OAK RIDGE NATIONAL LABORATORY GUNITE AND ASSOCIATED TANKS STABILIZATION PROJECT LOW-TECH APPROACH WITH HIGH-TECH RESULTS

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ABSTRACT

Environmental restoration of the Gunite™ and Associated Tanks (GAAT) at the Oak Ridge National Laboratory (ORNL) was a priority to the U. S. Department of Energy (DOE) because of their age and deteriorating structure. These eight tanks ranging up to 170,000 gallons in capacity were constructed in 1943 of a Gunite or "sprayed concrete material" as part of the Manhattan Project. The tanks initially received highly radioactive waste from the Graphite Reactor and associated chemical processing facilities. The waste was temporarily stored in these tanks to allow for radioactive decay prior to dilution and release into surface waters. Over time, additional wastes from ongoing ORNL operations (e.g., isotope separation and materials research) were discharged to the tanks for storage and treatment. These tanks were taken out of service in the 1970s.

Based on the structure integrity of GAAT evaluated in 1995, the worst-case scenario for the tanks, even assuming they are in good condition, is to remain empty. A recently completed interim action conducted from April 1997 through September 2000 removed the tank liquids and residual solids to the extent practical. Interior video surveys of the tanks indicated signs of degradation of the Gunite material. The tanks continued to receive inleakage, which generated a relatively high volume waste stream that required periodic removal, treatment, and disposal. For these reasons, DOE chose in-place stabilization of Tanks W-3 through W-10 as a non-time-critical removal action under Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA).

Tank stabilization activities involved removal of liquid from inleakage and placement of a grout mixture or "flowable fill" into the tanks to within 3-ft of the ground surface. Placement of the grout was through a fabricated riser cover that contained a port for the grout hose for placement of the flowable fill and a port for the dry material dispersion device and for the connection of a portable high-efficiency particulate air (HEPA) unit. Another riser cover made of clear Plexiglas was fabricated for viewing the interior of the tank during grouting operations through other risers on the same tank.

The riser covers were placed on the tank riser and a dry powder to stabilize any residual liquid left in the tanks was dispersed into the tank prior to grouting operations. Once the residual

liquids were stabilized, the tank was stabilized by pouring grout from the concrete truck to the hopper of a grout pump for transfer into each tank. A visual inspection through the fabricated clear riser cover was used to evaluate the stabilization progress.

Bechtel Jacobs Company, LLC (BJC) awarded Safety and Ecology Corporation (SEC) a subcontract in March 2001 to complete the documentation and fieldwork necessary to achieve tank stabilization in accordance with the Action Memorandum. Tank stabilization activities began on April 23, 2001, and were completed one month ahead of schedule on August 31, 2001. Over 7400 cubic yards of grout were placed in these tanks stabilizing over 4,000 Ci of radioactive material in place. This schedule acceleration was the result of good pre-planning during pre-mobilization by working with BJC, grout vendor, and pumping company, and other subcontractors. This planning allowed refinement of the pump and hose system used to convey the grout and the formulation of the grout mixture. Because of expediting the work, additional activities could be accomplished at the GAAT site that resulted in complete site restoration to a paved area for future parking, which was completed by September 30, 2001.

This paper will focus on the following items associated with this successful environmental restoration project.

- Regulatory Process
- Integrated Safety Management Systems used to achieve zero accident performance while expediting the schedule
- Tank stabilization design and implementation
- Implementation strategies involving partnering of multiple subcontractors, DOE, and regulators

SITE DESCRIPTION

The ORNL GAAT Stabilization Project involved two separate tank farms at ORNL. The North Tank Farm (NTF), located northeast of the intersection of Central Avenue and Third Street, contains Tanks W-3 and W-4. The capacity of these tanks is 42,500 gal each. The South Tank Farm (STF), located south of the NTF across Central Avenue, contains Tanks W-5, W-6, W-7, W-8, W-9, and W-10. The capacity of these tanks is 170,000 gallons each.

