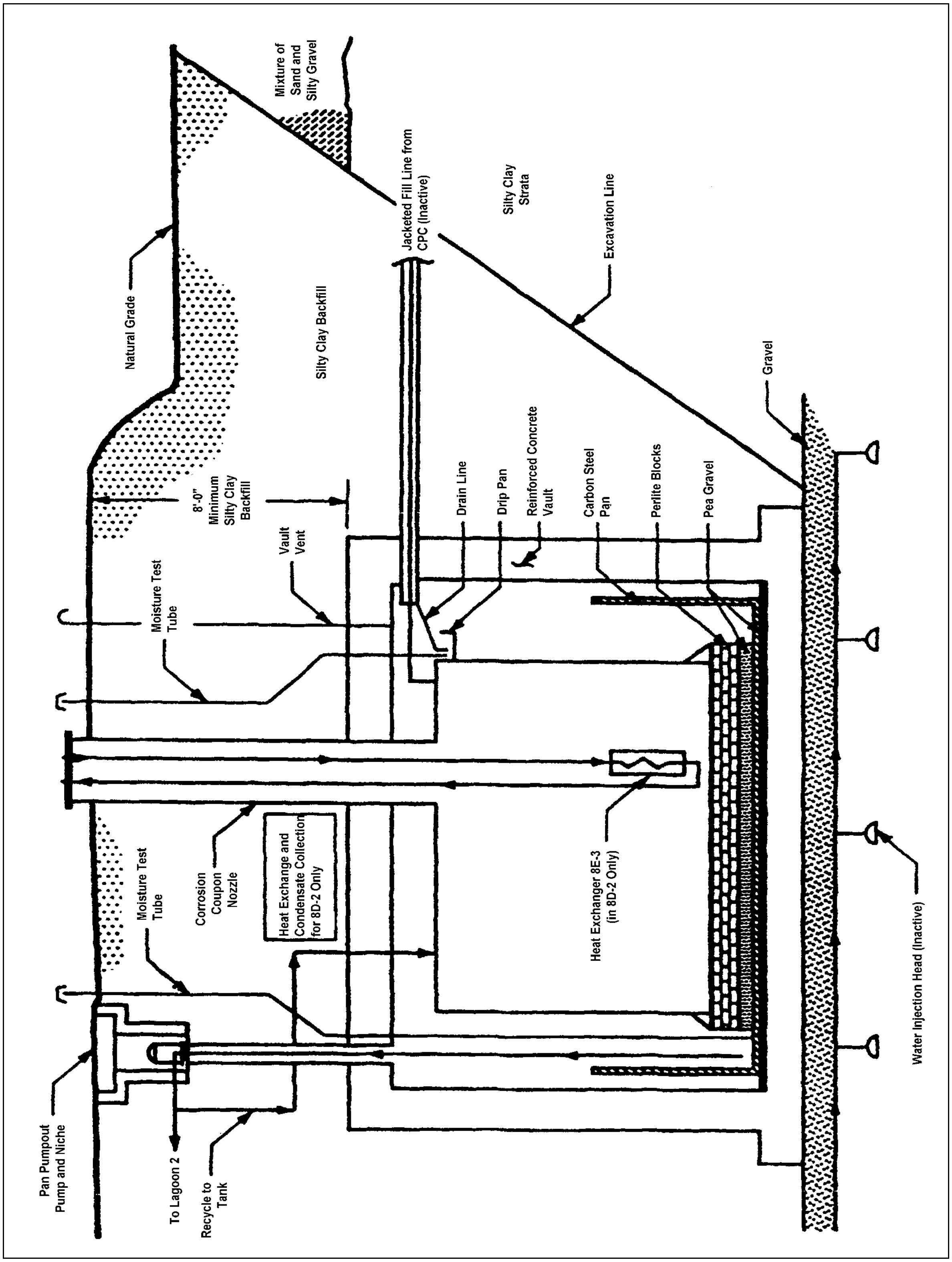

Fig. 1. Schematic of Waste Tanks 8D-1 and 8D-2

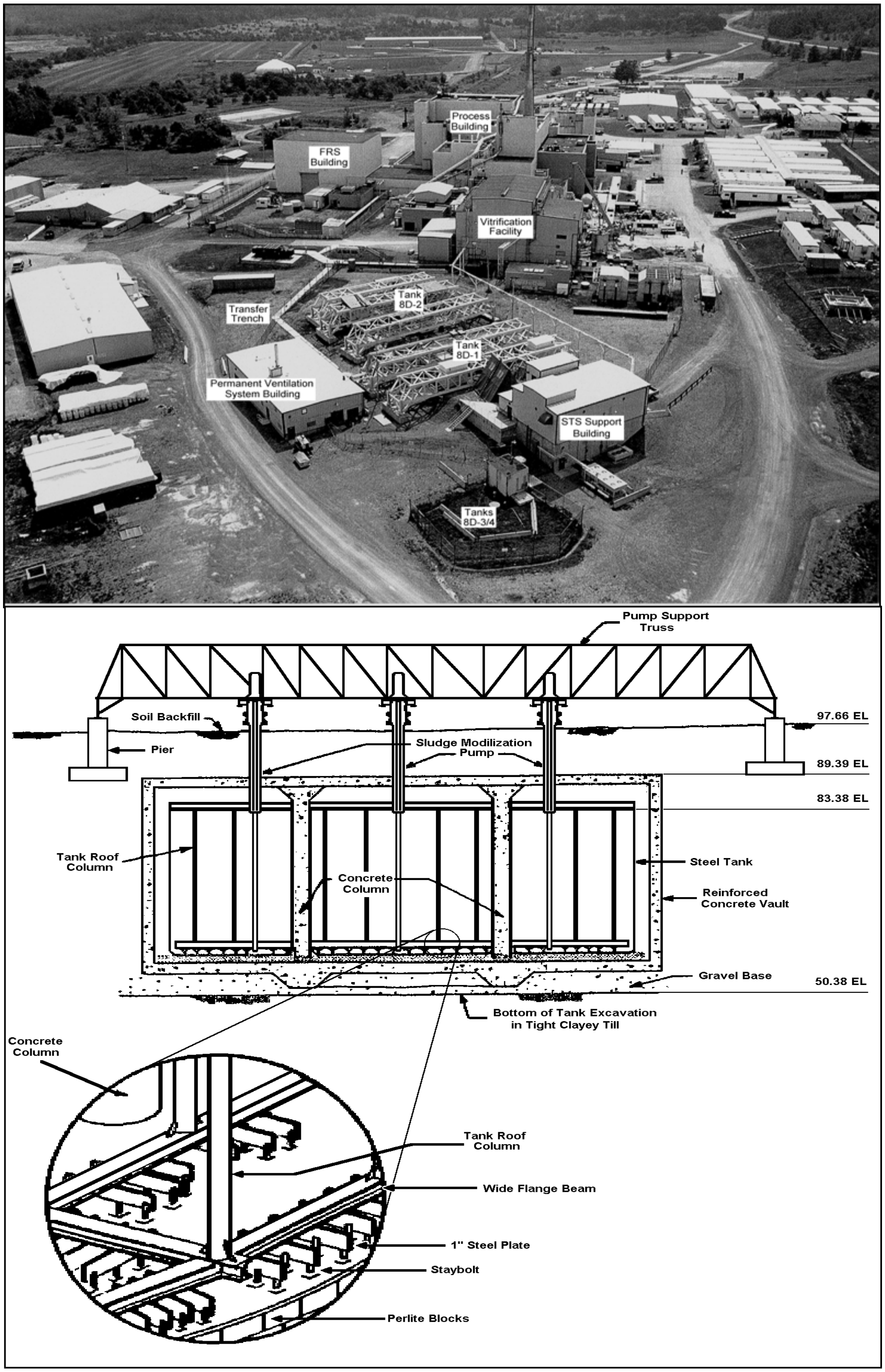

Fig. 2. Structural Components of West Valley Demonstration Project HLW Tanks

There has been no leakage of waste from the tanks. However, very small amounts of contamination have been detected in water pumped from inside the tank 8D-2 vault. The contamination is believed to be from small leaks during transfers of waste from the process building that were washed into the vault by water percolation from the surface.

DECISION CRITERIA

The primary objective for temporary tank lay-up is to maintain the tanks in a safe and stable configuration with minimum capital and operating costs until final closure is completed. Some of the decision criteria listed below are firm requirements (e.g., safety) while others are more value based (e.g., stakeholder acceptance). Weighting factors are assigned as part of the decision process to provide a means for ranking alternative lay-up strategies. The weighting factors are used to vary the importance or influence of the different requirements. The decision criteria identified for lay-up of the WVDP tanks were the following.

- **Comply with regulations and permit requirements** – All regulations and permit requirements must be complied with during the lay-up period.
- **Ensure acceptable risk to workers and the public**
  - **Short-term risk:** The risks associated with the installation of any new equipment required for the selected option must be as low as reasonably achievable.
  - **Long-term risk:** The selected option should result in a reduced risk to workers and the public during the lay-up period.
- **Maintain integrity of the tanks** – The ability of the tanks to continue to contain the waste residual must be maintained. Corrosion of the tanks must be controlled, and the structural integrity of the tanks must be ensured.
- **Establish a safe operating envelope during temporary lay-up** – The operational requirements during the lay-up period must continue to be within safe limits, but reduced monitoring and surveillance should be considered in evaluating options.
- **Control costs**
  - **Capital costs:** of new equipment or modifications to existing systems.
  - **Routine operating costs:** during the lay-up period.
- **Utilize accepted methods and technologies** – The preferred option should be based on proven construction methods and demonstrated technologies.
- **Avoid production of secondary wastes during construction and operation** – Options that may produce secondary wastes, especially radioactive wastes that will require further treatment and disposal, should be generally avoided.
- **Preserve future options for decontamination and final closure** – The selected lay-up option must maintain the ability to sample the waste, perform additional waste removal, and complete

additional decontamination of the tanks if necessary. Also, the lay-up option selected must not preclude candidate final closure options, such as in-place stabilization or complete tank removal.

