Recent Progress in DOE Waste Tank Closure - 8396

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ABSTRACT

The USDOE complex currently has over 330 underground storage tanks that have been used to process and store radioactive waste generated from the production of weapons materials. These tanks contain over 380 million liters of high-level and low-level radioactive waste. The waste consists of radioactively contaminated sludge, supernate, salt cake or calcine. Most of the waste exists at four USDOE locations, the Hanford Site, the Savannah River Site, the Idaho Nuclear Technology and Engineering Center and the West Valley Demonstration Project.

A summary of the DOE tank closure activities was first issued in 2001. Since then, regulatory changes have taken place that affect some of the sites and considerable progress has been made in closing tanks. This paper presents an overview of the current regulatory changes and drivers and a summary of the progress in tank closures at the various sites over the intervening six years. A number of areas are addressed including closure strategies, characterization of bulk waste and residual heel material, waste removal technologies for bulk waste, heel residuals and annuli, tank fill materials, closure system modeling and performance assessment programs, lessons learned, and external reviews.

REGULATORY CHANGES

Prior to 2002, the Waste Incidental to Reprocessing (WIR) process, as defined in the Department of Energy (DOE) Order 435.1 and associated manual and guidance documents, was used as the regulatory basis for planning and operation of the tank closure activities at Hanford Site, Idaho Cleanup Project, the Savannah River Site (SRS), and the West Valley Demonstration Project (WVDP) [1]. This order describes the criteria and process for determining whether a waste is incidental to reprocessing and thereby can be classified and managed in accordance with the requirements for either Transuranic (TRU) waste or low level waste (LLW).

In February 2002, the Natural Resources Defense Council (NRDC) filed suit against DOE, stating that the Nuclear Waste Policy Act did not allow DOE to reclassify HLW and dispose of it anywhere except in a geologic repository [2]. In July 2003, the U. S. District Court of Idaho granted summary judgment to NRDC and declared the DOE WIR process, as described in Order 435.1, to be invalid. The DOE appealed the decision and, in November 2004, the U. S. Court of Appeals for the Ninth Circuit vacated the lower court's decision on ripeness[1] grounds [3].

In October 2004, while the NRDC law suit was under review, the National Defense Authorization Act of 2005 (NDAA) was passed [4]. Section 3116 of the NDAA is applicable to two of the four states where tanks store high level waste, Idaho and South Carolina. This section states that the term "high-level radioactive waste" does not include radioactive waste resulting from reprocessing of spent nuclear fuel if the Secretary of Energy, in consultation with the U. S. Nuclear Regulatory Commission (NRC), determines that:

(1) The waste does not require permanent isolation in a deep geologic repository for spent fuel or high level radioactive waste; and
(2) The waste has had highly radioactive radionuclides removed to the maximum extent practical; and
(3) The waste does not exceed concentration limits for Class C low-level waste as set out in 10 CFR 61.55 and will be disposed in compliance with the performance objectives in 10 CFR 61, Subpart C and pursuant to a State-approved closure plan or State-issued permit; or
(4) The waste exceeds concentration limits for Class C low-level waste as set out in 10 CFR Part 61.55 but will be disposed of in compliance with the performance objectives in 10 CFR 61 Subpart C, pursuant to a State-approved closure plan or State-issued permit, and pursuant to plans developed by the Secretary of Energy in consultation with the NRC.

Consequently, since late 2004, tank closures at Idaho and Savannah River have been and are being conducted under the Waste Determination (WD) process defined under Section 3116 of the NDAA, whereas, tank closure at Hanford and West Valley, are being conducted under the DOE-WIR process defined under DOE Order 435.1.

To comply with Section 3116, DOE- Savannah River (DOE-SR) is planning to submit a WD for each of the two tank farms covering all HLW tank planned for closure.[2] DOE-Idaho (DOE-ID), similarly, submitted one document that covered their entire tank farm facility [6]. After technical consultation with the NRC and review by the State of Idaho, the U.S. Secretary of Energy issued the WD for tank closure for Idaho.

A Performance Assessment (PA), approved by DOE-Environmental Management (DOE-EM), is required to support on-site disposal of waste determined to be low level by either the WD (Idaho, SRS) or WIR (Hanford, West Valley) process. The DOE Low-level Waste Facilities Review Group (LFRG) provides a review of PA to support the DOE approval process. The Idaho Tank Farm Facility PA was reviewed in 2003 [**7**]. The SRS F Area Tank Farm PA was submitted to DOE-SR in December 2007 [8]. PAs for the Hanford tank farms and for the WVDP are in the development stage.

DOE tank closure activities must also comply with other regulatory requirements. For example, high-level waste tank waste sites at Hanford, Idaho and the SRS have been identified as Superfund Sites by the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), which requires the sites to develop Federal Facility Agreements (FFA) or Interagency Agreements. FFAs include negotiated binding solutions and time lines for disposition of these facilities [9, 10, and 11].

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[1] In United States law, ripeness refers to the readiness of a case for litigation; "*a claim is not ripe for adjudication if it rests upon contingent future events that may not occur as anticipated, or indeed may not occur at all*." For example, if a law of ambiguous quality has been enacted but never applied, a case challenging that law lacks the ripeness necessary for a decision.

[2] The first SRS WD was prepared for the Saltstone disposal system and was reviewed by NRC and South Carolina Department of Health and Environment Control (SCDHEC) in 2006 [5].

The HLW tanks at the WVDP are not a CERCLA site and much of the clean up is being performed as National Environmental Policy Act (NEPA) activities under a Cooperative Agreement [12].

In Section 3146 of the NDAA, the U.S. Congress commissioned the National Academies of Science (NAS) to evaluate the Department of Energy plans for retrieval and on-site disposal of certain radioactive wastes stored in underground tanks at Hanford, Idaho, and Savannah River and to make recommendations to improve those plans. The final report from the NAS committee concluded:

> "DOE's overall approach for management and disposal of tank wastes is workable, but important technical and programmatic challenges remain. In particular, the essential question, "How clean is clean enough?" applies to all cleanup activities and does not have a unique, numerical solution. The amount of waste to be retrieved from these tanks and how much of that should be disposed on-site is a decision in which DOE must consider a range of technical and non technical factors, including technical capabilities for waste retrieval and radionuclide separation from the removed wastes; cost, both in terms of dollars spent and worker doses incurred per increment of risk reduction achieved; and the potential risks from other wastes to be left on-site. DOE should pursue a more risk informed, consistent, participatory, and transparent process for making decisions about how much waste to retrieve from each of its tanks or group of tanks, and how much of that waste to dispose at each of the three sites" [13].

