DOE/EM-0360

Tanks Focus Area

ANNUAL REPORT

1997

TFA
TANKS
FOCUS AREA

U.S. Department of Energy

Office of Environmental Management

Office of Science & Technology

Tanks Focus Area

Contents

Available to DOE and DOE contractors from the Office of Scientific and Technical Information, P.O. Box 62, 175 Oak Ridge Turnpike, Oak Ridge, TN 37831; prices available at (423) 576- 8401, fax: (423) 576-5725, e-mail: reports @adonis.osti.gov.

Available to the public from the National Technical Information Service, U.S. Department of Commerce, 5285 Port Royal Road, Springfield, VA 22161; phone orders accepted at (703) 487- 4650.

WGB 98-0055

In less than three years, our nation moved from discovering the atom to harnessing its power. During World War II, the United States constructed plants to enrich uranium, reactors to produce plutonium, and reprocessing plants to extract plutonium for the production of nuclear weapons. These activities continued to grow as we increased production during the Cold War thereby creating large volumes of radioactive waste. Today, we are faced with a recalcitrant nuclear waste legacy that is found in many forms, compositions, and storage configurations. Approximately 90 million gallons of these radioactive wastes are currently stored in tanks.

In 1989, the U.S. Department of Energy (DOE) established the Office of Environmental Management (DOE-EM) to clean up these legacy waste sites that span the nation. Because this technical challenge is only paralleled by the original development of nuclear fuel and the atomic bomb, technology development is a crucial component for the long-term success and accomplishment of this environmental mission. The DOE-EM has assigned the Tanks Focus Area the responsibility for development and complex wide integration of technical solutions to enable and enhance the remediation of the DOE's waste tanks. The Tanks Focus Area supports EM by addressing critical scientific and technical challenges of characterizing, retrieving, treating and immobilizing tank waste to support our nation's goal to close the tanks in a way that is environmentally and technically sound.

The Tanks Focus Area is an integrated team of dedicated, highly motivated people, bringing together our nation's leading technology developers and site users to safely, efficiently and expeditiously remediate the tanks and their associated waste. The Tanks Focus Area efforts are strategically focused on four locations: Hanford Site, Idaho National Engineering and Environmental Laboratory, Oak Ridge Reservation, and the Savannah River Site. Tank waste remediation is the most expensive and challenging of the Department's many cleanup activities. By providing timely technology cleanup solutions and through effective complex-wide integration, the Tanks Focus Area is playing a major role in meeting that challenge.

Jeff Frey
Tanks Focus Area Program Manager

THE TANKS FOCUS AREA: A SHORT SUMMARY

The U.S. Department of Energy Office of Environmental Management is tasked with a major remediation project to treat and dispose of radioactive waste in hundreds of underground storage tanks. These tanks contain about 90,000,000 gallons of high-level and transuranic wastes. We have 68 known or assumed leaking tanks, that have allowed waste to migrate into the soil surrounding the tank. In some cases, the tank contents have reacted to form flammable gases, introducing additional safety risks. These tanks must be maintained in the safest possible condition until their eventual remediation to reduce the risk of waste migration and exposure to workers, the public, and the environment. Science and technology development for safer, more efficient, and cost-effective waste treatment methods will speed up progress toward the final remediation of these tanks.

In less than three years, the Manhattan Project, led by the U.S. Army Corps of Engineers, created the infrastructure necessary to build the world's first atomic bomb. Facilities ranging from production reactors to fuel reprocessing plants, such as B-Plant at the Hanford Site, were built to achieve this mission.

The DOE Office of Environmental Management established the Tanks Focus Area to serve as the DOE-EM's technology development program for radioactive waste tank remediation in partnership with the Offices of Waste Management and Environmental Restoration. The Tanks Focus Area is responsible for leading,

High-Level and Low-Level Waste

Radioactive waste in the United States is defined and regulated by the source of the waste, not its radioactivity. High-level waste is waste created by the chemical separation of uranium and plutonium from undesirable radioactive elements. Low-level waste is a default category for radioactive waste that is not spent fuel, high-level, or contains large amounts of transuranic waste. Transuranic elements are those occuring after uranium in the periodic table. It can include liquid waste or contaminated clothing, tools, and equipment.

coordinating, and facilitating science and technology development to support remediation at DOE's four major tank sites: the Hanford Site in Washington State, Idaho National Engineering and Environmental Laboratory in Idaho, Oak Ridge Reservation in Tennessee, and the Savannah River Site in South Carolina. The technical scope covers the major functions that comprise a complete tank remediation system: waste retrieval, waste pretreatment, waste immobilization, tank closure, and characterization of both the waste and tank. Safety is integrated across all the functions and is a key component of the Tanks Focus Area program.

Refining uranium and creating plutonium for atomic bombs generated radioactive wastes. Some waste was stored in underground tanks until it could be processed later.

The waste has undergone a number of chemical reactions. These reactions resulted in several waste forms, from liquids to rock-hard saltcake. Some waste has adhered to in- tank equipment and tank walls.

Status of Major Tank Programs

The development of nuclear weapons, testing of reactors, and production of specialty isotopes generated billions of gallons of nuclear waste. A significant portion has been stored in underground tanks over the last 50 years. Coming from many different processing sources, this waste is made up of a vast array of hazardous chemicals and radioactive elements. Approximately 90 million gallons of waste are currently stored in 273 underground tanks across the U.S. Department of Energy complex.

The DOE-EM is working to convert the waste into a stable form for storage, preventing release into the environment. To reduce the costs associated with the maintenance of the tanks and their waste, called "mortgage" costs, the DOE-EM is closing tanks. These activities are documented in a plan titled "Accelerating Cleanup: Paths to Closure," formerly called the "2006 Plan."

The cleanup is progressing at different schedules, and with different approaches, at each of the four tank sites. All sites used different variations of nuclear production processes, resulting in different wastes and storage tank designs. Currently, the Savannah River Site has the only facility to prepare tank waste for permanent disposal. An estimated 33,000,000 to 34,000,000 gallons of waste at this site contain about 534,000,000 curies of radioactivity. The radiation levels associated with the curie content are so high that specialized handling and processing equipment is required. While some equipment to perform these tasks exists in industry, it must be modified to survive the harsh radiation, chemical, and thermal conditions. The Savannah River Site is retrieving, treating, and immobilizing waste into solid glass logs. Glass logs are created at a rate of 200 per year at the Defense Waste Processing Facility. At this rate,

DISCLAIMER

DISCLAIMER

Portions of this document may be illegible electronic image products. Images are produced from the best available original document.

it will take until FY 2028 to process all of the Savannah River Site waste.

The Hanford Site is bringing in private companies to build and operate tank waste treatment facilities. According to the current schedule, the Hanford Site will complete treatment of its 55,000,000 gallons of waste, containing about 200,000,000 curies of radioactivity, and close its 177 tanks by FY 2032.

The Idaho National Engineering and Environmental Laboratory is determining the preferred option for treating its tank waste. This is an early step in the process for treating 2,000,000 gallons of liquid waste, containing about 2,000,000 curies of radioactivity and 176,550 ft^3 of calcine waste, containing 50,000,000 curies of radioactivity. The Idaho National Engineering and Environmental Laboratory will provide treated waste for transport to the national repository by FY 2035.

The Oak Ridge Reservation also plans to use private companies to treat its 600,000 gallons of waste containing 31,000 curies. To prepare for waste treatment, the Oak Ridge Reservation is consolidating all of its tank waste around the site to a single location. The Oak Ridge Reservation will prepare its inactive tanks for closure by FY 2000.

Hanford Site

- We are ensuring the feed and waste products meet contract requirements for the private vendor's vitirfication programs.
- Our technologies are preparing for vitrification by retrieving waste from tanks, processing sludge, vitrifying waste, and examining waste product to ensure it meets high level waste acceptance criteria.
- The Hanford Site is using our technology to close single-shell tanks and ensure safe operations and lower operating costs for double-shell tanks.

Idaho National Engineering and Environmental Laboratory

- We are providing technical options for complete processing of acidic wastes to meet Environmental Impact Statement and Title 1 Design schedules.
- Our technologies are sampling tank heels to determine requirements for wastes left after cleanup and end tank use.

Savannah River Site

- We are helping the DWPF meet annual goals for glass production in support of DOE Strategic Goals
- To ensure DOE meets long-term waste processing requirements, we are providing a second-generation supernate treatment process.
- Our Salt Dissolution and Retrieval Programs are required for the DWPF to meet glass production goals and provide much needed tank storage capacity.
- TFA's technologies are retrieving sludge heels, cleaning tank surfaces, and stabilizing tank structures of four tanks - two of which are the first high-level waste tanks to be closed in the DOE complex.
- Our technologies are reducing the volume of immobilized waste products and the volumes returned to the tanks from the immobilization process.

Oak Ridge Reservation

- Our technologies are cleaning and stabilizing seventeen tanks so they can be closed by the year 2002.
- We are pretreating waste as part of the consolidation process to meet the requirements outlined in the Accelerating Cleanup: Paths to Closure

The total projected cost for removing the waste, treating and immobilizing it for disposal, and closing the tanks is approximately $50,000,000,000 over the next 30 years. Many critical decisions will occur in the next ten years - investing in technical solutions to these challenges can provide a large return on its investment.

The Importance of Waste Tank Remediation

Many tanks storing these wastes were built over 50 years ago and now exceed their design life. As tanks continue to be used past their design life, the likelihood of leaks to the soil and groundwater increases. To date, 68 tanks are known or are suspected of leaking waste. Once released to the environment, the waste is difficult and costly to characterize, recover, and treat. Based on stakeholder participation, the U.S. Department of Energy plans to remove the waste and convert it into a stable long-term waste form.