- **Gain acceptance for lay-up** – The selected option must be acceptable to stakeholders. Any changes to permits or other requirements must be acceptable to regulatory agencies.

- **Reduce monitoring and surveillance** – Reductions in monitoring and surveillance, consistent with requirements, is desired.

ALTERNATIVE LAY-UP STRATEGIES

Several alternative strategies were identified to provide for continued safe storage of the residual waste in the tanks prior to final closure (1). The lay-up strategy selected should provide the best balance among the evaluation criteria for placing the tanks in a safe, stable, and minimum maintenance mode that does not compromise final closure options. The following strategies were identified for consideration (1).

Current System

The historical methods of corrosion control have been to periodically remove water from the containment pan, control the pH and nitrite/nitrate ratio of the liquid inside the tanks, and maintain a nitrogen purge inside the vaults. The corrosion rate of the tank internals is believed to be controlled in the range of 0.013 to 0.025 mm/yr (0.5 to 1.0 mils per year) (2). However, pH and nitrite/nitrate limits have not been rigorously maintained since waste retrieval operations began, decreasing the level of the confidence of corrosion control.

Pumps are currently used to remove water from outside and inside the tank vaults. However, there will continue to be a concern that corrosion to the external surfaces of the tanks could eventually result in penetrations during the lay-up period. Corrosion of the external tank walls is primarily from the wet conditions inside the vaults. General corrosion rates determined from corrosion coupons are generally less than 0.075 mm/yr (3 mils per year) and the highest measured rate is 0.188 mm/yr (7.4 mils per year) (2). The external pitting corrosion rate has been estimated at up to 0.3 ± 0.075 mm/yr (12 ± 3 mils per year) (3). If this rate has been experienced since the tanks were built, there may be little remaining corrosion allowance at locations prone to pitting.

The nitrogen inerting system has been in operation since August 1996. The oxygen concentration in the vault exhaust gas has been maintained at about 13.5% to 15.5% (oxygen concentration in air is 21%) even though the system was originally designed to maintain the oxygen concentration below 0.99% (4). Assuming an even distribution of nitrogen in the vaults, use of the system has resulted in an estimated decrease in the external corrosion rate of tank 8D-1 by about 33% (2). The nitrogen inerting system also reduces the concentration of other impurities in the gas surrounding the tanks, such as sulfur dioxide, that can also accelerate corrosion.

Cathodic Protection for External Tank Surfaces

One alternative method for cathodic protection is to use the containment pan as the sacrificial anode. The tank 8D-2 containment pan is known to have a hole in it, so use as a sacrificial anode would be reasonable because its original purpose is already compromised. There are several technical and engineering issues that must be resolved before this cathodic protection could be implemented. These include (a) galvanic corrosion on the bottom of the tank; (b) runaway voltage with the impressed current system; (c) protection of welds; and (d) assurance that no electrical shorts are present (e.g., pan pump, dip tubes) (2).

Vault Drying System

General textbook corrosion rates of carbon steel in water are generally 0.075 to 0.20 mm/yr (3 to 8 mils per year) and pitting corrosion rates are generally 2.5 to 3.5 times the general corrosion rate. External tank corrosion could be virtually eliminated if the tank surfaces were kept dry. The criterion would be to maintain the relative humidity below 30% in the air surrounding the tanks (3). The drying system would include a dehumidifier and heater for air forced into the vaults. The exhaust air leaving the vaults would pass through high-efficiency particulate air filters.

Vault and Tank Drying

An additional enhancement to also reduce corrosion inside the tanks is to install drying systems both inside the vaults and inside the tanks. Drying the inside of the tanks could result in contamination of the exhaust air by particles of dried solids in the tanks being suspended by the airflow through the tanks. However, once all the liquid inside the tanks was evaporated, only a very low-flow of heated, dehumidified air would be required to maintain low humidity inside the tanks. Keeping the tank internal surfaces the same temperature as the external surfaces would also prevent condensation of water on the tanks' external walls.

Nitrogen Blanket

The current nitrogen inerting system has not been effective in maintaining the desired concentration of oxygen in the vault below 0.9% as specified in the design criteria (4). Sealing the vault as well as possible and then adding additional amounts of cold nitrogen to displace air from the vault should result in a more effective blanket and lower oxygen concentrations.