PROGRESS AT SAVANNAH RIVER

SRS has a total of 51 HLW tanks. The F-Tank Farm (FTF) and H-Tank Farm are located within F-Area in the General Separations Area (GSA) of the Savannah River Site (SRS). The GSA contains the F- and H-Area Separations Facilities, the S-Area Defense Waste Processing Facility, the Z-Area Saltstone Facility, and the E-Area Low-Level Waste Disposal Facilities. The FTF includes twenty-two waste tanks constructed between 1951 and 1976 and comprises approximately 20 acres (Figure 1). The HTF includes twenty-nine waste tanks that were constructed between 1952 and 1986 and comprises approximately 75 acres (Figure 2). Status of each of the SRS HLW tanks is presented elsewhere [14].

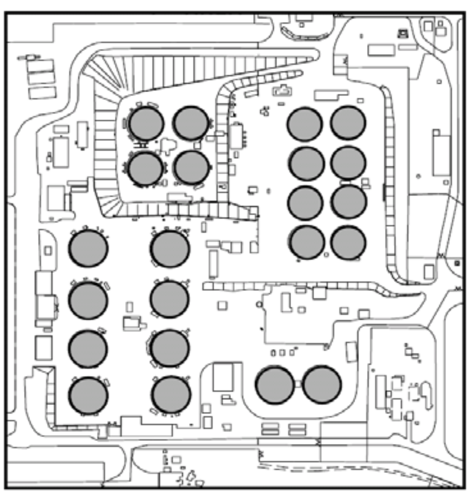

Fig. 1. General layout of the SRS FTF.

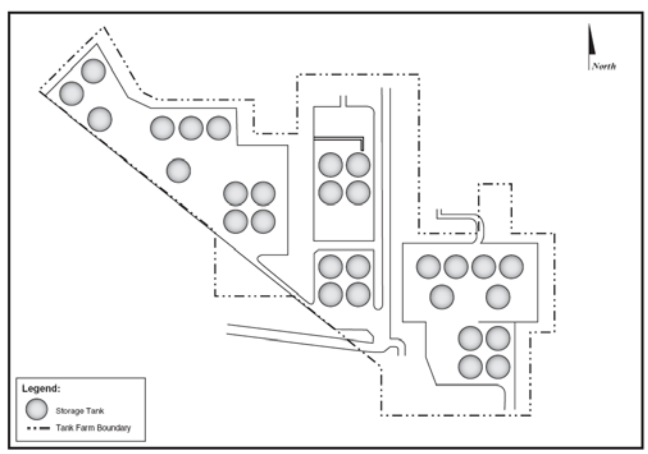

Fig. 2. General layout of the SRS HTF.

HLW tank closure at SRS is coupled to ongoing and planned operations at the SRS. Bulk waste removal and tank cleaning generate more waste volume than is freed up by these activities. Removing waste from the non-compliant waste tanks inevitably results in adding volume to the compliant tanks. Reduction of waste volume in the tank farm system is accomplished by either evaporation or by treatment that results in a final waste form. SRS has two operating facilities that produce final waste forms: the Defense Waste Processing Facility (DWPF) which treats HLW and produces a borosilicate glass waste form and the Saltstone Facility which treats decontaminated liquid salt waste and produces a cement-based (hydrated ceramic) waste form. Currently, the availability of freeboard (available volume capacity) in the tank farm system is a limiting factor for tank closure activities at the SRS.

The Site Regulatory Integration and Planning (SRIP) organization is in the process of preparing regulatory documentation (PAs, groundwater models, etc.) for closing several other waste tanks in the FTF and the HTF. The current closure concept for all of the FTF and HTF waste tanks is to fill the majority of each tank with a chemically reducing cementitious grout and then to fill the top of certain tanks with a strong grout to protect against inadvertent intrusion after closure.

Bulk waste removal was completed for Tanks 17-F and 20-F (two of the eight Type IV single shell, low heat tanks), and they were operationally closed in 1997 [15]. Over the past five years, SRS has changed direction with respect to retrieving waste from Tanks 18-F and 19-F (Type IV) which are the next tanks scheduled to be closed in 2010. These tanks do not contain cooling coils or other obstructions and are, therefore, candidates for additional residual waste removal using a robotic technology. Bulk waste retrieval was completed in these tanks in 2004. Robotic technology is currently being designed and demonstrated at a vendor in Denver CO. If successful, robotic retrieval will significantly reduce the residual waste heel in these two tanks. After mechanical cleaning, Tanks 18-F and 19-F will be permanently removed from service by filling them with cement-based grout. At SRS filling HLW tanks with grout constitutes operational closure. The final end state involves filling and contouring the surface and installing a landfill cap to shed infiltrating water.

To date, bulk waste removal has also been completed in Tanks 6-F (Type I) and 16-H (Type II).[3] Additional bulk waste removal and mechanical cleaning of Tank 5-F (Type I) and chemical cleaning for both Tanks 5-F and 6-F are currently scheduled for FY08. Additional heel removal is also scheduled for Tanks 1-F (Type I) in FY08.

Progress has also been made on cleaning the annulus space in Tank 16-H, which was emptied and chemically cleaned in 1981-82 [16]. During 2007, waste removal technology developed by Safety Ecology Corporation, Oak Ridge, TN, and SA Robotics, Denver, CO, was successfully demonstrated. This technology utilizes carbon fiber arms (light weight) mounted on a robotic crawler that is designed to deploy robotic tools to break up and remove the waste. Modifications are currently being made to the equipment and waste removal techniques to perform the work in the annulus of Tank 16-H [17].

SRS Tank Bulk Waste Retrieval Initiatives

Washington Savannah River Company (WSRC) tank farm engineering determined that a new slurry pump design was needed to significantly improve bulk waste retrieval and to accelerate sludge removal to support DWPF and tank closure and contracted with the Electromechanical Division of Curtiss-Wright to design and build the next generation mixer pump. The new Submersible Mixer Pumps (SMPs) were intended to replace the standard Lawrence Slurry Pumps and the Quad Volute Pumps (used in the Type 3A tanks). The SMPs were designed to last for 10,000 hours and to be relocated from one tank to another. The control room and hydraulic systems for the SMP pumps are also designed to be readily relocated. This concept is referred to as Waste on Wheels (WOW) because the control room and pumps are portable.