Magnitude of the Problem

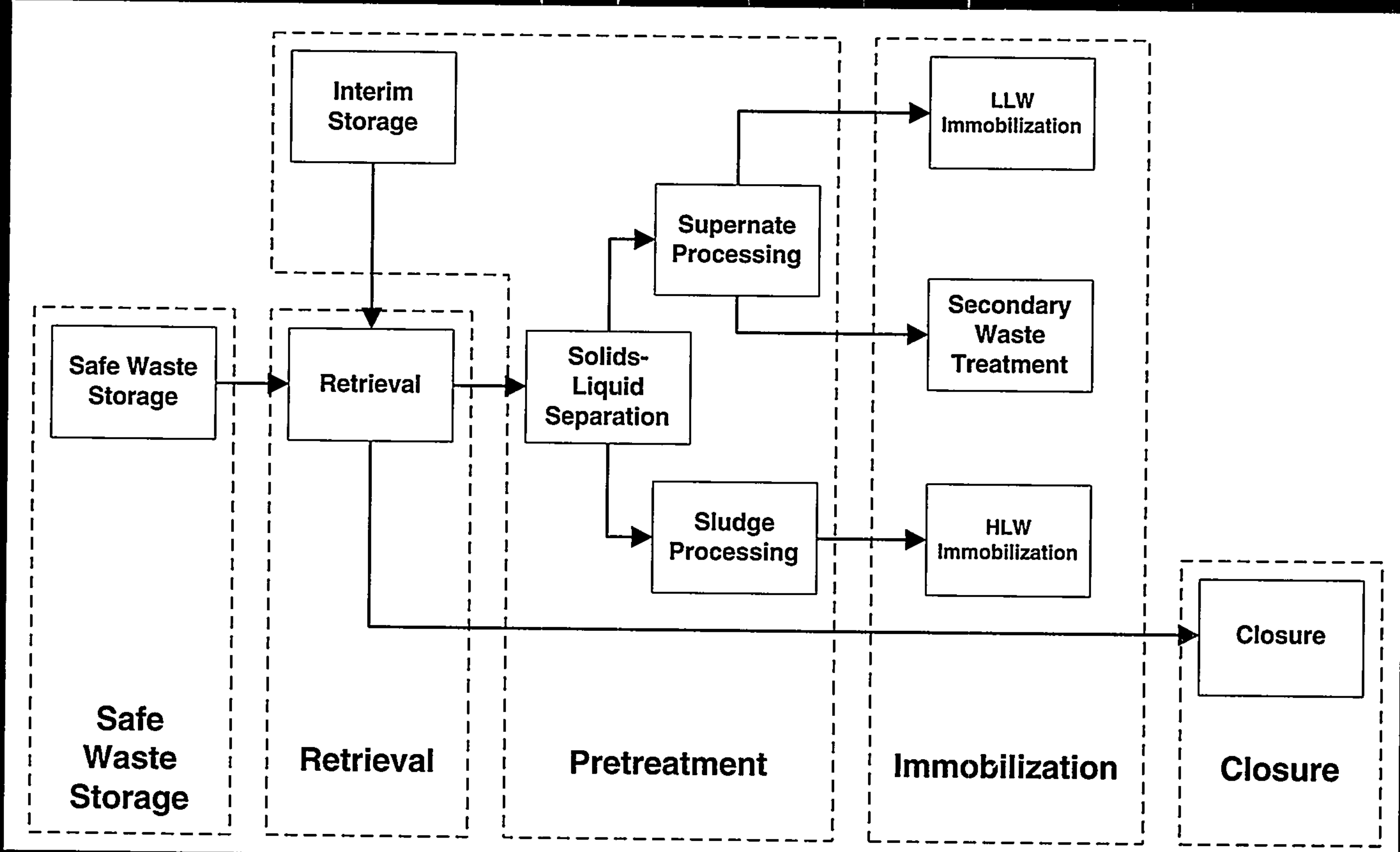
If the tank waste were spread across a football field, the waste would stretch up 28 stories - half the height of the Washington Monument.

Challenges Abound

The U.S. nuclear legacy tank waste problem is like no other problem in the nation; several technical challenges must be overcome.

The first significant challenge is the sheer amount of waste and size of the radioactive material inventory involved. Stated simply, this is a lot of waste to retrieve and process over the next 30 years. Not all of the technical issues have been resolved to support processing within this time. Financial resources to address these problems are limited, thus, technical solutions need to fit within what the taxpayer is willing to pay.

Second, the waste is chemically complex and unique - different from anything else in the world. Approximately 98% of the tank waste is alkaline. The remaining 2% is the Idaho National Engineering and Environmental Laboratory acidic tank and calcine wastes. Typically, tanks were constructed of carbon steel and designed to contain alkaline wastes. Chemicals, primarily sodium hydroxide, were added to change acidic wastes to alkaline wastes because acids corrode through carbon steel. Most of the rest of the world's experience with radioactive



The Tanks Focus Area provides technical solutions to tank waste remediation chellenges using a system approach that encompassesfive functions (shown above in bold type). This conceptual diagram illustrates the path to complete radioactive waste tank remediation.

waste treatment is with acidic wastes, limiting the pool of existing knowledge and technology and requiring first-of-a-kind processes.

Third, the U.S. Department of Energy is committed to manage the tanks and conduct remediation processes safely. Tank activities must avoid operating situations with a potential for igniting the waste or causing it to leak from the tank, either of which results in highly undesirable release to the environment. Operations must comply with all applicable federal and state regulations, which vary for each site.

Tank Cleanup is a Multifaceted Problem

Our primary goal is to ensure that all activities occurring in and around the tanks are as safe and cost effective as possible. We must find timely ways to retrieve waste from tanks at rates that meet the glass canister production and tank closure schedules. We must find ways to prepare and separate the waste so that only the elements that are highly radioactive are vitrified, that is, turned into glass logs. Immobilization processes that transform liquid waste into solid waste forms must be efficient and result in environmentally acceptable waste forms that can be stored for thousands of years. We must determine the most effective and cost-efficient way to close tanks. We must characterize tanks and wastes and monitor the performance of all process steps.

Problem Element	Site Implementation Strategy			
	Hanford	INEEL	ORR	SRS
Safe Waste Storage				
Monitor Tank Integrity	■	▒		■
Ventilate Tanks	▒			■
Characterize Waste In-Situ	▒		■	■
Analyze Waste	■			
Reduce Source Streams		■		
Reduce Recycle Streams				■
Waste Mobilization and Retrieval				
Mobilize Bulk and Heel Wastes	■		■	■
Mix Waste	▒			
Transfer Waste	▒		▒	■
Detect and Mitigate Leaks	■			
Monitor and Control Retrieval Process	■		■	▒
Integrate Retrieval and Pretreatment Technology Systems	▒			
Calcine Waste		■		
Dissolve Waste	▒	■		
Prepare Retrieved Waste for Transfer and Pretreatment	■		■	▒
Tank Closure				
Close Tanks		▒		
Characterize Heels	■	■	■	
Define Closure Criteria	■	■	■	■
Stabilize Tank for Closure	▒	■	■	■
Monitor Waste for Acceptance	■		■	
Determine Performance of Waste Form	■	▒		▒
Waste Pretreatment				
Clarify Liquid Stream	■	■	■	
Remove Radionuclides	▒	■	■	■
Process Sludge	■			■
Prepare Pretreated Waste for Immobilization	■			■
Waste Immobilization				
Immobilize LLW Stream	▒	■	■	
Monitor and Control HLW Immobilization Process				■
Prepare Sludge Feed				■
Immobilize HLW Stream	■	■		■

Legend	
Primary Benefitting Site	■
Secondary Benefitting Site	▒
Problem Element Not Applicable at Site	

Hanford - Hanford Site
INEEL - Idaho National Engineering and Environmental Laboratory
ORR - Oak Ridge Reservation
SRS - Savannah River Site

The Tanks Focus Area strives to deliver the technical solutions that provide the most benefit to the waste tank sites.

The Tanks Focus Area Provides the Solutions

Working with our partner programs at the waste tank sites and within the Department of Energy, Office of Environmental Management's, Office of Science and Technology, we are focusing to solve the critical technical challenges of tank remediation. Science and technology for waste treatment are necessary to advance Tanks Focus Area objectives. We work with the sites to identify key challenges and balance today's needs with tomorrow's risks.

Solutions mean savings down the road

The cost savings resulting from the use of Tanks Focus Area technologies are critical to achieving cleanup goals within the available budget.

The Tanks Focus Area Adds Value

The Tanks Focus Area works with the sites to provide technical solutions to prevent cost increases above those currently projected, by reducing technical risk and establishing viable baselines. The program emphasizes the site's ownership of the technology - building teams focused on providing specific solutions within the Tanks Focus Area's scope.

The Light Duty Utility Arm is a flexible arm, designed to work in the harsh tank environments, with a gripping tool that can grasp small objects such as this characterization probe.

The Tanks Focus Area uses a technical framework to respond to the changing site priorities. This framework builds upon the DOE-EM goals set for its waste management and environmental remediation programs. The DOE-EM Office of Waste Management has performance objectives for the number of high-level waste canisters to be produced and the number of tanks to be closed. The DOE-EM Office of Environmental Restoration has performance objectives for the number of radioactive waste tanks to be cleaned and ready for closure. The Tanks Focus Area, along with its partner programs, provides the technical solutions that enable the sites to meet these performance objectives. Our partner programs include Industry, University, International, Crosscutting, and EM Science Programs led by the Office of Science and Technology.

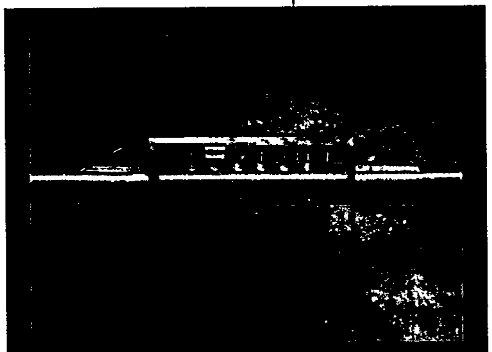
The technical solutions from the Tanks Focus Area and its partners are grouped within the following five problem elements: safe waste storage, waste mobilization and retrieval, tank closure, waste pretreatment, and waste immobilization. These problem elements comprise a system approach, meaning each problem element is part of the system solution to solving tank remediation problems.