Nitrogen Blanket with Oxygen Removal

Oxygen removal from the gas surrounding the tanks to a low level (the original design criterion for the nitrogen purge was less than 0.9% oxygen) may provide adequate protection without additional measures taken to keep the vaults dry. An efficient nitrogen blanket (recirculating system) would also be required for this option. Recirculated blanket gas could be passed through a device to remove oxygen. Such a system would be efficient only if air in-leakage is significantly reduced.

Argon or Other High Density Inert Gas Instead of Nitrogen

Argon would be used instead of nitrogen to improve the displacement of oxygen and other corrosion-inducing gases from the vaults because argon is heavier than air. Proper use of an argon blanket should not require additional capability for oxygen removal. This option has been considered in the past, as early as 1997 (5).

Argon Blanket with Cathodic Protection

Argon would be used instead of nitrogen to improve the displacement of oxygen and other corrosion-inducing gases from the vaults in combination with cathodic protection for additional assurance of corrosion control.

Interceptor Trench/Drying

One of the primary methods of preventing or significantly reducing corrosion on the outside of the tanks is to maintain very low humidity in the vaults. To do this, the ingress of water into the vaults must be prevented. The principal source of water into the vaults appears to be from percolation of rainwater and snowmelt through the soil layer above the vaults and groundwater flow in the soil/sand layer above the compacted clay layer. One method to significantly reduce this infiltration is to divert runoff and groundwater flow. This could be accomplished by installing an interceptor trench down to the compacted clay layer upgradient of the tanks. This trench would be filled with coarse gravel and perforated pipe would be installed at the bottom of the trench to collect and remove excess water. The trench would be connected to a culvert to carry water to an appropriate location downgradient from the tanks and vaults. This would be a totally passive system. Pumping of water from the vaults and the well between the vaults could be eliminated or significantly reduced.

Trench/Infiltration Barrier/Drying

To increase the effectiveness of a trench, a domed clay cap, roof, or some other cover barrier could be added above the vaults to divert rainwater and snowmelt to the trench rather than infiltrating through the soil to the vaults.

A principal source of water ingress into the tank vaults appears to be from infiltration from above the vaults. A cover to divert rainwater away from the area would be effective in preventing this water from entering the vaults. This barrier could be a clay cap, a membrane, a roof, or some other cover.
The superstructure that was installed to support the mobilization pumps and penetrations into the soil above the tanks and vaults complicates installation of a barrier above the vaults.

Infiltration Barrier/Drying/Enhanced Pumping

To ensure that water will not infiltrate into the vaults from groundwater around and below the vaults, the capability to pump water from the gravel bed below the vaults could be maintained or enhanced. Water is currently pumped from a well between the vaults, but the water table is not pumped to below the bottom of the vaults. The hydrology is not known well enough to determine the volume of water that would need to be pumped to maintain the water table below the level of the vaults. More frequent operation of the current system or additional wells and pumps may be needed. Elimination of surface water infiltration and possibly also a reduction in groundwater flow (as described in the preceding sections) may be necessary for this approach to be effective.

If the combination of a trench, infiltration barrier and drying system was not effective, then additional pumping of water from inside and below the vaults could be instituted. The need for additional pumping is unlikely.

Groundwater Barrier/Drying

A solid barrier to groundwater flow could be installed if more positive exclusion of groundwater from the vaults is needed. This barrier could be a solid grout wall, a frozen soil barrier, or a viscous liquid barrier.

A barrier around the vaults may be a more positive means to preclude water intrusion than would an interceptor trench; however, this would be a much more costly approach and may not be necessary.

Infiltration Barrier/Drying

A barrier above the tanks would be very effective in preventing water intrusion into the vaults.
The combination of a barrier above the vaults and a drying system (no interceptor trench or barrier) may be adequate for keeping the vault humidity within an acceptable level. This is dependent on the amount of water that could infiltrate the vaults from groundwater flow alone, which appears to be quite small.

Corrosion Inhibitors in the Water Outside the Tanks

Adding corrosion inhibitors to water in the containment pans may reduce the corrosion on the outer walls below the liquid level. The same corrosion inhibitors would not be effective for reducing corrosion in the high-humidity vapor space above the liquid level.

Sorbents in Annulus

An ion exchange and/or sorbent material could be added to the secondary containment pan and/or the vault to capture the radioactive species before they could migrate outside the vault. Additional information would be required to determine if a combination of materials could be selected that would be effective for all the species of concern.

Sorbents with Cathodic Protection

A relatively low-cost approach would be adding a cathodic protection system and also sorbents for added protection in the unlikely event of a leak. However, reliable corrosion control with cathodic protection alone is uncertain.