The new SMPs were installed in three of the SRS Type I tanks, 4-F, 5-F, and 6-F, and were successfully used to accomplish the activities listed below:

- Removal of more than 72 of the 95 m^3 of sludge from Tank 6-F using 11 liquid addition-slurry mixing-and transfer campaigns. Internal obstacles (twelve 2-foot diameter roof

[3] Types I and II are the older style SRS double shell tanks.

supports and several hundred 2 inch diameter cooling coils) limited further removal. Tank 6-F is ready for chemical cleaning which will involve dissolution of the metal hydroxides and oxides using concentrated oxalic acid. Applicability and cost effectiveness of enhanced chemical cleaning technologies using oxalic acid are also being evaluated.

- Removal of about 72 of the 130 m^3 of sludge from Tank 5-F in 2 liquid addition-slurry mixing-and transfer campaigns.

Two SMPs were used in Tanks 5-F and 6-F. A third SMP will be installed in Tank 5-F to complete waste removal and improve efficiency by reducing the number of campaigns and volume of extra liquid waste generated by the removal activities. Waste that will be removed from Tank 4-F will be blended with the heels from Tanks 5-F and 6-F to provide feed for the next batches of DWPF feed [18].

During the last 5 years, WSRC tank farm engineering has set up hub tanks in the FTF and HTF to receive and blend sludge retrieved from the tanks scheduled for closure. The wastes retrieved from Tanks 4-F, 5-F, and 6-F are currently being held in Tank 7-F (Type I) which provides contingency and capacity for blending retrieved sludge upstream of the DWPF without directly impacting DWPF operation. The concept will also be used in the HTF where Tank 13-H (Type II) will be used as a hub tank. Sludge retrieved from Tank 12-H will be sent to Tank 13-H where it will bended before sending it on to Tank 51-H, the feed tank for DWPF [18].

By acquiring and successfully operating the new SMPs, the ability to respond to the DWPF sludge feed needs is no longer an issue with respect to waste retrieval. However, since removing sludge from tanks generates more waste volume than the original sludge, and since the tank storage capacity is fixed, the future ability to empty and clean tanks will depend on the rate of treatment and on-site disposal of the decontaminated salt liquid waste which currently accounts for over 90 volume percent of the stored waste.

The current SRS FFA agreement calls for bulk waste removal to be completed for a total of 24 tanks by the end of 2019 [11].

SRS Tank Waste Processing Initiatives

In order to reclassify the salt waste as LLW, decontamination to remove Cs, Sr, and actinides must be to the level authorized by the Section 3116 Determination for Salt Waste Disposal at the Savannah River Site. As LLW, decontaminated supernate can be worked off through the Saltstone Facility and disposed on site. The Modular Caustic Side Solvent Extraction Unit (MCU), Sodium Titanate Process (STP), and Actinide Removal Process (ARP) are currently being constructed at SRS as 1/10 scale pilot facilities for cesium, strontium and actinide decontamination, respectively. These facilities are expected to come on line in March 2008 [18].

The Salt Waste Processing Facility (SWPF), the full-scale cesium decontamination process, is scheduled to be complete in 2012 [18]. In the meantime, decontaminated salt waste is being produced by an interim process referred to as Dissolution, Decontamination, and Aggregation (DDA). DDA Batch 2 is currently being processed in the Saltstone Facility.

SRS Tank Stabilization (Filling) Initiatives

The closure concept has evolved from a three-layer cementitious grout fill (Reducing Grout, Bulk Fill, and Strong Grout) to a two-layer strategy, Reducing Grout and Strong Grout, for the Type IV tanks and a single fill material, Reducing Grout, for the Type I, II and III tanks, since these tanks have substantial concrete roofs that will serve as intruder deterrents.

The current SRS tank closure grout mix designs are provided in Table 1. The grout mixes used for the three layer strategy deployed in Tanks 17-F and 20-F in 1997 are also described in Table 1. Recent design and testing of a lower permeability, flowable, no-bleed grout and concrete for the single mix concept resulted in alternative lower permeability mixes which are also listed in Table I. [4] The flowable non-segregating pea gravel concrete mix listed in Table I had an average permeability (6.6 E-09 cm/sec), which is about 6 times less than the mix in the current specification (2007 reducing grout). Additional tank fill mix design work to further lower the permeability of the tank fill grouts is planned in FY08.

Table I. SRS Tank Closure Grouts

		1997 Grout [19] Tanks 17-F & 20-F			2007 Specification [20] Tanks 18-F & 20-F		Next Generation Tank Fills [21]	
Ingredients	**Units**	**Reducing Grout**	**Bulk Fill**	**Strong Grout**	**Reducing Grout & Bulk Fill**	**Strong Grout**	**Alternative Low Permeability Tank Closure Grouts**	
Portland Cement	kg/m^3	800	90	330	45	330	180	110
Slag	kg/m^3	120	Not Used	Not Used	120	Not Used	180	150
Fly Ash	kg/m^3	Not Used	300	N/A	220	N/A	470	500
Silica Fume	kg/m^3	53	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used
Water	l/m^3	428	310	320	300	320	310	300
Sand	kg/m^3	960	1360	1360	1360	1360	840	560
3/8 stone		Not Used	Not Used	Not Used	Not Used	Not Used	Not Used	946
Viscosity Modifier*	g/m^3	Not Used	360 Kelco-Cretre	360 Kelco-Crete	360 Kelco-Crete	Not Used	280 Kelco-Crete	280 Kelco-Crete
High Range Water Reducer*	ml/m^3	8800	3200 Adva Flow	3200 Adva Flow	3200 Adva Flow	3200 Adva Flow	1900 Viscocrete	1900 Adva Flex
Hydration Stabilizer* (Recover)	ml/m^3	2600	Not Used	Not Used	Not Used	Not Used	Field Adjusted	Field Adjusted
Initial Reducing reagent (Sodium Thiosulfate)	kg/m^3	1.2	Not Used	Not Used	1.2	Not Used	1.2	1.2
Water to Total Cementitious Material Ratio		0.44	0.81	0.96	0.76	0.98	0.37	0.39

*Adva Flow and Recover are manufactured by W. R. Grace, Inc. Viscocrete is manufactured by Sika, Inc. Kelco Crete is manufactured by Kelco, Inc.