SAFE WASTE STORAGE

The Tanks Focus Area emphasizes leak detection, leak avoidance, and cost effective tank farm operation. All four waste tank sites have taken measures to remove excess liquids from tanks that have exceeded their design life expectancy, reducing the potential for release to the environment. This includes all single-shell containment tanks. Although there are no indications of leakage, even the double-shell containment tanks are approaching the end of their design lives. These tanks must be used up to 25 more years to support cleanup schedules. Tools to monitor corrosion are needed to detect and avoid leaks. Developments to upgrade the tank farm infrastructure will reduce annual operating and maintenance costs.

Corrosion Probe Saves Money and Reduces Worker Exposure

The Hanford and Savannah River Sites control waste chemistry by adding corrosion inhibitor solutions to prevent corrosion. Currently, corrosion inhibitor additions are made based on laboratory chemical analysis of waste samples taken every two years. This method is slow, labor intensive, and adds to the waste volume that must ultimately be processed, adding to the overall processing cost. Real-time monitoring of the corrosion processes will better define when to add corrosion inhibitors, saving money and reducing worker exposure. The Tanks Focus Area is developing a real-time, in-tank corrosion probe to realize these benefits at the Hanford and Savannah River Sites. A first generation corrosion probe was demonstrated in FY 1997 at the Hanford Site. During FY 1998, data generated by the first probe is being analyzed to define improvements for a second generation probe. The Hanford and Savannah River Sites plan to have fully operating systems available in FY 2000.



The first generation corrosion probe is designed with strategically placed electrode arrays that measure the electrochemical noise generated by tank corrosion processes.

$NO_3/NO_2/OH$ Monitor Reduces Worker Exposure and Regulates Corrosion Inhibitor

The $NO_3/NO_2/OH$ monitor continuously monitors in-tank chemistry. Currently, the Savannah River Site samples and analyzes tank waste to ensure that the ratios of nitrate (NO_3) to nitrite (NO_2) to hydroxide (OH) are within limits that minimize the corrosion of their carbon steel tanks. In FY 1997, the Tanks Focus Area and the Characterization, Monitoring and Sensor Technology Crosscutting Program contracted with a vendor to develop an $NO_3/NO_2/OH$ monitor based on Raman spectroscopy technology. With this technology, additional, and more timely data will be available allowing rapid response to changing $NO_3/NO_2/OH$ concentrations. The cost for sampling and associated worker exposure decrease with use of the in-tank monitor. Constant monitoring will allow smaller and more frequent chemical additions to adjust the tank's chemistry. For this technology, the Tanks Focus Area linked the producer of the monitor, the Savannah River Site users, and the Tanks Focus Area's technical experts into a team focused on both development and deployment of the technology. This team is working toward FY2000 deployment. If successful, the technology could be deployed in a number of tanks at the Savannah River and Hanford Sites.

Metal Filters for Waste Tank Ventilation Reduce Cost and Worker Exposure

High Efficiency Particulate Air (HEPA) filters are used throughout the U.S. Department of Energy complex to assure that air emissions to the environment are free of radioactive particulates. HEPA filters are generally constructed of a fiberglass paper, capturing at least 99.97% of particles 0.1-micron in diameter and larger. These filters are susceptible to moisture, causing high pressure drops across the filters and even the eventual failure of the filters. The filters must be replaced periodically; this is a labor intensive operation resulting in personnel radiation doses, potential exposures to contamination, and generation of radioactive wastes. The Tanks Focus Area, together with Industry Programs, is developing an alternative filtration technology. The sintered stainless steel metal HEPA filter can provide durable filtration that eliminates many shortcomings of fiberglass media filters. Preliminary tests show that the metal filters are as efficient as traditional fiberglass filters, but can be cleaned with water, are suitable for reuse, and are unaffected by moisture. These filters will save money, reduce waste, and protect workers.

WASTE MOBILIZATION AND RETRIEVAL

As of FY 1997, 273 tanks in the U.S. Department of Energy complex require closure. Recently, two tanks at the Savannah River Site were the first high-level radioactive waste tanks to be officially declared closed. For a tank to be declared closed, the tank must be out of service and in a condition that will prevent any release of the residual wastes. The closure criteria are defined by stakeholder groups including state regulatory agencies. Most of the remaining tanks require the retrieval of wastes before the tank can be closed. The waste types to be retrieved include liquids, saltcake (a concrete-like crystalline solid), sludges (a thick suspension of solids and liquids), and miscellaneous debris (pieces of metal, concrete, etc.). Each waste type and combination represents a technical challenge. Technical solutions that enable sites to remove the various waste types are needed to meet the plan titled "Accelerated Cleanup: Paths to Closure."

Retrieval processes must not add excess water to the system. Additional water increases the cost of processing the waste and could cause problems in tanks susceptible to leaks. In addition, retrieval processes must not cause the waste to congeal or solidify and plug the waste transfer pipes. All four tank sites are retrieving wastes from their tanks.

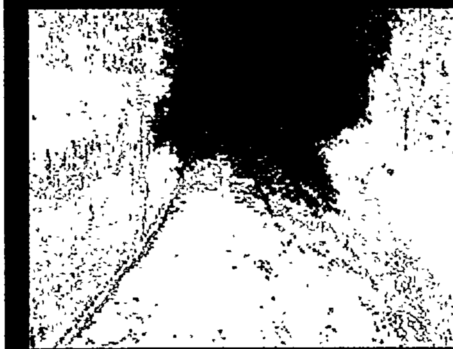
Fluidic Sampler Takes More Representative Tank Waste Samples

The Savannah River Site needs an improved method to verify the composition of retrieved waste before it is sent for processing. With the current method, a grab sampler is inserted into the tank, waste is maneuvered into the sample chamber, and the sample is withdrawn from the tank. This method is hands-on labor intensive, resulting in substantial radiation exposure to workers. Tank mixing must be stopped to take the sample, and laboratory analysis completed, before waste transfer can begin. This creates a significant disadvantage for waste tank operations. AEA's Fluidic Sampler is an improvement because workers are not exposed during sampling, it requires less maintenance, it can gather more representative samples, and mixing operations can continue while the sample is acquired. During FY 1997, the Tanks Focus Area and International Programs, designed, fabricated, cold tested, and delivered two samplers. The Savannah River Site received a third sampler for deployment in FY 1998 under the Accelerated Site Technology Deployment Program. The Hanford Site is adapting the fluidic sampler system to collect samples at varying depths in a tank. These samples are critical to private vendor vitrification contracts: representative samples and rapid analyses are needed to ensure the waste meets vitrification specifications. An on-line analytical technique, Laser Ablation/Mass Spectrometry (LA/MS), will be included with the variable depth fluidic sampler at the Hanford Site to meet this requirement in FY 2000.

The radioactive waste in Tank 19 contains sludge, water, and other materials. Samples are needed of this waste to determine how much cleaning is required before the tank can be closed.

Dissolving Saltcake in Tank Annulus Reduces Secondary Waste

Several years ago, the Savannah River Site's Tank 16 leaked waste into the space between the primary and secondary containment walls. This space is called the tank annulus. A portion of the leak overflowed the containment and was released to the soil. Most of the waste was immediately removed and the tank interior cleaned. However, residual waste in the annulus has dried into saltcake. This saltcake may need to be removed before tank closure. In FY 1998, the Savannah River Site HLW program is deploying a saltcake sampler to retrieve samples from the annulus. From these samples, total quantity of chemicals and radionuclides remaining in the annulus will be determined. If these quantities exceed limits set by the U.S. Department of Energy and South Carolina State regulators, the Department of Energy will deploy saltcake dissolution and retrieval technologies to reduce the saltcake volumes to acceptable limits. The goal is to use a technique that transfers dissolved salt at the same rate as the salt dissolves to avoid excess water accumulation in the annulus. This controlled salt dissolution and removal ensures that the water level never exceeds the secondary containment wall. Lessons learned from removing the saltcake from the Tank 16 annulus will be transferred for future use in other tanks at the Savannah River Site.



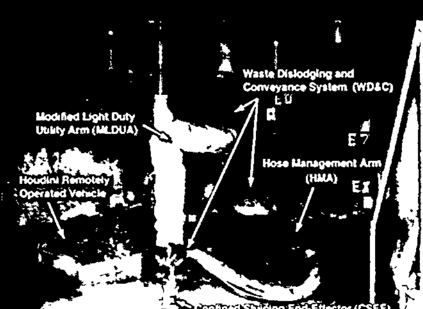
In Tank 16, waste leaked through the primary tank into a secondary shell. Removing this waste will require a retreival technology capable of working in tight spaces.

Sludge Heel Retrieval Prepares Tank 19 for Closure

Recently, the Savannah River Site, with support from the Tanks Focus Area, closed two high-level waste tanks. The site will close two additional tanks by the end of FY 2000. Tank 19, has a sludge heel that contains a sand-like material called zeolite. This heel must be removed to meet negotiated closure requirements. The conventional method for heel removal uses pressurized water jets to mix the sludge into a slurry that can be pumped from the tank. Because of the nature of the waste in this tank, the conventional removal method has not worked. In addition, the conventional method adds to the waste, increasing treatment costs. The Tanks Focus Area is working with the Savannah River Site to test commercially available pumps and mixers to suspend the sludge with a modest amount of water before transfer. These mixers are an inexpensive alternative to conventional mixing technologies because they operate in the tank and do not require extensive external support systems and structures. If the FY 1998 activities are successful, the Oak Ridge Reservation will deploy this technology under the Accelerated Site Technology Deployment Program to suspend sludge in their active waste tanks in FY 1999.