Low-Strength Grout

The objective of using a low-strength grout is to provide a method for temporarily fixing the residual waste in the tank. Nearly all the residual liquid would have to be removed before the grout was added. A low-strength grout would be necessary so that it could be removed in the future if final closure requires additional decontamination of the tanks or complete removal of the tanks. Adequate mixing of the grout with the residual waste has not been demonstrated.

Low-Strength Grout/Drying

Adding a low-strength grout would be combined with a drying system for the tanks and vaults. The drying system would be very effective in reducing corrosion and the grout would stabilize the radionuclides and reduce or possibly prevent leakage even if a penetration in the tank wall developed.

Contamination Fixative

Another method for temporary stabilization of the residual material in the tank would be to spray a coating to prevent any suspension of contamination. This fixative could be used in combination with keeping the inside of the tanks dry to prevent corrosion or to reduce contaminated solids suspension if the tank contents are allowed to dry during the lay-up period. In fact, the tank contents would first have to be dry before a fixative could be applied. The drying system would reduce corrosion and the fixative would stabilize the radionuclides and prevent dispersion into the offgas system.

Monitors

Radiation and/or contamination monitors in the tanks or vaults would indicate changes in conditions and possible leaks. There are several monitors on the market that could be installed to give early warning of a tank failure. A gamma monitor would need to be shielded from the background radiation inside the tank, or an alpha and/or beta monitor could be used.

Continuous corrosion monitors could also be installed in the tanks and vaults. These monitors would provide an indication of accelerated corrosion due to unexpected changes.

Depending on the composition of waste in the WVDP carbon-steel tanks, the tanks may be susceptible to nitrate ion-induced stress corrosion cracking. Monitoring and maintaining adequate nitrite/nitrate ratio and hydroxide ion levels prevents this degradation. Sensors that could monitor all three species could reduce the costs of current baseline sampling and laboratory analysis methods and could minimize the addition of corrosion inhibitor solution. Savannah River Site (SRS) personnel are currently evaluating a Raman spectroscopy-based method for in situ analysis of OH^-, NO_2^-, and NO_3^-.

Waste Removal

Very aggressive decontamination could be employed prior to temporary tank lay-up. Removal of all but a very small amount of residual contamination may preclude the need for any further action prior to final closure. Waste removal might have a lower life-cycle lay-up cost than other strategies that require continued operation of equipment (such as the nitrogen purge system) and surveillance. However, the criteria for what constitutes adequate decontamination are not established and any residual contamination could present a risk to the environment.

Table I is a summary of the lay-up strategies considered for the WVDP tanks.

DECISION PLAN METHODOLOGY

A methodology for ranking the strategies was developed. The methodology consists of scoring each strategy with each of the selection criteria. Team members supply weighting factors from 1 to 5 for each of the criteria, and scores from 1 to 5 for how well each strategy meets the criteria. A total score for each strategy is then calculated as a sum of the products of each score times the associated criterion weighting factor.

A flowchart of the methodology is shown in Figure 3.