PROGRESS AT IDAHO

The Idaho Nuclear Technology and Engineering Center (INTEC) Tank Farm Facility (TFF) is relatively small and consists of eleven 1,100 m^3 stainless steel tanks and four additional 110 m^3 stainless steel tanks that were taken out of service in the early 1980's. See Figure 3.

Significant progress has been made at the INTEC TFF with respect to closing the waste tanks over the last five years. Between 2002 and 2005, waste was consolidated into three of the 1,100 m^3 tanks. Seven of the eleven large 1,100 m^3 empty tanks and the four small 110 m^3 empty tanks were cleaned and sampled.[5] Since issuance of the 3116 Waste Determination on November 2006, all four of the cleaned 110 m^3 tanks and the seven cleaned 1,100 m^3 have been filled with grout.

[4] Lower permeability contributes to improving durability of the fill materials.

[5] One of the 1,100 m^3 tanks is being maintained as an operational spare tank.

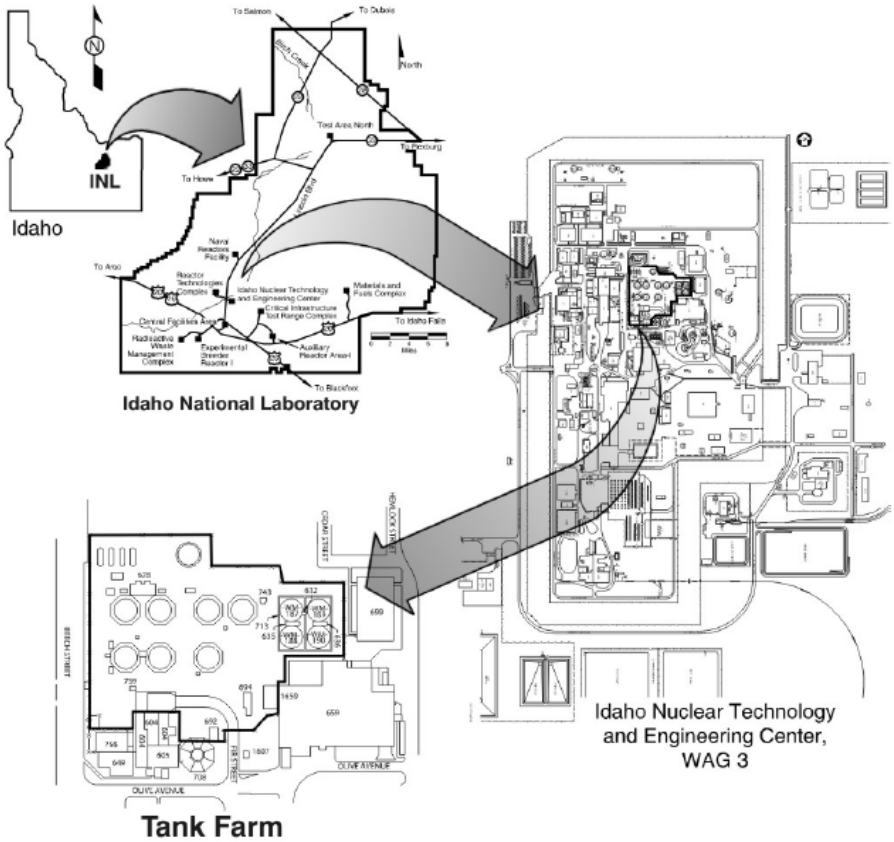

Fig 3. Idaho Nuclear Technology and Engineering Center (INTEC) Tank Farm Facility [22].

Regulatory Drivers

The strategy adopted by DOE Idaho for closing the TFF tanks was in response to a January 1990 Notice of Noncompliance and subsequent Consent Order [23, and 24, respectively]. The Idaho Department of Health and Welfare and the EPA issued the Notice of Noncompliance to DOE Idaho because the tanks in the TFF did not meet the secondary containment requirements as set forth by Idaho Administrative Procedures Act 58.01.05.009 (40 CFR 265.193). The resulting 1992 Consent Order required DOE Idaho to permanently cease use of the five 1,100-m^3 tanks contained in five pillar-and-panel vaults by June 30, 2003.

The Consent Order also required DOE Idaho to permanently cease use of the remaining 1,100-m^3 tanks by December 31, 2012 or to bring the tanks into compliance with secondary containment requirements. DOE Idaho decided to close the TFF tanks because radiation fields made compliance with the secondary containment requirements impractical. Also, DOE Idaho did not anticipate a need for such storage after 2012 [10].

To demonstrate that the TFF waste residuals and associated ancillary equipment at final closure met the NDAA Section 3116 criteria, DOE Idaho reviewed and analyzed historical waste management information, PA results, and sampling and analysis results from the recent tank cleaning activities. In addition, the residual waste inventory was updated to reflect the results of TFF cleaning activities [6]. A 3116 Waste Determination was finalized in November 2006 after consideration of NRC, State of Idaho, and public comments were completed and closure plans which met DOE and Idaho state requirements were approved [6].

INTEC Tank Cleaning Activities

The tank cleaning process used in the TFF was designed to remove as much residual waste as practical and was tested in a full-scale mock-up system. The empty tanks were cleaned using a washball, directional nozzle and modified steam-jet pumping system. Radiation levels were monitored on the steam-jet transport line to evaluate cleaning effectiveness. Visual inspection via a remote-controlled camera was used to determine tank cleaning effectiveness, and samples were collected and analyzed. During the visual inspection, residual solid heel depths were estimated by comparing the solids depths to benchmarks within the tanks, such as cooling coil support brackets and associated welds. The residual waste was sampled using small submersible pumps deployed through the tank risers.

The tank vaults surrounding the tanks were also cleaned by iterative water flushing. Process piping in the TFF was cleaned by flushing three piping system volumes through the system with a pressure equal to previous waste transfers to ensure that the pipe area contacted by waste was rinsed during the flushing operations. The overall cleaning process is illustrated in Figure 5. Before and after cleaning pictures of Tank WM-183 are shown in Figure 4 (a) and (b), respectively.