New and Existing Technologies Clean Gunite Tanks

At the Oak Ridge Reservation Gunite and Associated Tanks Remediation Project, new and existing technologies have been combined to remove sludge from Tanks W-3 and W-4 in FY 1997 and FY 1998. Sludge removal is difficult because the tank interiors have limited access and small objects are often found at the bottom of the tanks. The Tanks Focus Area and its partners developed the Gunite Tank Cleaning System. The system consists of a Modified Light-Duty Utility Arm, Confined Sluicing End Effector, and a multi-functional and remotely operated vehicle called Houdini. Together these technologies help clean the tank to meet closure criteria. The Confined Sluicing End Effector uses a high-pressure water jet paired with a jet pump to loosen sludge from the tank bottom and transport the sludge from the tank. The system is designed to mobilize sludge without damaging the gunite tank. The Confined Sluicing End Effector is moved around inside the tank with the Modified Light Duty Utility Arm and Houdini. Houdini can be fitted with a robotic



Waste needs to be consolidated at the Oak Ridge Reservation to allow a private company to treat the waste. The Confined Sluicing End Effector and Houdini vehicle were used to remove hazardous waste from Oak Ridge's Tank W-3.

arm, a plow, and a camera depending on task to be done. Overview cameras in the tanks, on the Modified Light-Duty Utility Arm, and Houdini, developed by the Tanks Focus Area provide equipment operators a view of the tank interiors and waste removal activities. This versatile and integrated system combines the best aspects of several technologies to retrieve tank waste. The Oak Ridge Reservation successfully used this system to retrieve tank waste in FY 1997 and will use it again in FY 1998. The Oak Ridge Reservation expects to complete retrieval operations in Tanks W-3 and W-4 during FY 1998. The removed wastes will be consolidated at the Oak Ridge Reservation's Melton Valley Storage Tanks by FY 2002 so private companies can treat the waste for disposal.

Pulse Air Mixer in Staging Tank Performs Large-Scale Mixing to Allow Complete Transfer

The Oak Ridge Reservation's gunite tanks are far from the facility where retrieved waste is being consolidated for private company treatment. Retrieved wastes must be transferred over several miles through a 2-inch pipe. The waste must be "staged" to avoid conditions that might cause plugging of the transfer line. Staging is the collection of waste in a holding tank - allowing the solids in the waste to settle. A mixing method is needed to keep the solids suspended, preventing problems during transfer. During FY 1997, the Tanks Focus Area tested Pulsair™ Incorporated's pulse air mixer to meet this need. Pulse air mixing requires less water addition, has no moving parts, and does not add heat - significant improvements over mixer pumps. Pulses of air are introduced near the tank floor using large horizontal, circular plates positioned just above the tank floor. The bubbles vigorously move the waste, mixing solids from the tank floor and maintaining solids in a uniform suspension ideal for waste transfer. In FY 1998, the Pulsair™ mixer will be used in the Oak Ridge Reservation Gunite and Associated Tanks remediation transfer staging tank.

Pulse Jet Pump Mobilizes Sludge

At the Oak Ridge Reservation, thick sludge must be retrieved from several cigar-shaped tanks. Waste is mixed with the pulse jet fluidic mixing pump. It works like a syringe, pulling out tank waste and then shooting it back into the tank under pressure.

Radioactive waste tanks were not designed with retrieval in mind. At the Oak Ridge Reservation, thick sludge must be retrieved from several cigar-shaped tanks known as the Bethel Valley Evaporator Service Tanks (BVEST). No simple method exists to deploy retrieval tools into these tanks. The Tanks Focus Area, together with International Programs and industry partner AEA Technologies, Inc., provided the fluidic pulse jet pump to mobilize the BVEST sludges in FY 1997. AEA's Pulse Jet Pump combines a tank's available liquid and sludge using pulse tubes and air ejectors. The air ejectors apply suction to the tubes, filling them with the liquid. Then, air is applied to the tubes forcing the liquid out and agitating the waste. This process is repeated until the waste, now a slurry, is suitable for retrieval with a pump. The AEA Pulse Jet Pump reduces maintenance costs, reduces the need to add liquid, and can use in-tank piping where available. These characteristics reduce operating costs. Operation of this system will continue through FY 1999 as part of the Accelerated Site Technology Deployment Program.

Adapted from Industry: Borehole Miner

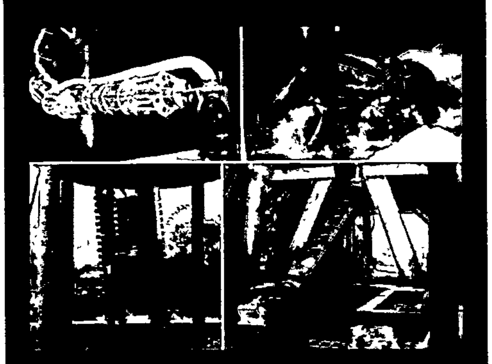
The Oak Ridge Reservation's Old Hydrofracture Facility tanks are inactive tanks with sludge heels that must be removed and transferred to a consolidation facility for subsequent treatment by private companies. The tanks are cylindrical, lie horizontally, and have very limited access - a challenge to retrieve waste from. The Borehole

Miner uses a high-pressure water jet discharged from an extendible nozzle to break up and mobilize saltcake and sludges for pumping. The Borehole Miner was adapted from the mining industry where it is used to selectively wash away ore-bearing soils from a borehole. The applications are extremely similar: both are very restricted places and require mobilization of heavy material for pump-based retrieval. The water jet nozzle operates at pressures up to 3,000 pounds per square inch and can be remotely extended, rotated, and angled. This range of motion enables thorough cleaning of the tank surfaces when compared with previous retrieval technologies. In FY 1997, design, fabrication, and testing of the system was completed in preparation for the retrieval of residual waste in the Oak Ridge Reservation's Old Hydrofracture Facility tanks during FY 1998.

The Borehole Miner uses a high-pressure water jet to remove radioactive waste, but adds less water than conventional methods.

Private Companies Demonstrate Technologies to Retrieve Tank Waste

The Hanford Tanks Initiative is a cooperative effort between the Tanks Focus Area and the Tank Waste Remediation System at the Hanford Site, tasked to define retrieval performance objectives that lead to tank closure. The goal is to help determine and resolve closure issues for tanks and to broaden industrial retrieval services for DOE-EM. Both goals support successful waste treatment by private companies.



Four companies demonstrated technologies that they believe could survive the harsh in-tank conditions and remove the waste.

At the Hanford Site, regulations require removal of waste to within specified limits or as much as technically possible, whichever is less. The existing technique, called past-practice sluicing, does not reliably remove hard heels from the tanks and adds a significant amount of water to the waste. Neither of these characteristics is desirable. In addition, the waste retrieved from tanks must meet Hanford Site specifications to prevent pipeline plugging. Commercially available vehicle-based and arm-based retrieval systems and real-time slurry monitors are being developed to meet the removal requirements.

Hanford Tanks Initiative

The Hanford Tanks Initiative (HTI) is demonstrating technologies and costs for characterizing and removing high-level radioactive waste from single-shell storage tanks. HTI will establish retrieval performance evaluation criteria objectives for the end-state definition for Hanford single-shell tanks.

Based on successful demonstrations of arm-based and vehicle-based commercial heel retrieval technologies in FY 1997, the Hanford Tanks Initiative awarded two contracts for system definition for use in Tank 241-C-106. After evaluating and comparing the two systems in FY 1998, a single system will be selected for use in Tank 241-C-106. This system will follow a bulk waste sluicing campaign, removing the residual waste to meet regulatory requirements. Real-time slurry monitors provide physical data, normally provided by time-consuming sampling and laboratory analysis, to verify the waste meets specifications during retrieval and transfer operations. During FY 1999, the slurry monitor will be evaluated to ensure the slurry monitor is ready for "hot" operations in FY 2000 and FY 2001.

TANK CLOSURE

Between FY 1997 and FY 2001, the U.S. Department of Energy will close or prepare to close 21 tanks; four at the Savannah River Site, sixteen at the Oak Ridge Reservation, and one at the Hanford Site. Two additional tanks will be closed at the Idaho National Engineering and Environmental by FY 2006. By closing the tanks, the U.S. Department of Energy greatly reduces the risk of exposing people or the environment to hazardous chemicals and harmful radioactive material. In addition, by closing tanks the U.S.Department of Energy reduces the cost of maintaining the sites and keeps its agreements with regulators and the public. To meet tank cleaning and closure goals, the sites require data gathering technologies to support the negotiation of closure criteria with their local regulators. They also require cleaning methods that do not introduce excess water or chemicals that have undesirable effects on downstream processes. Finally, the sites require stabilization technologies to encapsulate or immobilize residual waste and provide structural integrity and isolation. Closure of radioactive waste tanks has become a key element in the tank sites' baseline plans for reducing mortgage and accelerating cleanup while reducing the potential for inadvertent release of tank wastes to the environment.

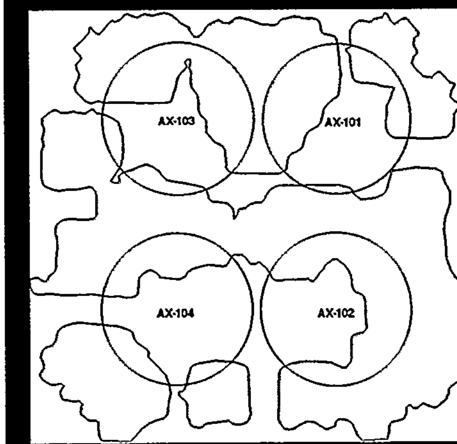
Closing Savannah River Site Tanks Minimizes Maintenance Costs

Tests show that sequentially pouring grout into Tank 20 would trap the small amount of remaining sludge. These tests were conducted in "swimming pools" with a diameter of thirty feet.

The Savannah River Site closed two of its underground radioactive waste storage tanks - Tanks 17 and 20. These were the first high-level waste tanks officially closed within the U.S. Department of Energy complex. The strategy for closing the tanks was to remove as much waste as feasible, to meet closure requirements negotiated with the state, and to create a cement-like monolith inside the tank to trap the small amounts of remaining waste and to stabilize the tank physically. It was determined that Tank 20 could be closed with a cement-like monolith alone. The Tanks Focus Area provided the reducing grout formulation and grout pour testing that ensured adequate encapsulation of the residual waste to meet closure criteria. Initial tests showed that sequentially pouring the cement-like material into the tank would effectively encapsulate the remaining sludge. The careful testing, preparation, and process monitoring contributed to the overall success of this project. As tanks are closed, many operations and maintenance costs are eliminated forever.

Tank closure required several steps. First, sludge-entraining reducing grout was poured into the tank to inhibit the spread of soluble radionuclides that could leach to the groundwater. Then, a controlled low-strength material was added to the tank. When the top of the tank sidewalls was reached, a high-strength, intrusion prevention grout was added to fill the dome. The high-strength material prevents future intrusion and provides stability for the tank dome. The tank risers - pipes leading from the tank dome through several feet of soil to the surface - were filled with the controlled low-strength material and the distribution pipes into the tank were capped. The resultant cement-like monolith is highly resistant to groundwater leaching and structurally very stable against external forces, such as earthquakes.