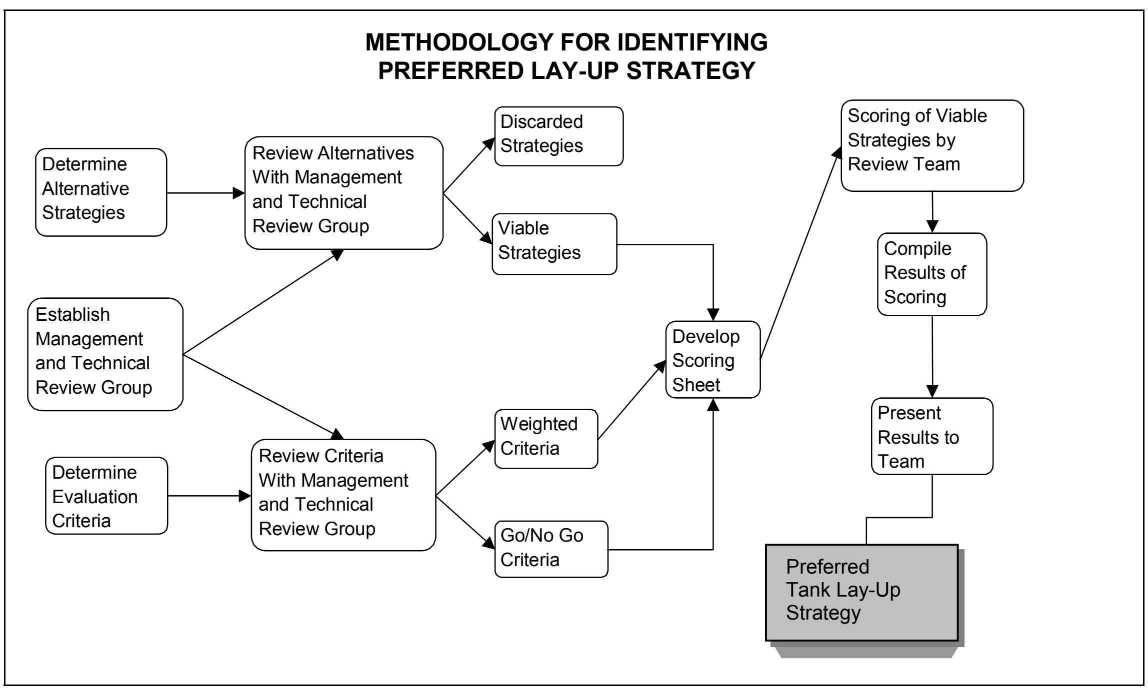

Fig. 3. Methodology for Identifying Preferred Lay-Up Strategy

Table I. Alternative Strategies for West Valley Demonstration Project Tank Lay-Up

Strategy	**Dry or Wet Option**	**Nitrogen Inerting**	**pH Control**	**Cathodic Protection**	**Vault Drying**	**Tank Drying**	**Nitrogen Blanket**	**Ar Inerting**	**Oxygen Removal**	**Interceptor Trench**	**Ground-water Barrier**	**Infiltration Barrier**	**Enhanced Pumping**	**Corrosion Inhibitors**	**Sorbents in Annulus**	**Low Strength Grout**	**Contaminati on Fixative**	**Corrosion Monitors**	**Radiation/ Contaminati on Monitors**	**Complete Waste Removal**
Current System	Wet	X	X																	
Cathodic Protection	Wet	X	X	X																
Vault Drying	Dry		X		X															
Vault & Tank Drying	Dry				X	X														
Nitrogen Blanket	Wet		X				X													
Nitrogen Blanket w/Oxygen Removal	Wet		X				X		X											
Argon Blanket	Wet		X					X												
Argon Blanket w/Cathodic Protection	Wet		X	X				X												
Interceptor Trench/Drying	Dry		X		X					X										
Trench/Infiltration Barrier/Drying	Dry		X		X					X		X								
Trench/Infiltration Barrier/Drying/Enhanced Pumping	Dry		X		X					X		X	X							
Groundwater Barrier/Drying	Dry		X		X						X									
Infiltration Barrier/Drying	Dry		X		X							X								
Corrosion Inhibitors in Vault	Wet	X	X											X						
Sorbents in Annulus	Wet	X	X												X					
Sorbents with Cathodic Protection	Wet	X	X	X											X					
Low Strength Grout	Wet	X														X				
Low Strength Grout/Drying	Dry				X	X										X				
Contamination Fixative/Drying	Dry				X	X											X			
Monitors	Wet		X															X	X	
Waste Removal	Wet																			X

DEMONSTRATION OF METHODOLOGY

A team with a broad range of experience was selected to provide scores on the matrix that were used to demonstrate the methodology. These sample scores provided a starting point for demonstrating the methodology. The ranking of strategies resulting from these scores are reported only to demonstrate the methodology and are not intended as a recommendation of preferred strategies.

The scoring team was comprised of three personnel from the Richland Jacobs office, three from the Denver Jacobs office, and three from Pacific Northwest National Laboratory. The disciplines represented were: chemist, chemical engineer, civil engineer, environmental engineer, corrosion engineer, hydrogeologist, mechanical engineer, and regulatory specialists (two).

A combined ranking of the strategies from the team member rankings is shown in Table II. The combined ranking is based on assigning a score of 5 to each #1 ranking, a score of 4 to each #2 ranking, etc. down to a score of 1 for each #5 ranking. Table II shows that the strategy of installing an interceptor trench in combination with an infiltration barrier and vault drying is clearly preferred. There is very little difference in the scores for the strategies ranked second through fifth. There are a number of strategies that ranked low indicating that there was little confidence by any of the team members that the strategies as described would meet the tank lay-up goals.

The criterion that scored highest was Prevent Release of Tank Contents. Other criteria that scored high were:

- Acceptable Long-Term Risk
- Maintain Tank Integrity
- Acceptable Short-Term Risk
- Safe Operating Envelope
- Preserve Closure Options.

UNCERTAINTY OF STRATEGIES

After the alternative strategies and evaluation criteria were identified, it was apparent that information gaps made evaluation and ranking of the strategies difficult. The effectiveness and acceptability of several of the options are not fully developed. The principal information needs identified to reduce the uncertainties are listed below.

- A better estimate of the remaining corrosion allowance for the tanks.

- An estimate of the maximum rate of surface runoff from rain and/or snowmelt to establish the size of an interceptor trench in order to determine a cost estimate for that option.

- Data and analysis to establish if pumping from below the vaults alone would reduce groundwater infiltration into the vaults to a rate low enough for a drying system to be effective.