The NTF and STF tanks were constructed in 1943 as part of the Manhattan Project. The site was excavated, concrete dishes were constructed that formed the foundation for the tanks, a dry well system to depress the water table was installed, and tanks were constructed using the sprayed concrete or Gunite™ method. Using this method, layers of concrete were sprayed onto a reinforcing wire mesh by a pneumatic gun, which hydrated the concrete during the spraying process. When construction was complete the tanks were covered by approximately 6 ft of earth for shielding. The GAAT initially received highly radioactive waste from the Graphite Reactor and associated chemical processing facilities. The waste was temporarily stored in these tanks to allow for radioactive decay prior to settlement, dilution, and release to surface waters. Over time, additional wastes from ongoing ORNL operations (e.g., isotope separation and materials research) were discharged to the tanks for storage and treatment. These tanks were taken out of service in the 1970s.

During the early 1980s, a campaign to remove solids transferred approximately 1,000,000 Ci of radioactivity from the GAAT to the New Hydrofracture Facility in Melton Valley where the material was mixed with grout and injected into deep shale formations. A recently completed interim action has removed the tank liquids and residual solids to the extent practical. These waste removal activities were conducted from April 1997 through September 2000 and resulted in the removal of 423,000 gallons of supernate/sludge containing over 88,000 Ci of radioactivity. The removed waste was sent to the ORNL low-level radioactive waste system for future processing/disposal. The residual sludge left in the tanks is estimated to be 7,580 gal containing 3920 Ci of radioactivity—less than 5% of original total. This residual radioactivity was stabilized in place with the tank shells. Additional information on the tank residual contents can be found in the *Remedial Action Report on the Gunite and Associated* Tanks (DOE 2001b).