In Tank 17, the site removed some residual waste with a sluicing technique (called a water monitor) and a "finishing" technique (called a water mouse). The sluicing technique used a focused water stream to break up and direct the sludge heel to a transfer pump intake. In this effort, some sludge was pushed to the tank edges. The water mouse, which was an easily controlled in-tank water jet unit, redirected the residual sludge from the tank edges so that it could be readily mixed with the entraining reducing grout. A modified grout pouring approach was used with the same grout formulations used in Tank 20. Future tanks will be closed with modified grout formulations that reduce the cost for closing tanks. These modified pouring and formulation approaches are a direct result of lessons learned during the closure of Tank 17 and Tank 20.



Waste leaked from Tank 241-AX-104 at the Hanford Site into the surrounding soil. The plume information shown in this model of the tank farm needs to be validated so the tanks can be closed.

Hanford Site Vadose Zone Monitoring Helps Develop Closure Criteria

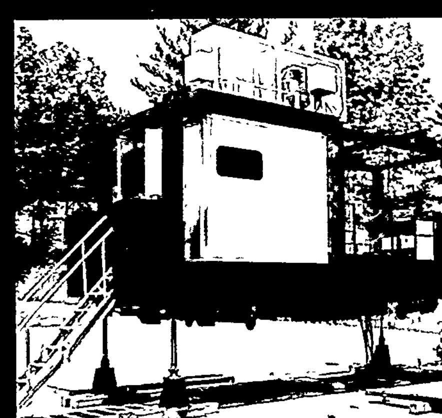
Because 67 of the Hanford Site's tanks are suspected leakers, tank closure criteria must consider not only the inventory of chemicals and radionuclides in the tank, but must also consider what has leaked into the surrounding soils (vadose zone). The Tanks Focus Area, through the Hanford Tanks Initiative, supports the development of closure criteria by developing the tools needed to learn how much waste is in the soil near the tank. The Hanford Tanks Initiative will select, fabricate, and demonstrate analytical instrumentation and soil samplers to be deployed with the cone penetrometer in the soil near Tank 241-AX-104 in FY 1998. Samples will be taken to verify the quantity and extent of contaminants leaked into the soil and vadose zone. Discrete soil samples will be taken and the contaminant signatures validated on-location before sample selection and shipment to the laboratories for analysis. Mapping the extent of contaminants and laboratory analysis of selective soil samples will reduce uncertainty associated with the estimates of radionuclides and hazardous chemicals in the plume. Determining the extent of subsurface contamination provides valuable data for developing closure criteria.

Mapping Leaks

Mapping the location, extent of migration, and concentration of radionuclides and hazardous chemicals in the soil around Hanford Site single-shell tanks is critical. With this information, the extent of tank waste leaks can be understood and characterization and removal tasks can be monitored to ensure additional waste is not released into the environment.

Characterizing Residual Waste Supports Tank Closure Decisions

Prior to tank closure, waste must be removed from those tanks where a performance assessment shows that the inventory of radionuclides and chemicals exceeds a negotiated limit. Past-practice sluicing has been used by all the tank sites including the Hanford Site to remove the bulk of wastes in tanks. However, this retrieval technique left residual waste at the bottom of some Hanford Site tanks that must be characterized to support performance assessment models and subsequent closure decisions. From a regulatory standpoint, sampling and laboratory analysis of retrieved samples is the only acceptable approach to establish the radionuclide and chemical inventory of the residual waste. Several Tanks Focus Area technologies are being used to sample and characterize the residual waste.



A skid-mounted cone penetrometer will push a state-of-the-art sensor system into the soil surrounding the tanks. The sensor system provides information on the location, extent of migration, and concentration of radionuclides.

Tank wastes are heterogenous; this requires samples to be taken at different locations. The Extended Reach End Effector is used to gather samples from previously inaccessible locations

When sampling tank waste heels, conventional sampling methods can only reach waste directly below the access locations. Techniques that enable the sampling of waste away from the riser are needed. Moreover, conventional sampling methods are designed for deep waste (i.e., a few feet thick). However, for waste tank heels the residual waste may be only a few inches thick, requiring new sampling techniques. In addition, enough locations in the tank need to be sampled for adequate characterization. The Light-Duty Utility Arm and the Extended Reach End Effector will take samples from the residual waste in Tank 241-AX-104 at locations away from the riser, on the walls, and on the floor of the tank. The depth of waste on the floor is typically less than 6 inches. Once retrieved, the sample will be analyzed in a laboratory hot cell using a Tanks Focus Area developed technology, the Laser Ablation/Mass Spectrometer. The Laser Ablation/Mass Spectrometer was deployed in the Hanford Site 222-S Laboratory in FY 1997. In FY 1998, further sampling will be done at remote locations in the tank using the Extended Reach End Effector.

Pipe Plugging and Grout Formulation for Gunite Tank Closure

To comply with tank closure procedures, each gunite tank at the Oak Ridge Reservation must be completely isolated. These tank have several openings including waste transfer pipes and risers. During rainstorms, water leaks through these pipes and into the tanks. Once emptied, the tanks must be isolated to enable tank closure by FY 2002 according to the plan titled "Accelerated Cleanup: Paths to Closure." These pipelines need to be plugged to prevent water from leaking into the tanks after retrieval activities are finished. Because the Modified Light-Duty Utility Arm is already being used in a tank, the Oak Ridge Reservation requested that the Tanks Focus Area add to the capability of this system to solve the tank isolation problem. A special tool for the Modified Light-Duty Utility Arm is being developed to isolate the incoming and outgoing pipelines. Isolation will be achieved without the traditional excavation, pipe cutting, and capping processes that involve substantial radiation doses to workers. A concept design and a prototype tool have been developed. The prototype will be tested using the Modified Light-Duty Utility Arm as the deployment system. Modifications will be made to the tool, if necessary. This work will be completed in FY 1999 and will be used in FY 2000.

The final step of closing the tank is to stabilize the tank physically and immobilize any residual waste. The Tanks Focus Area is developing and testing grout formulas and a system for in-situ grouting. This system will undergo large-scale testing in FY 1999 and be deployed in an Oak Ridge Reservation tank in FY 2000.

WASTE PRETREATMENT

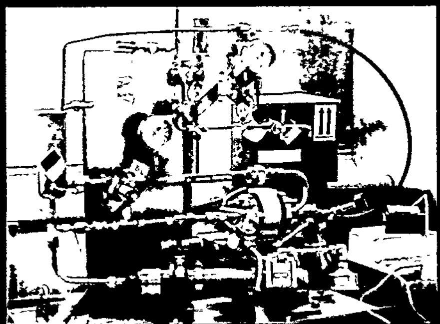
Once retrieved, the liquid waste must be converted, by a process called vitrification, to a more stable glass waste form. If the U.S. Department of Energy immobilized all of the retrieved waste as glass logs, it would cost hundreds of billions of dollars and the vitrified waste would exceed available storage space in the planned repository. Fortunately, front-end processing steps can be taken to separate long-lived and highly radioactive isotopes from non-radioactive chemicals, leaving a smaller portion of the waste for vitrification and subsequent disposal. This pretreatment processing can avoid the expenditure of billions dollars and reduce long-term storage impacts. As a result, the Tanks Focus Area and its partners at the tank sites are pursuing waste pretreatment options.

Pretreatment involves three process steps: 1) separate the waste into solid and liquid portions, 2) reduce the radionuclide content of the liquid, and 3) remove the chemicals from the solid portion. With lower levels of radioactivity the waste can be immobilized using much easier and less expensive methods than those required for higher activity waste. Removing certain chemicals from the high-activity liquid and solid portions means fewer, better quality glass logs. Certain liquid waste types require removal of strontium, technetium, and the transuranic elements. Treating sludge removes aluminum, chromium, phosphates, sulfates, and other chemicals from the solids. Small amounts of these constituents can complicate glass formation and greatly increase the volume of high-level waste glass produced, increasing processing and disposal costs. Removal of these constituents reduces waste volume and aids the glass in meeting long-term waste form performance specifications.

The Tanks Focus Area is also focusing on waste volume reduction of the low-activity waste before stabilization. First, converting excess sodium from the salts in the liquid waste to the caustic sodium hydroxide yields low-activity waste and allows reuse of the recovered caustic throughout the process. Second, excess water from the process adds to low-activity waste volume, waste processing and disposal costs, and occupies precious tank space. The Tanks Focus Area is working to decontaminate waste water streams, allowing the liquid to be disposed of through the site's existing effluent treatment facility.

Crossflow Filtration Effectively Filters Solids and Sludges

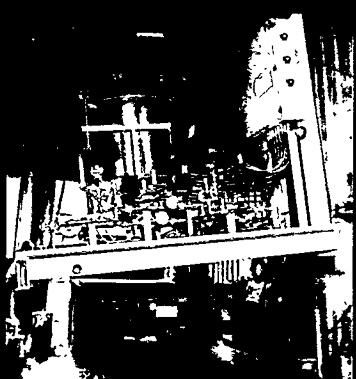
Solid-liquid separation is needed to control the solids content in waste. Waste feed delivered to the private companies at the Hanford Site, waste being transferred across the Oak Ridge Reservation, and before solvent extraction at the Idaho National Engineering and Environmental Laboratory require control of solids to prevent damage to processing equipment and pipeline plugging. Bench scale test units, the cells unit filter, were fabricated for each site. In FY 1997, tests were performed using actual tank waste at the Hanford Site, Idaho National Engineering and Environmental Laboratory, and Oak Ridge Reservation to determine the effectiveness of crossflow filtration for each site's waste. Results at all sites suggest that crossflow filtration effectively filters solids and sludges from liquids. A full-scale crossflow filtration system will be used for separation of tank wastes at the Oak Ridge Reservation in FY 1999 in preparation for a private vendor to vitrify the waste. At the Idaho National Engineering and Environmental Laboratory, the results of the bench-scale tests are being used in the Environmental Impact Statement scheduled for public comment in FY 1999. The results of crossflow filtration tests on Hanford Site wastes are available to the private waste remediation companies for use in selecting baseline solid-liquid separations processes.