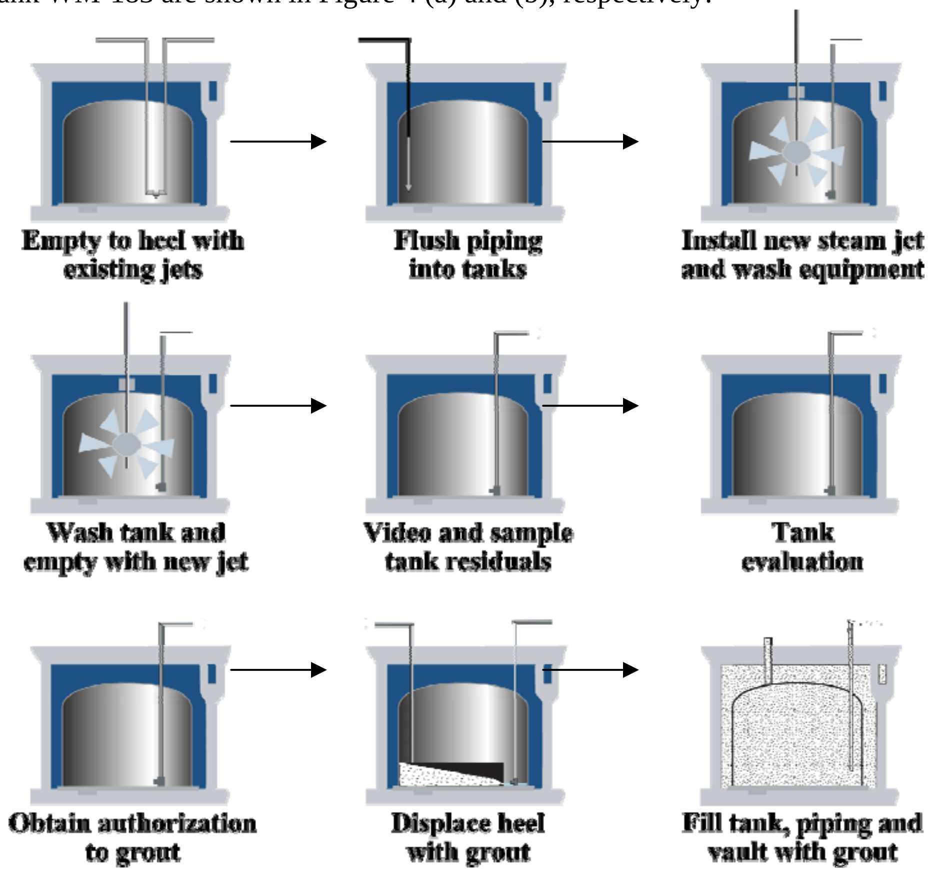

Fig. 5. INTEC tank closure sequence [22].

Residual Stabilization and Tank Filling

Residual radioactivity in the small amounts of solids and contaminated flush water that could not be removed from the tanks by the cleaning process or other technically practical means was stabilized in the tank with cement based grout. Grout was used to push waste residuals toward the removal equipment where it was removed from the tanks using jet pumps. The residual inventories for each of the cleaned tanks are given in Table II.

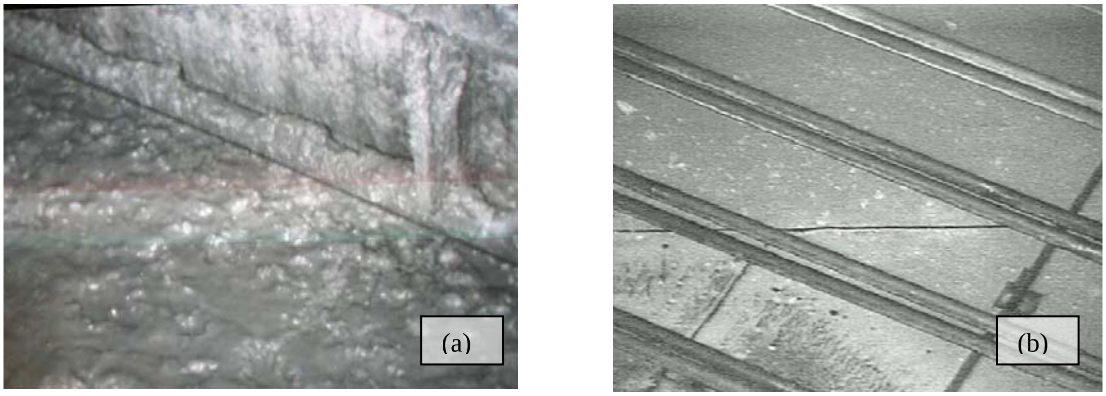

Fig. 4. Interior of TFF Tank WM-183 before (a) and after tank cleaning [22].

Table II. Residual Inventory in Cleaned Tank Farm Facility Tanks [22]

Tank	Residual Inventory (GBq)*
WM-103 - 106	5,300
WM-180	39,000
WM-181	28,000
WM-182	89,000
WM-183	50,000
WM-184	40,000
WM-185	51,000
WM-186	24,000

* Cs-137/Ba-137m accounts for ~95% of the total activity.

In the large tanks, the first 3-4 feet of grout in the bottom of each tank was placed as an engineered pour so as to surround the residual waste and push it toward the steam jet. This technique provided some uplift of the waste and also facilitated mixing and encapsulation of the solids with the grout. Slag cement was used in the grouts deployed as engineered pours to ensure chemical reducing conditions and chemical stabilization of selected radionuclides such as Tc-99.

The remainder of each tank (top of the engineered fill to the top of the dome) was filled with Controlled Low Strength Material (CLSM). Piping and ancillary equipment were filled with a low viscosity pipe fill grout. The mix designs for these materials are shown in Table III. The various grouts were produced at a nearby batch plant and delivered to the tank farm in transit mixer concrete trucks. The INTEC closure team has advanced into the next stage, which involves filling the vault top sections and all remaining associated piping and ancillary equipment with grout. The target completion date on this phase is summer of 2008.