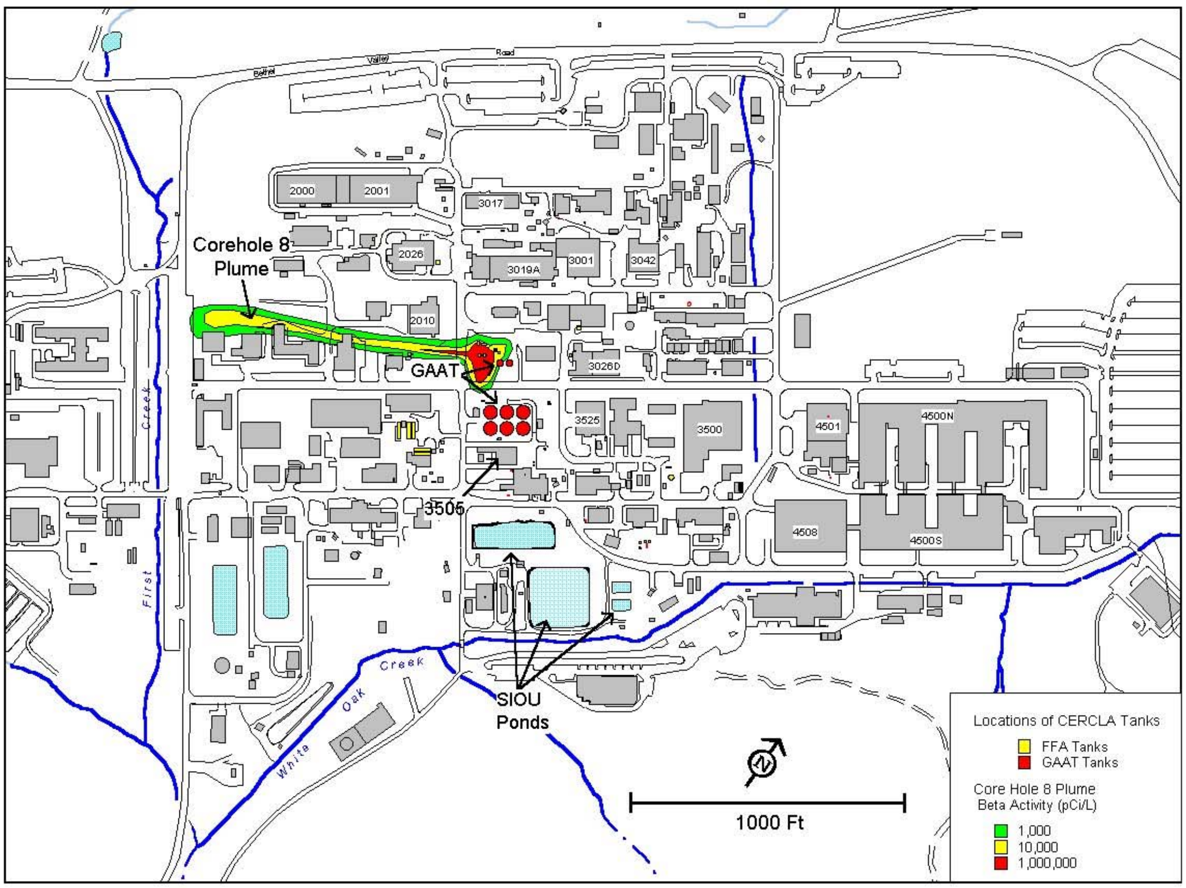

Fig. 1. GAAT Stabilization Project Site.

REGULATORY PROCESS

GAAT shells and risers together with associated internal residual contamination were stabilized in place via a non-time critical removal action under CERCLA. This activity was previously evaluated and presented for public comment as one of the DOE's preferred alternative for CERCLA remedial actions at sites within the Bethel Valley watershed as documented in the *Proposed Plan for Interim Actions in Bethel Valley, Oak Ridge, Tennessee* (BV PP). However, with a decision on remedial actions pending for all of Bethel Valley, concerns about tank structural integrity and continued inleakage of water led DOE to conclude that stabilization activities on the Gunite tanks must proceed prior to the *Record of Decision for Interim Actions in Bethel Valley, Oak Ridge, Tennessee* being finalized. Accordingly, DOE proceeded with the GAAT shell- and riser-stabilization activities as a removal action.

New Engineering Evaluation/Cost Analysis (EE/CA) was not required for this removal action. The *Remedial Investigation/Feasibility Study for Bethel Valley Watershed at Oak Ridge National Laboratory, Oak Ridge, Tennessee* and the BV PP, both of which were completed in the course of analyzing and proposing Bethel Valley remedial actions, encompass this stabilization response activity and constitute an EE/CA 'equivalent' as authorized by the National Oil and Hazardous Substances Pollution Contingency Plan (i.e., the National Contingency Plan) at 40 Code of Federal Regulations 300.415(b)(4)(i). These documents fulfill the goals of identifying the objectives for the action and evaluating the effectiveness, implementability, and costs of alternatives for satisfying these objectives.

GAAT STABILIZATION

Prior to tank stabilization, isolation of each tank from other tanks and from the active low-level radioactive waste (LLLW) system was verified by interviewing personnel involved with past LLLW operations and interim waste removal activities, in addition to review of historical documents and engineering drawings. Once confirmed that the tanks were isolated from the active LLLW system, excess liquid inside the tanks was removed and transferred to the ORNL active LLLW system for treatment prior to tank stabilization.

The BJC Radiological Controls Organization (RADCON) provided a pre-job survey of the GAAT site to verify area radiological conditions to plan for personnel protection equipment requirements for radiological hazards. These survey results; in conjunction with an applicable activity hazards analysis (AHA), a project-specific work plan, and an associated instructions/procedure for tank stabilization activities; were used to establish radiation protection. The RADCON staff prepared the Radiation Work Permits that prescribed the controls necessary for individual work activities. The RADCON staff provided the radiological surveys and monitoring of the personnel and the site to ensure compliance with applicable program and federal regulations, to protect personnel from unnecessary or unmonitored exposure, and to ensure that there is no release of radioactivity to the environment.

To facilitate continuous operation, two tanks were stabilized in parallel so that the flowable fill could cure in one tank for 24 hours while the other tank was being filled. Stabilization began by using Aquasorbe or Portland cement to solidify any residual liquid left in the tanks. This dry powder was blown into the tank through an existing riser using a dry material dispersion device.

The dry powder added to absorb the liquids did not adversely affect grout performance. Tank grouting began when the liquids had been verified visually to be stabilized. Grout was pumped from a concrete batch truck to the hopper of a pump truck for transfer into each tank. The grout was pumped from the pump truck via hoses to the tank. The hose had a plastic sleeve around it and was covered with Herculite geofabric for contamination control measures. The geofabric material's durability prevented tearing because of contact with gravel and kept the exterior of the hose from potential contamination. The trucks were kept out of the contamination/radiation areas at all times.