Many waste remediation processes require incoming waste to be virtually free of particles. These particles can damage costly equipment. The crossflow filtration unit can remove these particles and has been tested on actual tank waste.

Understanding Tank Chemistry Unites National Laboratories, Industry, and Academia

When the Hanford Site contracts private companies to treat tank waste, the Hanford Site management contractor will retrieve the liquid waste and precipitated salt wastes for treatment and disposal. The baseline plan is to re-dissolve the precipitated salts simply by adding water. Although most salts are expected to go back into solution, this has not been verified with large volumes of actual waste. Also, different waste types may be incompatible causing reprecipitation of solids when mixed. Solids in the waste stream can plug transfer lines and foul separations equipment, carry excess radioactivity into the low-activity waste stream, or add excess volume to the high-level waste sludge stream. The chemistry of liquid tank waste and sludge wash liquids is quite complex. Additional water also can cause precipitation of some salts. Therefore, understanding the conditions that avoid precipitation in the liquid waste and dissolved salt solutions is important to the retrieval operations that support waste treatment. This task supports the Hanford Site baseline.

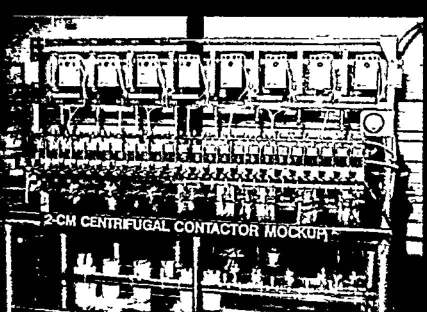


A large scale demonstration of the Cesium Removal Demonstration System and an inorganic ion-exchange resin was performed at the Oak Ridge Reservation.

The Tanks Focus Area has established a university, national laboratory, and Hanford Site contractor team to test actual waste samples and confirm thermodynamic models of waste component solubility. The information will be transferred to the Hanford Site's Tank Waste Remediation System to support preparation of feed and treatment specifications for the private companies by FY 2000. Salt dissolution also supports Savannah River Site saltcake retrieval.

Cesium Removal from Alkaline Waste

Cesium is one of the main radioactive constituents in the liquid tank waste. Cesium removal from liquid waste is required to treat and dispose of the liquid as low-activity waste, reducing the cost of treatment and disposal. In FY 1997, the Tanks Focus Area completed a large-scale demonstration of cesium removal from tank waste using a newly developed inorganic ion-exchange material. Approximately 1,100 curies of cesium-137 were removed from 31,000 gallons of waste from one of the Oak Ridge Reservation tanks. The cesium was adsorbed into 70 gallons of ion-exchange media. A similar compact processing unit is being pursued to remove cesium from the Defense Waste Processing Facility recycle stream under the Accelerated Site Technology Deployment Program. Removing the cesium and other constituents would enable the stream to be discharged through a permitted outfall rather than be sent back into the high-level waste tanks.



Cesium, strontium, technetium, and transuranic elements comprise less than 1% of the total volume of acidic waste in the Idaho National Engineering and Environmental Laboratory tanks. Separating these elements from the bulk waste greatly reduces the cost and risk involved with disposing of the waste.

Radionuclide Removal Reduces Waste Volume and Disposal Costs

The radioactive waste at the Idaho National Engineering and Environmental Laboratory is acidic. Transuranic elements, cesium, strontium, and technetium comprise less than 1% of the radioactivity. Separation of these radionuclides from the rest of the waste will result in a significant reduction of high-level waste volume and corresponding reductions in processing and disposal costs. Solvent extraction and ion-exchange technologies are being demonstrated with actual acidic wastes to ensure that full-scale processes can adequately remove these radionuclides to below low-activity waste specifications.

This activity provides data for the site Environmental Impact Statement due in FY 1999. Transuranic and strontium extraction has been demonstrated in a hot cell with actual tank waste. In FY 1998, solvent extraction and ion-exchange for cesium removal are being evaluated, and cesium removal from actual waste will be demonstrated. In FY 1999, an integrated cesium removal, transuranic, and strontium extraction flowsheet will be tested.

Thermal Denitration Process Improves Quality and Reduces Waste Volume

The thermal denitration process will reduce the Idaho waste volume by three to eight times, saving millions in low-activity waste storage costs. The thermal denitration process will be demonstrated at the pilot-scale in FY 2000 for Idaho National Engineering and Environmental Laboratory low-activity waste. The current baseline for treating low-activity waste at the Idaho National Engineering and Environmental Laboratory is being established through an Environmental Impact Statement process; grouting with thermal denitration is one option. Thermal denitration destroys or reduces the nitrates in the feed to produce a more stable grout waste form and reduce grout volume. The Idaho National Engineering and Environmental Laboratory reports a potential cost reduction of $10,500,000 over 15 years assuming annual operating costs of $3,200,000 for a denitration facility.

Alkaline Technetium Removal to Meet Waste Disposal Requirements

Technetium is typically present in alkaline liquid waste as a soluble component, has an extremely long half life (210,000 years), and is very mobile if released to the environment. To meet low-activity waste disposal criteria, technetium may need to be removed from the waste in several tanks at the Hanford Site. High performance ion-exchange material has been developed for technetium, but most are designed to remove only the soluble species. Waste samples from several Hanford Site tanks suggest that a substantial amount of insoluble technetium is present. The Tanks Focus Area, along with the Efficient Separations and Processing Crosscutting Program, investigated the presence of insoluble species and evaluated possible treatments for removing this material. Ion-exchange flow studies conducted showed effective removal of technetium. These data are available for private companies to use in FY 1998 for selecting their baseline technologies for technetium removal.

Sludge Treatment Reduces Waste Volume and Assists Immobilization

Tank waste sludges at the Savannah River Site, Hanford Site, and Oak Ridge Reservation require processing to remove components that either increase the volume of the waste or adversely affect the immobilization process. Three areas need to be addressed: 1) performance of the baseline enhanced sludge washing process, 2) chemistry of sludge treatment, and 3) continuous sludge processing. The baseline pretreatment for Hanford Site tank sludges is enhanced sludge washing, which is a caustic leach followed by washing with dilute sodium hydroxide. The primary purpose of enhanced sludge washing is to remove aluminum and phosphates from the waste to minimize high-level waste glass volume. To date, 34 of 57 samples from Hanford Site tanks have been tested representing approximately 80% of Hanford Site sludge. Many samples must be tested because there are more than 25 different sludge types in Hanford Site tanks. The results were used in a report to the Washington

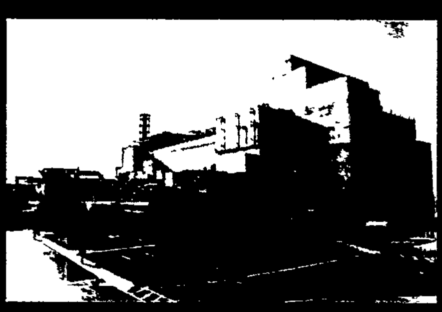
Tank sludge results from a variety of chemical reactions. To immobilize the waste and reduce risks, we must understand what the sludge contains and how it will react when it is vitrified.

State Department of Ecology in FY 1997. This was part of the Tri-Party Agreement milestones dealing with performance of baseline sludge washing. Because the chemistry of the sludge is complex, studies are continuing to evaluate the effects of a variety of parameters to help the U.S. Department of Energy evaluate options presented by the private companies. A definitive approach using data and parametric models to optimize processing conditions will be demonstrated and documented by FY 2000 to support private vendor waste vitrification at the Hanford Site. In FY 1997, the Tanks Focus Area evaluated the use of a continuous countercurrent sludge washing process called countercurrent decantation for efficient treatment of Savannah River Site sludges that would reduce processing time and minimize sludge wash liquid volume for disposal as low-activity waste.

Recycling Caustic Creates Less Waste and Saves Money

The liquid fraction of the high-level waste in tanks at the Savannah River and Hanford Sites consists of concentrated salt solutions containing primarily sodium nitrate, nitrite, hydroxide, and aluminate. Greater than 99% of these salts will be treated and disposed of as low-activity waste after removal of radionuclides. Recovery of sodium hydroxide from this concentrated salt solution could significantly reduce the low-activity waste volume requiring treatment and disposal. Recovered caustic could be recycled for use neutralizing newly generated waste, inhibiting corrosion in the tanks, or dissolving alumina in the enhanced sludge washing process. At the Hanford Site, using recycled caustic would eliminate the addition of approximately 10,000 metric tons of sodium to the low-activity waste stream.

An electrochemical process has been developed for regenerating sodium hydroxide from alkaline tank waste. Progress to date has included laboratory tests using actual Savannah River Site liquid waste. Full-scale tests with surrogate waste solution have also been completed. Another process for recovering sodium salts from tank waste is selective crystallization, also known as the clean salt process. Sodium nitrate recovered from tank waste could be split electrochemically into sodium hydroxide and nitric acid. A procurement will be initiated through Industry Programs in FY 1998 to demonstrate caustic recycle from tank waste based on either the electrochemical or clean salt processes. The sites will use results to decide if deployment of this technology would result in substantial cost reduction.



The Defense Waste Processing Facility immobilizes waste by turning it into glass logs. The process, called vitrification, adds glass-forming materials to the waste, heats the mixture in a melter, and pours the molten glass into canisters.

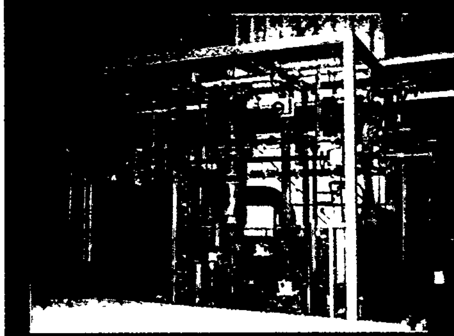
Defense Waste Processing Facility Recycle Treatment Reduces Waste Returned to Tanks

Waste solution from the Savannah River Site Defense Waste Processing Facility contains levels of cesium, mercury, and solids that exceed concentrations accepted by the site's effluent treatment facility. Current plans for this waste stream include conversion to an alkaline pH and return to the high-level waste tanks. With proper treatment, the bulk of this waste stream could be routed to the site's effluent treatment facility for disposal. This would significantly reduce the waste returned to the tanks. The Tanks Focus Area and Industry Programs are working with the site to decide whether cesium removal, mercury removal, and organic treatment will allow the waste to be routed to an alternate disposition. Demonstration of this treatment is scheduled for FY 1999.