Table III. Grout Mix Designs at INTEC [25]

Ingredients	**Layer 6 Mix**	**Heel Displacement Grout**		**CLSM**	**Pipe Grout**
		Grout-100	**Grout-100-2**		
Portland Cement (kg/m^3)	140	135	136	178	400
Slag (kg/m^3)	210	208	208	Not used	Not used
Fly Ash (kg/m^3)	70	70	70	119	950
Water (L/m^3)	240 max	262	262	188	480
Sand (kg/m^3)	1500	1478	1478	1121	Not used
High Range Water Reducer (mL/m^3)	1100 max	3094	1470	3675	2300 max
Foam Additive (BASF Rheocell) (mL/m^3)	Not used	Not used	Not used	Not used	561

INTEC Waste Treatment and Closure of Remaining Tanks

The final phase for the tank closure project involves cleaning and grouting of the tanks, vaults, interconnecting piping and ancillary equipment associated with the four currently operational tanks which are being used to store approximately 3400 m^3 of Sodium Bearing Waste (SBW). The waste is highly acidic (1-3M H^+), relatively homogeneous except for a layer of solid particles that have settled on the bottom of the tanks, and is identified as RCRA hazardous waste because of acid corrosivity, and hazardous metals and trace organics. Consequently, it is regulated by the State of Idaho as mixed waste. A new waste processing facility using steam reforming technology is currently under construction at the INTEC for treating the SBW. The SBW is scheduled to be treated between 2009 and 2011 and the remaining tanks are scheduled to be closed by December 2012 [26].

PROGRESS AT HANFORD

The U.S. DOE, Office of River Protection (ORP) and the CH2M Hill Hanford Group, Inc. are responsible for the operations, cleanup, and closure activities at the Hanford Tank Farms which contain a total of 177 tanks; 149 single-shell tanks and 28 double-shell tanks. The single-shell tanks, which were constructed 40 to 60 years ago, all have exceeded their design life and do not meet current environmental standards. Consequently, radioactive waste is currently being retrieved from the single-shell tanks and transferred to double-shell tanks for storage prior to treatment through vitrification and disposal. Following retrieval of as much waste as technically possible from the single-shell tanks, the single-shell tanks will be closed in accordance with the Hanford Federal Facility Agreement and Consent Order and the DOE requirements.

Hanford Bulk Waste Retrieval Initiatives

The major focus of the tank closure efforts at Hanford in the past five years has been on waste retrieval. A number of tanks have been cleaned using a variety of techniques. As of July 2007, waste retrieval from seven tanks has been completed, three were in progress, and two more were identified for retrieval. Retrieval methods are listed for each tank in Table IV. Although oxalic acid dissolution was used to remove waste from Tank C-106, this method will not likely be used in the future because mechanical cleaning techniques using low volumes of high-pressure liquid were found to be more efficient. Some of the more successful tools developed and used at Hanford are shown in Figure 5.

Table IV. Hanford Tank Cleanup Status [27]

Tank Number	Capacity	Retrieval Method
Retrieved		
S-112	2800 m^3	Saltcake Dissolution/Modified Sluicing/Salt Mantis
C-204	210 m^3	Vacuum Retrieval
C-103	2000 m^3	Modified Sluicing
C-201	210 m^3	Vacuum Retrieval
C-202	210 m^3	Vacuum Retrieval
C-203	210 m^3	Vacuum Retrieval
C-106	2000 m^3	Modified Sluicing/Oxalic Acid Dissolution
In Progress		
C-109	2000 m^3	Modified Sluicing
C-108	2000 m^3	Modified Sluicing
S-102	2800 m^3	Salt Cake Dissolution/Modified Sluicing
Planned		
C-104	2000 m^3	Modified Sluicing
C-110	2000 m^3	Modified Sluicing

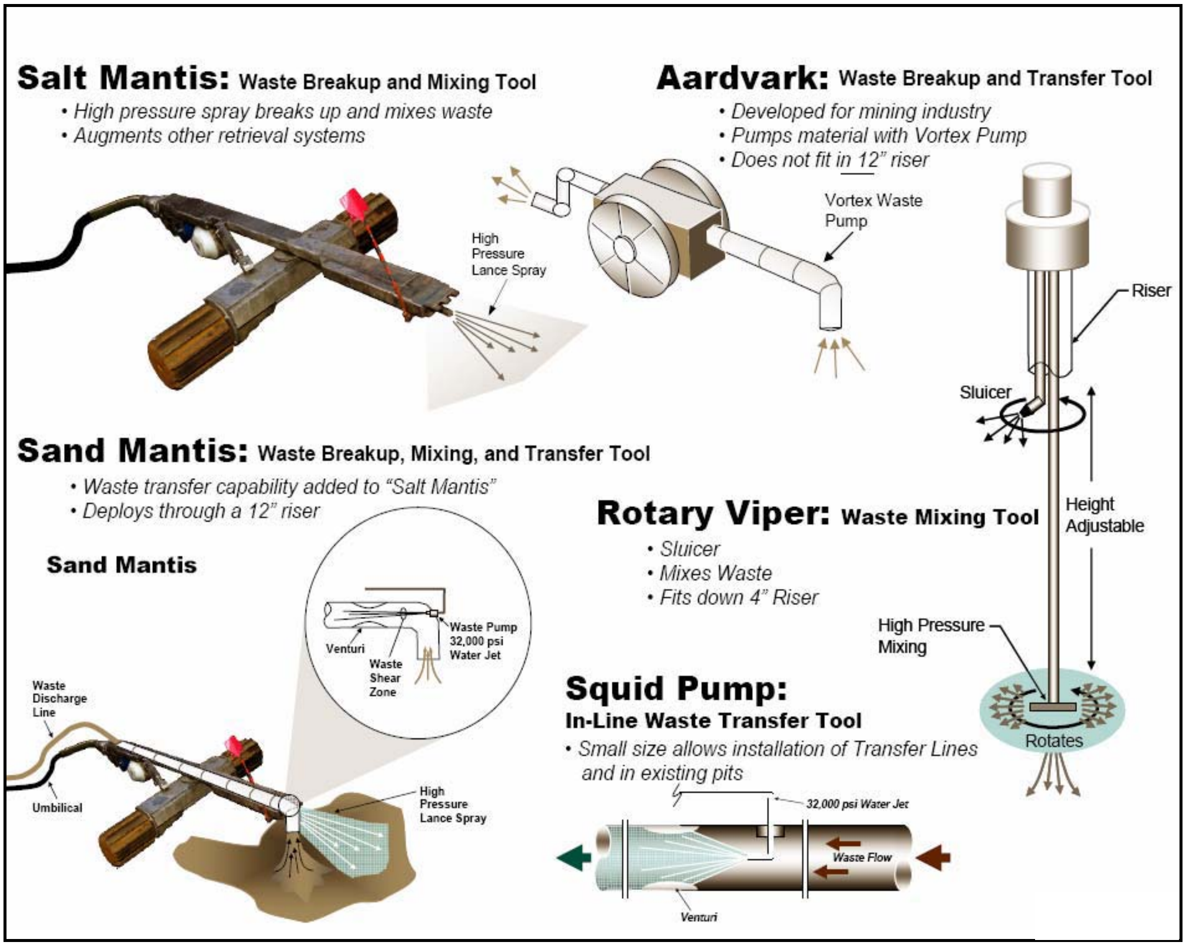

Fig. 5. Innovative tank waste retrieval technologies used at Hanford [27].