The metal riser cover was replaced with a modified riser cover that provided a port for placement of the flowable fill and for connection of the off-gas hose. This modified riser cover provided for improved contamination control as opposed to simply putting the grout hose through an open riser. Other riser covers were removed and replaced with clear Plexiglas for viewing the interior of the tank during grouting operations.

The existing HEPA filtration system was initially utilized to provide negative pressure in the tank to prevent the release of any airborne contamination during tank stabilization activities. When the grout level reached the dome of each tank, the existing HEPA filtration system was disconnected and a portable HEPA unit was used until the tank was completely stabilized.

The tanks were filled incrementally in lifts. Once completed, the lift was allowed to cure for at least 24 hours. While the first tank was curing, grouting operations began in an adjacent tank. This allowed for the continued grouting of the tanks without moving the grout pump, eliminated downtime between lifts, and incrementally filled two tanks in parallel. Once cured, the lift was visually inspected for the presence of condensate or other liquids (i.e., "bleed water") on top of the cured grout. When liquids were found, it was stabilized using Aquasorbe or Portland cement. This sequence of lifts was followed until each tank was full.

The grout mixture used to stabilize the tanks in place is based on the same grout mixture used over the past four years for stabilization of 25 other ORNL tanks. This grout mixture was enhanced to reduce the amount of "bleed water" and cure time. The technical specifications for the grout mixture utilized for stabilizing the tanks is as follows:

- Minimum compressive strength of 50 psi
- Flowable mixture that is self-leveling
- Cure time less than 72 hours
- Minimum bleed water
- Minimum heat generation during curing

A visual inspection through the modified clear riser cover was used to evaluate the stabilization progress. This visual inspection was performed from the tank riser having the lowest elevation. As the lowest riser will be the first to fill up, this approach ensured that the tank or any individual riser was not overfilled. The existing continuous tank liquid level indicator was utilized to determine the top of grout to evaluate stabilization progress. Upon completion of tank stabilization activities, the cell ventilation and continuous level monitoring systems were disconnected from the active systems.

Once each tank was filled, it was inspected to ensure no free liquid had collected on top of the grout. If water was observed, dry cement dust was added to absorb/solidify the free liquid. The grouting of the risers was performed such that the lower risers (e.g., lower portion of the dome) were filled first and allowed to cure prior to filling the central riser. The stabilization of the tanks was documented by photographing the riser interior.

Fig. 2. GAAT Stabilization Field Activities.

Because stabilization of the GAAT was completed one month ahead of schedule, the surface stabilization of the GAAT site was also completed ahead of schedule. This work included the demolition of all above-grade structures including the tank risers, HEPA units, large storage tent, and other miscellaneous piping and structures. Three buildings were also removed from the site to another staging area at ORNL. Once all the structures were removed, the GAAT site was leveled with gravel and stabilized with asphalt material for future development for parking and/or equipment storage.

The estimated cost in the baseline for this removal action was $4.5M; the actual cost of the action totaled $3.1M. The cost avoidance of $1.4M can be attributed to:

- Stabilizing two tanks in parallel instead of stabilizing them one at a time
- Improved grout formula and capacity of grout pump
- Accelerating field activities (12-h workdays instead of 8-h workdays)
- Placing contaminated equipment and piping used in waste transfer activities into the tanks prior to tank stabilization instead of packaging these materials for off-site disposal