- Determination of whether maintaining a liquid inventory inside the tanks with continued chemistry adjustments is adequate to control internal corrosion.

- Determination of whether effective control of the oxygen concentration in the gas in the annuli alone can control external corrosion within an acceptable rate. If so, is an oxygen removal system needed or will a better inert gas system suffice?

Table II. Combined Rankings of Team Members

Sorted by Rankings Score	Ranked #1	Ranked #2	Ranked #3	Ranked #4	Ranked #5	Rankings Score
Trench/Infiltration Barrier/Drying	1	3	2	0	0	23
Trench/Infiltration Barrier/Drying/ Enhanced Pumping	2	1	0	1	0	16
Low Strength Grout/Drying	2	1	0	0	1	15
Waste Removal	2	0	0	2	1	15
Low Strength Grout	0	2	1	1	1	14
Interceptor Trench/Drying	2	0	0	0	0	10
Vault & Tank Drying	0	0	3	0	1	10
Contamination Fixative/Drying	0	1	1	0	0	7
Vault Drying	0	1	1	0	0	7
Current System	0	0	1	0	1	4
Groundwater Barrier/Drying	0	0	1	0	1	4
Infiltration Barrier/Drying	0	0	0	1	1	3
Nitrogen Blanket	0	0	1	0	0	3
Corrosion Inhibitors in Vault	0	0	0	1	0	2
Monitors	0	0	0	1	0	2
Sorbents in Annulus	0	0	0	1	0	2
Cathodic Protection	0	0	0	0	1	1
Argon Blanket						0
Argon Blanket w/Cathodic Protection						0
Nitrogen Blanket w/Oxygen Removal						0
Sorbents with Cathodic Protection						0

- Determine if a system to maintain the vaults and all external surfaces of the tanks in a dry condition is necessary to ensure an acceptable corrosion rate. The primary concern is keeping the bottoms of the tanks dry.

- Determine if a tank wall penetration must be prevented during lay-up or if small penetrations that would not result in releases outside the tanks or vaults would be acceptable.

- Resolution of the technical and engineering issues related to cathodic protection.

- Determination of the acceptability of using argon rather than nitrogen due to the higher cost and safety concerns.

- Determination of whether the pumps in the catch pans need to be relocated to be at the lowest point.

- Determine if sorbent material(s) could capture all leaking radionuclides of concern.

- Estimates of the expected life of potential groundwater barrier systems.

- A more detailed assessment of adding and maintaining corrosion inhibitors in the water in the vault.

- Feasibility of decontamination prior to lay-up precluding the need for any further preparation for lay-up.

- Updates to existing preliminary cost estimates and new preliminary cost estimates for several options, including:

  - Installation of an interceptor trench or an underground barrier
  - Installation of an infiltration barrier
  - Addition of a roof above the vaults and tanks
  - Installation and operation of an oxygen removal system
  - Continuous corrosion monitoring of tanks’ external surfaces.

FUTURE WORK

DOE is responsible for 283 large, underground storage tanks that contain millions of liters of radioactive waste. The tanks are located at the Hanford Site, SRS, WVDP, Idaho National Engineering and Environmental Laboratory (INEEL), and Oak Ridge Reservation (ORR). As a result of processing spent nuclear fuel, DOE has generated over 400 million L of liquid HLW complex-wide. Approximately 90% of this waste remains in storage in liquid form. DOE is proceeding with plans to treat the liquid HLW, converting it to solid forms that would not be readily dispersible into air or leachable into groundwater or surface water. The baseline technology is vitrification. Approximately 22,000 canisters (varying in volume from 0.6 to 1.2 m^3) will be produced if the total current inventory of HLW is vitrified.

The tanks were built from the 1940s through the 1980s and have capacities ranging from 50,000 to over 3.8 million L. The waste in these tanks is classified as HLW, transuranic waste, and/or mixed waste. Several of the tanks have exceeded or are approaching the end of their design life. Sixty-eight tanks are known or suspected to have leaked waste to the ground (67 at the Hanford Site and 1 at SRS). The tank wastes differ both physically and chemically between sites, between tanks on a site, and in some cases, between phases of waste within a tank.

As tanks age, the possibility of waste entering the environment increases. To minimize the risk of waste release and subsequent exposure to workers, the public, and the environment, and to adhere to cleanup agreements entered into by DOE, the waste must be retrieved and the tanks closed.

When generated, HLW is a highly radioactive, acidic liquid that generates heat and must be handled remotely behind heavy shielding in corrosion-resistant vessels, usually made of stainless steel. At the Hanford Site (Hanford), because stainless steel was in short supply, HLW was neutralized with caustic soda (sodium hydroxide), and sodium nitrite was then added for corrosion control so that the HLW could be stored safely in carbon-steel tanks. This practice continued at the Hanford Site, the SRS, and the WVDP, even when stainless steel became more readily available.