The retrieved waste is transferred to an evaporator system for volume reduction. The evaporator bottoms are then sent to the double-shell tank system. Waste is being retrieved from the Hanford single-shell tanks at the rate of about one tank per year. This rate is somewhat limited by capacity in the double-shell tanks available to receive the removed waste. Vitrification of the waste in the double-shell tank system is scheduled to begin in 2019 when the Waste Treatment and Immobilization Plant is scheduled to come on line [28].

Hanford Tank Closure Actions

Final closure actions for the Hanford tanks are currently being evaluated using the Environmental Impact Statement process. A range of closure actions ranging from No Action to waste retrieval and tank stabilization using cementitious grout[6] to complete removal of the tanks and their contents are being evaluated. The Environmental Impact Statement is scheduled for completion in August 2008 and the final Record of Decision is expected about a year later.

PROGRESS AT WEST VALLEY

[6] Numerous technical studies have been performed to support waste characterization, tank cleaning, grouting, waste characterization, and waste-grout interactions [29, 30, and 31].

Waste Retrieval and Final Waste Form Production and Disposal

The waste tank farm at the WVDP consists of two 2.88E+06 L (760,000 gallon) carbon steel tanks (8D-1 and 8D-2) each in a separate secondary containment vault and two small 5.3E+04 L (14,000 gallon) 304L stainless steel tanks in a common secondary containment vault (8D-3 and 8D-4). Since 2000, the West Valley Nuclear Services Company (WVNSCO) has made considerable progress in eventual tank closure by: 1) removing and pre-treating (cesium removal using a zeolite process) supernate and sludge, 2) producing final waste forms for disposal using vitrification (HLW) and cement solidification (LLW decontaminated supernate), and 3) removing and processing tank residuals (LLW).

HLW pretreatment was performed between 1988 and 1995 and included decontamination of the HLW supernate and cement solidification of the resulting LLW. HLW sludge and zeolite vitrification was conducted between June 1996 and August 2002 with the production of 66 batches of the borosilicate glass waste form.[7] On September 5, 2002, the vitrification melter was powered down and the molten glass in the melter was transferred into two evacuated canisters.

Canisters of the glass waste form are currently in interim storage at the WVDP. On October 2007, the West Valley Environmental Services LLC (WVES) completed shipment of 19,962 drums of cement stabilized decontaminated supernate to the NTS for final disposal. This waste form was produced between 1988 and 2005. Each of the original 71 gallon square drums contained about 40 gallons of decontaminated supernate.[8]

Residual Waste Retrieval and Management

In 2003, approximately, 5.3E+05 L (140,000 gallons) of residual diluted waste, referred to as Sodium Bearing Wastewater (SBW)[9] was retrieved from tanks, processed through the Supernate Treatment system (STS) zeolite process, and then concentrated in the WVDP LLW evaporator. In 2004, the resulting 1.35E+04L (11,500 gallons) of concentrated liquid were treated for final disposal to remove metal toxicity due to chromium and other hazardous constituents using an in-container cementitious stabilization process. The process produced seventeen 4.8 cubic meter cylindrical IP-2 containers (6 x 6 foot) which were shipped to the NTS in 2007 after they were classified a low-level waste through a successful WIR determination.

In 2003, two former WVDP HLW tanks, 8D-2 and 8D-3, were placed in minimum maintenance mode. Since 2003, passive evaporation has reduced the volume of liquid in each tank by about 4 m^3 per year. Currently, the residual liquid in tank 8D-2 is less than 6 m^3 which is below the tank level indicator. A proposal was prepared and submitted to DOE and New York State to install a vault and tank drying system to remove all of the liquid and to maintain <30 % relative humidity (to halt corrosion of the carbon steel tanks) in the tanks until a decision is made on final disposition structures.

A proposal was prepared and submitted to empty and treat the liquid in the two smaller stainless steel HLW tanks; 8D-3, which contains about 6 m^3 of very dilute liquid wastewater, and 8D-4, which contains approximately 19 m^3 of flush water from the vitrification process and about 14,000 Ci of

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[7] Bulk waste removal was completed in September 2001 with the completion of 207 waste transfers.

[8] The original drums were over packed shortly after production and were placed in covered storage. WVNSCO decontaminated the 1524 over pack containers and secured six drums per pallet for shipment to NTS. The remainder of the drums were shipped using an improved drum packaging process designed to utilized triple-layer, IP-2 soft-sided containers for drum over packing, thus eliminating the need to decontaminate the original metal over pack drum [32].

[9] The WVDP SBW is a dilute waste water and is not the same as the INTEC sodium bearing waste (SBW) which contains significantly higher concentrations of soluble ions and radionuclides.

soluble Cs-137. Treatment includes decontaminating the liquid using the zeolite process and then sending the liquid to Tanks 8D-1 and 8D-2 for evaporation or cementitious stabilization and off-site disposal.

Highlights from a detailed chronology of the waste retrieval and tank cleaning activities [33] are listed in Table V.

Table V. WVDP HLW Processing Chronology Highlights

ACTIVITY	START	FINISH
HLW Pretreatment		
• Supernatant Processing	May 1988	Nov. 1990
• Sludge Wash 1 and Processing	Oct. 1991	May 1994
• Sludge Wash 2 and Processing	May 1994	Aug. 1994
• THOREX Addition	Jan. 1995	Jan. 1995
• Sludge Wash 3 and Processing	Jan. 1995	May 1995
Decontaminated Supernate Stabilization/Solidification	May 1988	1995
Zeolite Mobilization and Retrieval	July 1995	Feb. 2001
HLW Mobilization, Retrieval	June 1996	Sep. 2001
HLW Tank Residual Characterization	July 2000	Nov. 2002
HLW Vitrification	June 1996	Sep. 2002
Tank Farm Residual Liquid Processing	Jan. 2003	Feb. 2003
HLW Tank Lay-up	Jan. 2003	July 2003
SBW Stabilized/solidified in 17 4.8 Cubic Meter Containers	Oct. 2004	Nov. 2004
Residual Liquids from Tank 8D-3 Consolidated and Evaporated	Aug. 2005	Aug. 2005
19,962 Drums of Stabilized Decontaminated Supernate Sent to the NTS for Final Disposal.	July 2006	Oct. 2007
Regulatory Documentation (EIS and PA)	ongoing	

Regulatory Status

The WVDP Environmental Impact Statement (EIS) and PA are still under development. The current drafts address the potential in-place closure of the former HLW tanks as well as other alternatives, including total removal of the tanks from the site. Currently, the tanks contain about 300 Ci of TRU alpha constituents and about 300,000 Ci of Cs and daughter products. DOE has committed to additional waste retrieval.