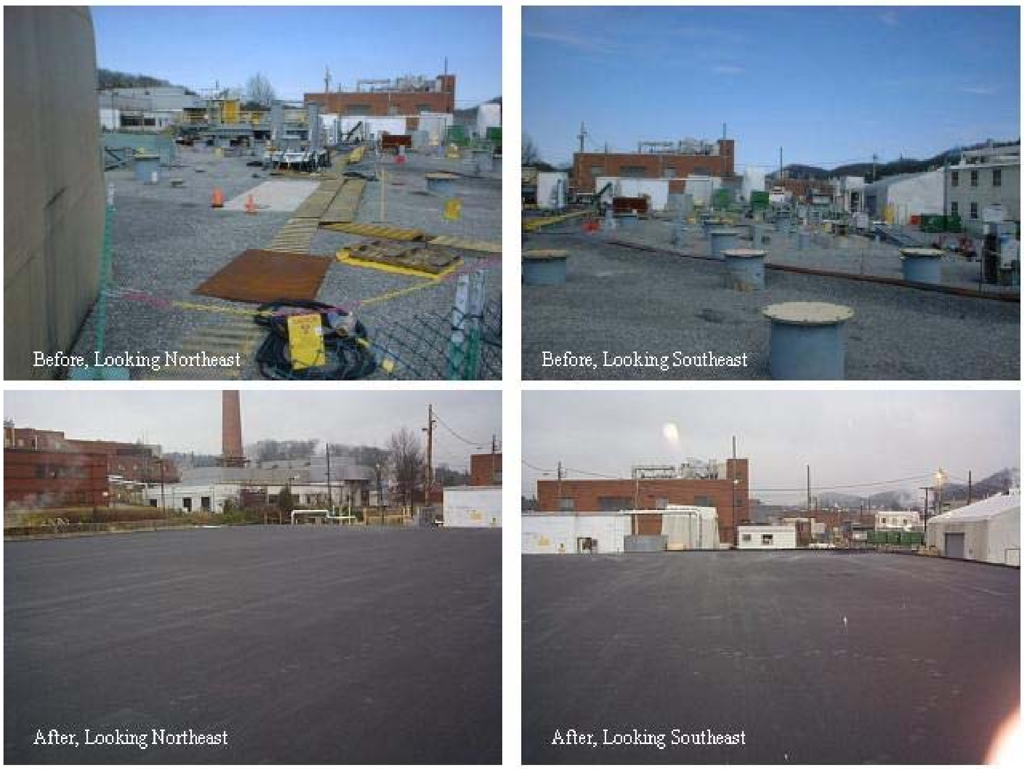

Fig. 3. GAAT Site Before and After Remediation Activities.

INTEGRATED SAFETY MANAGEMENT SYSTEM

The integrated project team's execution of Integrated Safety Management System (ISMS) to enhance worker safety consists of a process involving the following steps.

- Required safety and ISMS training at all levels of management and project execution including solicitation of lessons learned from workers' past experience
- Promulgation of safety policies, programs, and procedures and acknowledgement from workers of their acceptance
- Requiring subcontractor commitment to **ZERO ACCIDENT PERFORMANCE** and to the core functions of ISMS from the contractual, training, and practical standpoints and full integration of subcontractors and craft workers into the BJC safety culture

- Reiteration, reinforcement, and feedback through daily safety meetings and active solicitation of worker input to address safety concerns or suggestions for improvement
- Enforcement of safety policies, programs and procedures

An intermediate step between the development/implementation of controls and the performance of work involved a work team pre-task evaluation that was conducted based on the complexity of the planned activity and the degree of associated hazards. At the activity level, implementation of a worker protection program is tailored to the activity/work, but always in a manner consistent with programs, policies, and procedures. Lessons learned are collected and incorporated into work procedures and ultimately into Environmental Safety and Health (ES&H) Program requirements.

All workers were required to attend "tailgate" or "toolbox" meetings at the start of each day's work. At such meetings, specific topics of discussion included

- Daily activity schedule
- Any applicable changes to the work
- Requests for worker suggestions on project improvement
- Reiteration of the ISMS core functions and guiding principles
- Reinforcement of general and site-specific safety requirements
- Solicitation of project worker comments and feedback on work activities.

Prior to the start of project activities, the project team conducted an investigation (AHA) to identify all potential hazards. The team, consisting of the project personnel, identified hazards by examining available site radiological and chemical data, facility industrial hazards, interviewing people with knowledge of the area or process, and by performing site walk-downs. For activity or task hazard categorization, engineering judgment and general health and safety guidance were used in categorizing the hazards.