Neutralization with caustic soda forms sodium nitrate (which remains in solution) and hydrated oxides of certain radionuclides and non-radioactive chemicals (which precipitate and collect as a sludge on the floor of the tank). The cesium-137 remains largely in solution. The supernatant liquid resulting from neutralization may also become concentrated by evaporation—either by self-boiling or in evaporators. If enough water is removed from the waste, sodium nitrate and sodium nitrite will crystallize from the solution. The crystals then will settle to the bottom of the tank liquid. If there are many crystals, a salt cake will form on top of the liquid.

The Hanford Site performed several different separations processes during plutonium production, and additional operations such as uranium, cesium, and strontium recovery. As a result, there are several different waste types at the Hanford Site. WVDP wastes were generated from commercial reprocessing of uranium and plutonium from spent nuclear fuel. ORR wastes are similar in composition to wastes at the Hanford Site and SRS because, during World War II, ORR developed and demonstrated many of the chemical separations processes used at those sites.

At INEEL, however, the waste has always been stored as an acidic liquid in stainless steel tanks. The majority of INEEL's waste has been calcined (converted to a dry, granular powder similar in consistency to dry laundry detergent), which is considered an interim storage waste form by the state of Idaho. Calcine waste requires further processing to convert it to a more durable, long-term waste form. In addition, INEEL has some tank-heel waste remaining that must be addressed.

Each site is at a different stage in remediation of its wastes and closure of tanks. All of the sites require technical assistance, scientific data, technology development, and baseline technology performance verification to improve efficiency, reduce costs, reduce risks, and enable the baseline tank waste remediation and closure activities to be implemented.

All the sites have programs in place to monitor the condition of the tanks to prevent leaks to the environment and have long-range plans for closure of the tanks. However, the selection of preferred alternatives for interim lay-up of tanks has not been rigorously pursued. In addition to the tanks themselves, several of the sites have concerns with piping and other auxiliary equipment associated with the tanks.

The proposed next step is to use a methodology similar to that developed for assessing WVDP tank lay-up alternatives to address any necessary lay-up activities needed for the other HLW tanks across the DOE complex. This could provide technically defensible strategies that minimize monitoring and maintenance costs, meet environmental regulations for tank closure, protect worker health and safety, and address stakeholder concerns.

CONCLUSIONS AND RECOMMENDATIONS

The methodology developed for ranking the potential strategies for lay-up of the WVDP tanks can be used to provide a basis for a decision on the preferred path forward. The methodology will provide a consensus ranking even with wide variations in scores from individual team members as long as the number of team members is large enough. A minimum of 8 team members is recommended, and 10 to 12 members would be better. Because of the number and types of technical issues associated with the strategies, the evaluation team should be comprised of a broad spectrum of technical experts and decision makers.

The current uncertainties associated with several strategies will tend to result in more costly and complex strategies to be favored. Strategy-specific performance data could result in simpler strategies. Also, there may be other strategies and criteria identified during the process that will be ranked higher than most or all of the strategies identified in this report. In the absence of performance data for the strategies, there is a tendency to rank the strategies on a relative basis because the minimum but sufficient effort to meet the tank lay-up goals is unknown.

All the strategies and criteria should be presented to the team members to ensure a common understanding. The team should then determine if additional strategies should be scored and if the decision criteria should be modified. Any changes to the strategies or criteria should be done before the scoring starts. Orientation, scoring, and discussions should be in a facilitated session or sessions.

A difficulty in evaluating the lay-up strategies for the WVDP tanks is that there is incomplete information on the cost and performance for several of the identified strategies. A recommended path forward would be to reevaluate the strategies identified in this report based on the example ranking and eliminate or reconfigure the strategies that were ranked at or near the bottom. Preconceptual engineering data should be developed for the remaining strategies to facilitate scoring and ranking using this methodology. The team members should be consulted to identify any additional information needs to support making informed decisions. The initial rankings will have to be made based on the available information.

Once each team member scores the strategies, the scores can be combined and the team members can then be reconvened to discuss the results. Any wide variations among scores should be discussed to ensure there are no errors. This discussion will also help team members share their points of view and expertise or experience on the strategies. The discussion can then focus on the composite ranking to determine if there is consensus. The team members should be allowed to discuss whether the list should be modified based on the information shared. The team should develop a final, consensus-ranked list of the top five strategies. The team, WVDP, and DOE management should then decide whether to proceed with conceptual design of the top one or two strategies or specify the additional information needed to make a final decision.

The methodology developed for WVDP is also applicable to determining preferred lay-up approaches at other DOE sites. Some of the alternative strategies identified for the WVDP should also be considered for implementation at the other sites. Each site has unique characteristics that would require unique considerations for lay-up.

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