In addition, the waste in the WVDP former HLW tanks is classified as mixed waste, and therefore disposition is regulated by the New York State Department of Environmental Conservation. To date, all hazardous waste tanks in the State of New York have been clean closed. The issue of clean closure versus closed in place needs to be resolved in order to draft the final closure plan for WVDP.

CONCLUSIONS

The U.S. DOE has made significant progress in the HLW tank closure program in the last five years. Seven of eleven large HLW tanks and the four small tanks at the Idaho TFF were closed. Waste retrieval and consolidation efforts were successful at all four of the DOE sites. Hanford and SRS developed and demonstrated improved, more efficient waste retrieval technologies in several tanks. WVDP successfully completed retrieval and treatment of their HLW. Final tank closure activities at WVDP depend on the outcome of Environmental Impact Statements (EIS) and resulting Record of Decision (ROD) which are still being drafted. Retrieval and treatment of HLW waste and subsequent tank closure activities at Hanford, Idaho, and SRS are coupled to new waste treatment facilities which are currently under construction (pretreatment and LLW vitrification, steam reforming, and HLW decontamination facilities, respectively). Tank closure activities at Hanford also depend on the outcome of EIS (expected to be issued in 2008) and resulting ROD. Tank closures at Hanford, SRS and WVDP require successful WIR or WD determinations. (The approved Idaho WD applies to all tanks.)

Between 2002 and 2005, waste at the INTEC Tank Farm Facility in Idaho was consolidated into three 1,100 m^3 tanks (one tank will be kept as a empty spare). Seven of the eleven large 1,100 m^3 empty tanks and the four small 110 m^3 empty tanks were cleaned and sampled. Since issuance of the 3116 Waste Determination on November 2006, all four of the cleaned 110 m^3 tanks and the seven cleaned 1,100 m^3 have been filled with grout. INTEC plans to complete filling the vault top sections and all of the remaining piping and ancillary equipment with grout by the end of the summer, 2008. The remaining tanks are scheduled to be closed by December 2012 after removal and treatment of the stored sodium bearing waste. A new steam reforming facility is currently being constructed and is expected to be operational between 2009 and 2011. This facility will produce a final waste form for disposal at the Waste Isolation Pilot Project (WIPP) and/or NTS.

The major focus of the tank closure efforts at Hanford in the past five years has been on waste retrieval. A number of tanks have been cleaned using a variety of techniques. As of July 2007, waste retrieval from seven tanks was completed, three were in progress, and two more were identified for retrieval. Retrieval methods are listed for each tank in Table IV. Oxalic acid dissolution was performed and evaluated on Tank C-106. However mechanical cleaning techniques using low volumes of high-pressure liquid were found to be more efficient and will be used for future waste retrievals. Waste retrieval is planned at the rate of one tank per year until the Waste Treatment and Immobilization Plant comes on line (scheduled for 2019).

Over the past five years, SRS has: 1) continued to produce two final waste forms, vitrified sludge HLW glass, and saltstone, a low level waste form from decontaminated supernate, 2) significantly accelerated sludge and bulk waste retrieval by installing new Submersible Mixer Pumps designed and built by the Electromechanical division of Curtis Wright, and 3) changed direction with respect to retrieving more waste from Tanks 18-F and 19-F (Type IV) which are the next tanks scheduled for operational closure (stabilization via filling with reducing grout) in 2010. Commercial robotic technology was designed and successfully tested to remove additional residual waste from these tanks and work is scheduled for 2008. Progress has also been made on cleaning the annulus space in Tank 16-H, which is already empty and chemically cleaned in 1981-82. Modifications are currently being made to annulus cleaning tools designed and demonstrated by Safety Ecology Corporation, Oak Ridge TN and SA Robotics, Denver CO. The equipment utilizes light-weight, carbon fiber arms mounted on a robotic crawler.

In 2002, the West Valley Nuclear Services Company (WVNSCO) completed vitrification of all of the HLW at the site and since then has evaporated and solidified much of the remaining waste volume. In 2003 and 2004, about 5.3E+05 L of dilute SBW waste were evaporated and solidified as a cement waste form using in-drum mixing technology. In 2006 and 2007, all of the 19,962 drums of a LLW cement waste form produced at the WVDP between 1988 and 2005 and the solidified SBW containers were successfully packaged, shipped and received at the NTS for final disposal.

Since the passage of the NDAA, in 2005, the DOE has been actively engaged in technical reviews with the National Academies of Science and the U.S. Nuclear Regulatory Commission concerning for treatment and disposal of tank waste and tank closures. The NRC was tasked with: 1) responsibility for reviewing DOE waste determinations and PAs at Idaho and the SRS and 2) monitoring activities associated with disposal of HLW that is determined by DOE to be suitable for near surface disposal.

During the past five years, the U.S. DOE has also continued to support information exchange and peer review of tank closure issues among the four sites through technical exchanges, vendor forums, and workshop that are open to stakeholders via on site participation and/or web casting. The most recent of these are listed below:

- The Tank Cleaning Technical Exchange, Atlanta, GA, March 27-28, 2006,
- Cementitious Materials for waste Treatment, Disposal, Remediation, and Decommissioning Workshop, Aiken, SC, December 12-14, 2006,
- Aluminum Chromium and Leaching Workshop, Atlanta, GA, January 23-24, 2007,
- Savannah River/Hanford/Idaho Technical Exchange, Atlanta, GA, October 9–11, 2007,
- 3116 Lessons Learned Workshop, Aiken, SC, October 15-19, 2007, and

A workshop on Performance Assessment Modeling is also being planned for 2008.

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