Mobile Evaporator Recovers Tank Storage Space

All four tank sites need to reduce waste volume by evaporating excess water from the waste. Typically this is done in large, expensive, centrally located facilities. The Tanks Focus Area demonstrated a skid-mounted, modular evaporator unit. This unit successfully evaporated 24,000 gallons of liquid waste at the Oak Ridge Reservation in FY 1996 creating 6,000 gallons of usable tank space. This evaporator unit has been transferred to the user organization and is being prepared for future waste volume reduction campaigns.

Another application has arisen for this technology at the Savannah River Site. Approximately 50,000 gallons per year of low-level waste from the Consolidated Incinerator Facility must be immobilized. The mobile evaporator technology can reduce this volume by 80% - recovering valuable tank space and reducing the volume of solid waste generated. The Tanks Focus Area, Industry Programs, the Savannah River Site, and the Oak Ridge Reservation through the Accelerated Site Technology Deployment Program are working together to transfer this technology from the Oak Ridge Reservation to the Savannah River Site in FY 1999.



The mobile evaporator removes the evaporable component of the tank waste, reducing the waste volume and increasing available tank storage space.

WASTE IMMOBILIZATION

All four sites must process retrieved waste to convert liquids and slurries to a solid form that does not readily release radioactivity or hazardous chemicals to the environment, (i.e., immobilize the waste). The Savannah River Site is converting the low-activity waste to saltstone, a cement-like waste form, and placing it in vaults at the site. The Savannah River Site is converting high-activity sludge to glass through the vitrification process housed within the Defense Waste Processing Facility. The site is currently processing only those wastes in a sludge form. In the future, the site will combine the high-activity cesium salts removed from saltcake and liquids with this sludge for vitrification. Optimization of that process is required to reduce the number of canisters produced to reduce final disposal costs.

The Hanford Site will rely on private companies to immobilize the waste. However, the U.S. Department of Energy must have methods and tools to ensure that the resulting waste forms, which they buy back from the vendor, are acceptable as early as FY 2000. The U.S. Department of Energy and the vendor require more data on the effect of waste loading on glass quality to ensure that viable proposals and processes are submitted by the private companies before FY 2002.

The Oak Ridge Reservation needs data to evaluate vendor proposals for waste treatment by private companies in FY 1998. As they begin processing the waste through the selected private companies by FY 2002, they too will need waste product acceptance tools and methodologies. The Idaho National Engineering and Environmental Laboratory requires data in FY 2000 to ensure that viable options are being considered in their Environmental Impact Statement in FY 1999 and that can be used in design of their high-level waste storage and treatment facilities.

Currently, our knowledge of glass is limited. By learning more about the glass during processing, we can increase how much waste is incorporated. Adding 2% more waste can save several hundred millions of dollars.

Optimizing Waste Loading Reduces the Future High-Level Inventory

More than 710,000 ft^3 of immobilized high-level waste will be generated by vitrifying the U.S. Department of Energy's current and future high-level waste inventory at the Hanford and Savannah River Sites. The waste volume can be reduced by more than 25% based on research to improve the models that predict glass durability and solubility during glass processing. Improved models will increase the waste oxides incorporated into each cubic meter of high-level waste glass. Currently, the uncertainty of these models results in conservative waste loading limits. Tools for waste loading maximization should be available by FY 2000. Increasing waste oxide loading at the Savannah River Site from 26% to 28% can eliminate 400 high-level waste canisters and has the potential to reduce cost by $633,000,000 over the life of the facility.

The Hanford Site's Tank Waste Remediation System process technical baseline allows a maximum waste loading of 45 weight percent (wt.%). This appears high when compared with the Savannah River Site, but accounts for the fact that the aluminum and silicon in Hanford Site waste act as glass formers. Total volume of high-level waste glass produced from Hanford Site waste after enhanced sludge washing with chromium oxidation is about 320,000 ft^3 at 45% waste oxide loading. This represents a 170,000 ft^3 reduction over the planning basis of 490,000 ft^3. At $17,000 per ft^3 (or more) for high-level waste treatment and repository fees, this could avoid almost $3,000,000,000 in costs.

Radioactive glass accumulates on the spout where the molten glass is poured from the melter into the large canisters for permanent storage. This glass must be periodically removed to prevent the spout from plugging. If we can understand how the glass pours over the spout and redesign it more efficiently, the Defense Waste Processing Facility can process more waste.

Redesigning Melter Pour Spout Increases Productivity

Preventing pour spout plugging can increase Defense Waste Processing Facility productivity by more than 10% or avoid costs of $10,000,000 per year resulting from downtime to restore the pour spout. The Defense Waste Processing Facility melter pour spout accumulates glass and crystalline deposits. These deposits must be periodically removed from the pour spout to prevent plugging and maintain melter operability. Florida International University conducted bench-scale tests in FY 1997 to understand flow over a knife-edge pour spout. Larger-scale tests are planned in FY 1998 to evaluate improved pour spout designs. Data will be available in FY 1999 in time to influence design of the fourth Defense Waste Processing Facility replacement melter and future melters.

Meeting Savannah River Site Monitoring Needs

Lower-cost, longer-life level and density probes have the potential to save $500,000 per year in probe replacement costs at the Savannah River Site Defense Waste Processing Facility. The probes and gages used for monitoring the volume and density of Defense Waste Processing Facility vessel contents have an unacceptably short service life and are costly to replace. The Tanks Focus Area and Industry Programs will conduct feasibility studies to learn if lower-cost, and longer-life probes are available from private industry. Sensor arrays available from Science and Engineering Associates can monitor the interfaces between water and organic compounds and between glass frit and water. This allows for better separation of water from the waste during the settle-decant process of extended sludge processing. In this way, the excess water can be recycled instead of transferred to the treatment process. The Characterization, Monitoring and Sensor Technology Crosscutting Program and Industry Crosscutting Program demonstrated these probes in principle in FY 1997 and an array was fabricated for the Hanford Site. By the end of FY 1999, similar probes will be fabricated and installed in the Savannah River Site process vessels.

Hanford Site Waste Product Acceptance Criteria Create Safe Waste Packages for Disposal

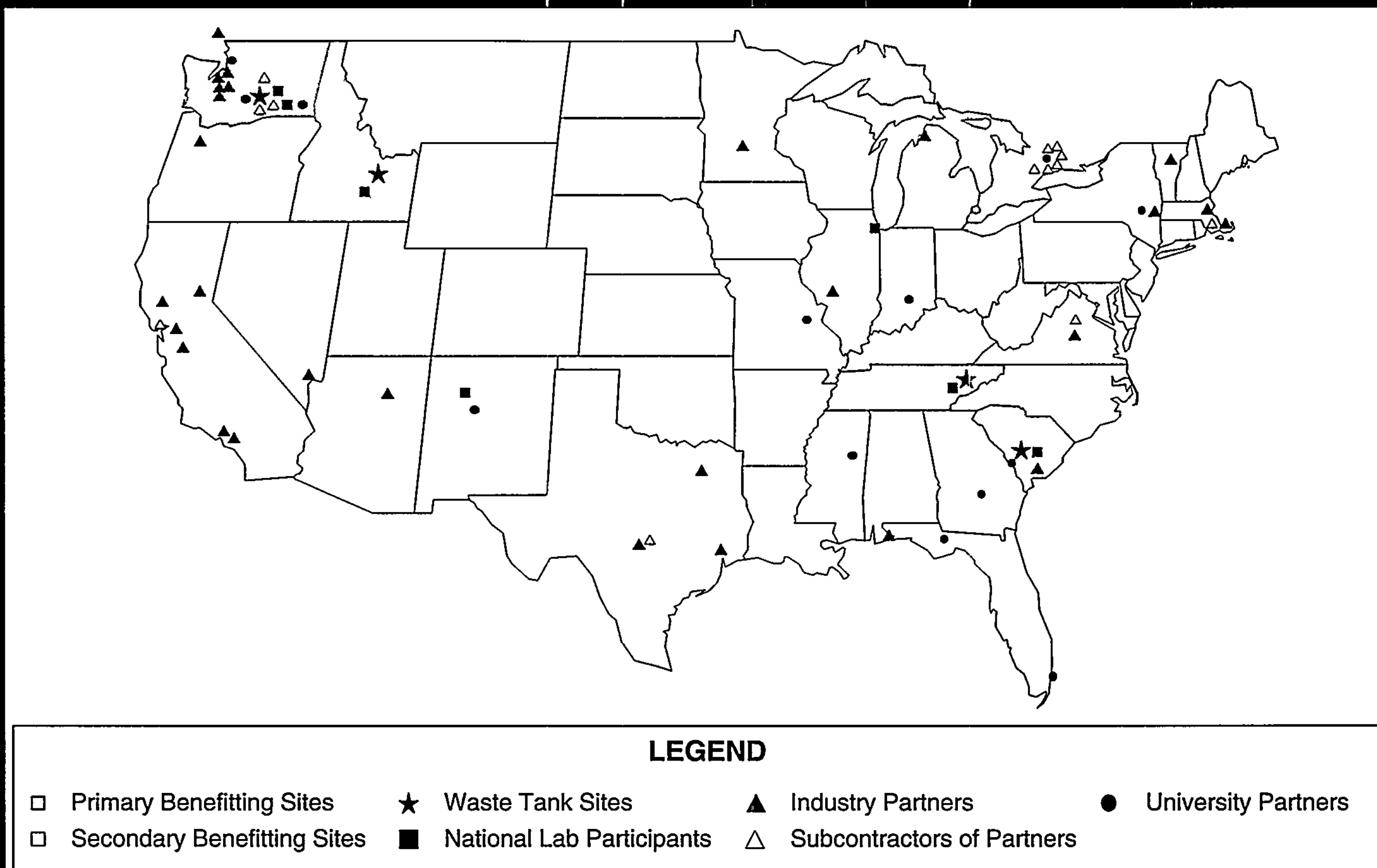
The U.S. Department of Energy must accept from private vendors only low-level waste glass products that do not later fail, causing safety and environmental concerns. Hundreds of millions of dollars would be required to prevent or remediate environmental impacts from failed waste packages. Product samples and sealed immobilization containers from vendors must undergo waste product acceptance testing and the vendor must use a well documented, defensible quality assurance program. In FY 1997, the Tanks Focus Area characterized a representative sample of the standard glass material from the first phase of private companies' vitrification. Candidate acceptance test methods are now being evaluated using the standard glass. A standard waste form acceptance test will be developed by FY 2000. Operating procedures will be prepared and inspection operations for the first phase will begin in June 2002.