The final step prior to implementation of the selected controls identified in the AHA was involving workers at all levels to ensure:

- Hazards are eliminated through the substitution of materials or implementation of engineering controls
- Project plans, task work plans, AHA, work permits, procedures, ES&H Plan, work instructions, etc., are adhered to
- Design changes are implemented
- Signs, markings, and other postings are posted as necessary
- Applicable personnel training is conducted
- Individual ownership and responsibility for safety through Line Management is emphasized
- Project worker authority for stopping work based on non-compliance to safety requirements is provided

ISMS was demonstrated by designing the modified riser cover to facilitate grouting operations. In past projects, the grout hose to the tank was held by several Environmental Technicians to keep the grout from spilling onto the ground. This was very physically demanding on the technicians. It was suggested that this process not be used on the GAAT project because of the duration and season of the project. Therefore, management designed the modified cover that allowed for the grout hose to be clamped to the riser thus eliminating the need for constant supervision and handling of the grout hose.

INTEGRATED TEAM EFFORT

The GAAT Stabilization Team was truly an integrated team of multiple subcontractors focused on working together for project success. BJC, as DOE's Management and Integration (M&I) contractor, worked with DOE, the regulators, and UT-Battelle, LLC who continues the research and development activities in support of DOE's mission at ORNL, to outline an end state for the GAAT Site. BJC then issued a subcontract to SEC, the successful Remedial Action/Decontamination and Demolition subcontractor, in March 2001 to perform tank stabilization activities. SEC then began working with BJC to prepare the necessary plans to support field implementation. SEC contracted with a large concrete vendor and a small grouting corporation to support tank stabilization. These subcontractors were challenged with designing a grout and grout delivery system to expedite stabilization activities without compromising safety performance and grout durability. The entire team—prime contractor, lower tier subcontractors, laborers, technicians, management, BJC—worked together to provide input to the design and implementation of the tank stabilization, resulting in a well-defined method of accomplishment to meet the aggressive schedule.

In addition to the subcontractors directly involved with the GAAT Stabilization Project, there were other subcontractors adjacent to this site performing remediation activities and waste management routine operations. Over 750 grout trucks (16–20 per day) filled with 9 cy of grout were required during field activities to stabilize the tanks, thus making daily traffic control and cooperation of others on site was essential to meeting the aggressive schedule. IT Corporation had a large radioactive soil removal project in the NTF while Florida International University (FIU) was performing building/hot cell decontamination and decommissioning on the southern boundary of STF. BJC's liquid waste operations subcontractor Duratek Federal Services removed the residual liquids from the tank and isolated the active systems from the tanks. UT-Battelle opened an access gate previously closed and unmanned and then provided a guard for use by SEC's grout trucks to facilitate delivery of tank stabilization material.

BJC achieved team integration by facilitating the communication between multiple subcontractors and encouraging all to work together with the common mission of ORNL site restoration. Integration was to a point that when a large specialty forklift was needed for just one day on the GAAT Site, hat FIU loaned it to SEC, who was the lower tier subcontractor on each other's projects. BJC displayed all aspects of what DOE anticipated from an M&I Contractor by pulling it all together to complete GAAT Site remediation twelve months early at a savings of over $1M.

REFERENCES

1. U.S. DOE 1992. Federal Facility Agreement for the Oak Ridge Reservation, DOE/OR-1014, U.S. Environmental Protection Agency Region IV, Atlanta, GA; U.S. Department of Energy, Oak Ridge Operations, Oak Ridge, TN; and the Tennessee Department of Environment and Conservation, Nashville, TN, January.

2. U.S. DOE 2000. *Proposed Plan for Interim Actions in Bethel Valley, Oak Ridge, Tennessee,* DOE/OR/01-1795&D3, May.

3. U.S. DOE 2000. *Record of Decision for Interim Actions in Bethel Valley, Oak Ridge, Tennessee,* DOE/OR/01-1862&D1, October.

4. U.S. DOE 2001. *Action Memorandum to Stabilize Gunite and Associated Tanks at the Oak Ridge National Laboratory, Oak Ridge, Tennessee,* DOE/OR/01-1957&D2, June 11.

5. U.S. DOE 2001. *Remedial Action Report on the Gunite and Associated Tanks Interim Remedial Action Project at the Oak Ridge National Laboratory, Oak Ridge, Tennessee,* DOE/OR/01-1955&D1, June.