Grout and Glass Performance and Cost Comparison Used to Evaluate Proposals

The U.S. Department of Energy's tank sites are trying to save money by contracting with the lowest cost bidder from private industry to immobilize waste. Solicitation of the lowest cost bidder requires that the U.S. Department of Energy provide adequate data and performance specifications in the Request for Proposals, so that the U.S. Department of Energy, bidders, and financiers have confidence that their proposed process will operate as expected. During FY 1997 and FY 1998, the Tanks Focus Area is demonstrating that acceptable glass and grout waste forms can be produced for all Oak Ridge Reservation tank wastes to meet the transportation and disposal criteria for the Nevada Test Site or the Waste Isolation Pilot Plant. Performance and costs of the grout and glass waste forms from Oak Ridge Reservation wastes are being compared in a preliminary report due in FY 1998. The performance and cost analysis will be used during the initial evaluation of private companies' treatment proposals in FY 1998.

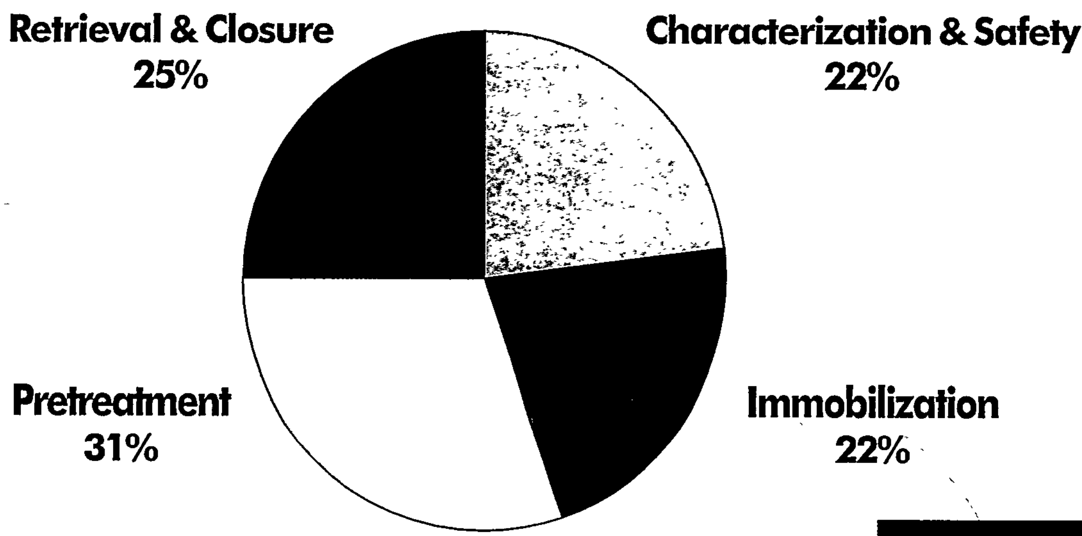
CONCLUSIONS

Key tasks identified as priorities for FY 1997 through FY 2000 by the users and Tanks Focus Area are being pursued in safe waste storage, waste mobilization and retrieval, tank closure, waste pretreatment, and waste immobilization. All the activities in this report have user program co-funding with the DOE-EM Office of Science and Technology funding. In the year of deployment, the sites are including these products in their annual operating plans to ensure coordination between the Tanks Focus Area and the user recipient as we transfer integrated technical solutions to the user programs. The Tanks Focus Area is centering heavily on enabling users to meet projected schedule and budget forecasts in the plan titled "Accelerating Cleanup: Paths to Closure." Often, the Tanks Focus Area with its partner programs is finding technical solutions that can potentially reduce costs where baseline operations have been established.



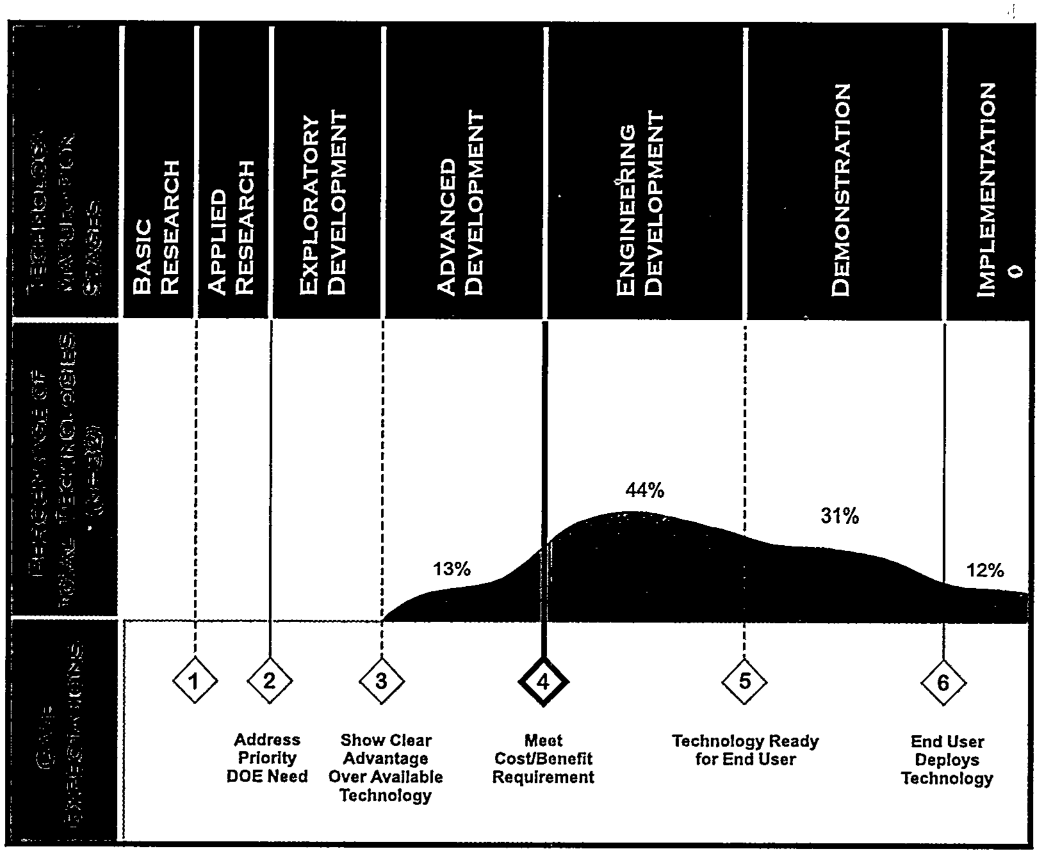
In partnership with the U.S. Department of Energy Offices of Waste Management and Environmental Restoration; Office of Science and Technology and the Industry, University, and Crosscutting Programs; the Tanks Focus Area brings together the resouces necessary to solve waste tank remediation technical problems.

BY CATEGORY TYPE
(32 Technologies)



Technology Distribution

BY MATURATION STAGE



FY 1997 Projects Funding Summary

Technology	1997 Funding ($1,000)
Safe Waste Storage	
Steel Tank Corrosion Prevention Technology	200
Waste Mobilization and Retrieval	
Light-Duty Utility Arm Supervisory Control	195
Light-Duty Utility Arm Deployment at Oak Ridge Reservation	970
Retrieval Process Development	2,450
Enhanced Retrieval Technology	500
Simulants for Retrieval Testing	350
Industrial Support for First Deployment of Retrieval Systems	380
Retrieval Process Analysis Tool	300
Russian Retrieval Equipment Testing	100
Light-Duty Utility Arm System	2,415
Characterization and Retrieval Process Deployment systems	300
Waste Retrieval and Closure Demonstration for Salt Removal and Zeolite Heel	905
Laser Ablation/Mass Spectroscopy	384
Hanford Tanks Initiative Project	7,000
Tank Closure	
Savannah River Site Closure Criteria	500
Characterize INEEL Tank Farm Heels - Light-Duty Utility Arm Deployment	75
Cone Penetrometer w/Raman Spectroscopy	267
Product Acceptance Testing - Low-Activity Waste	350
Waste Pretreatment	
Conduct Sludge Wash/Alkaline Leach Tests of Actual Hanford Site Waste	400
Pretreatment Process Analysis Tool	150

FY 1997 Projects Funding Summary

Technology	1997 Funding ($1,000)
Waste Pretreatment (continued)	
Radiochemical Removal by Solvent Extraction for INEEL	550
Solid/Liquid Separation for Oak Ridge Reservation	380
Sludge Treatment Chemistry	500
Cesium Removal Demonstration	1,840
Sludge Partition Chemistry	473
Enhanced Sludge Washing	400
Alternative Alkaline Processing	250
Tecnetium Removal Flow Studies	400
Crossflow Filtration - Hanford Site	380
Cesium Flow Studies at Hanford Site	620
Caustic Recycle	500
Counter-current Decanting	200
Crossflow Filtration - Savannah River Site	400
Waste Immobilization	
Thermal Denitration of INEEL Low-Activity Waste	350
Grout Waste Forms for Oak Ridge Reservation Tank Wastes	734
Immobilization - Hanford Site	97
Optimize Waste Loading in Glass	300
Corrosion of Melter Materials by INEEL High-Activity Waste Glasses	100
Glass Waste Forms for Oak Ridge Reservation Tank Wastes	500
Immobilization of Ion-Exchange Resins	1,350
CORE PROGRAM TOTAL	**28,515**