Environmental Management Engineering and Technology – Making A Difference

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Office of Environmental Management




Innovative Technologies Put the Department of Energy's Office of Environmental Management on the Road to Success

Since 1989, the Department of Energy's (DOE) Office of Environmental Management (EM) has faced many significant challenges in cleaning up legacy wastes generated during the Cold War. To safely and efficiently accomplish its mission, DOE-EM utilizes many innovative technologies and approaches to meet DOE's specific needs. Although DOE has made great progress, including closure of significant sites such as Fernald, Rocky Flats, and Mound, much remains to be done. Many of the remaining challenges, such as those at the Hanford and the Savannah River Site (SRS), will require unique approaches utilizing new technologies developed by an effective applied research and engineering program. By mitigating the technical risks and uncertainties through application of sound technology solutions, DOE will solve these challenges, and also enhance safety and efficiency throughout the DOE complex.

Earlier this year, EM published its draft Engineering and Technology Roadmap (available on the web at www.em.doe.gov) to guide the Engineering and Technology Program by identifying technology risks – those technical issues that could prevent project success – and developing strategic initiatives to address these risks. Following input from diverse stakeholder organizations, the Engineering and Technology Roadmap now includes thirteen strategic initiatives, categorized into six technical areas:

Waste Processing – High-Level Waste (HLW)

- Improved waste storage technology
- Reliable and efficient waste retrieval technologies
- Enhanced tank closure processes
- Next-generation pre-treatment solutions
- Enhanced stabilization technologies

Groundwater and Soil Remediation

- Improved sampling and characterization strategies
- Advanced predictive capabilities
- Enhanced remediation methods

Deactivation and Decommissioning

- Adapted technologies for site-specific and complex-wide D&D applications

DOE Spent Nuclear Fuel (SNF)

- Improved SNF storage, stabilization, and disposal preparation

Challenging Materials

- Enhanced storage, monitoring, and stabilization systems

Integration and Cross-Cutting

- Enhanced long-term performance evaluation and monitoring
- Improved packaging of SNF, transuranic waste and nuclear materials

Waste processing, primarily of HLW, presents the highest priority technical challenge for DOE at the Hanford, Savannah River, and Idaho sites. Strategies to reduce significant technical risks and uncertainties are being developed to address tank waste storage, waste retrieval, waste pretreatment and stabilization, and tank closure. EM is providing a significant investment in solutions to ensure safe operations and accelerated cleanup.

Waste Processing

Decomposing Legacy Organics in SRS Tank 48

Two technologies have shown promising test results for decomposing the legacy organics in the SRS High Level Radioactive Waste Tank 48, a high-priority project to make the tank available for continued service. Organic tetraphenylborate (TPB) compounds currently in Tank 48 are incompatible with the SRS waste treatment facilities, and must be removed or treated to destroy the organics in order to return the tank to routine service. A path forward has been established for Savannah River National Laboratory's (SRNL) continued testing of these two candidate technologies, while a decision is made by EM as to which will be the preferred alternative and which will be the backup.

Fluidized Bed Steam Reforming (FBSR) uses pyrolysis – heat in the absence of oxygen – to destroy organics and nitrates, and convert them to alkali carbonates that are compatible for processing in the SRS waste vitrification facility. FBSR has been used as a chemical process for more than 100 years. In recent years, it has been used for treating radioactive waste from commercial nuclear power plants and has been demonstrated for the treatment of radioactive sodium-bearing waste at the Idaho Cleanup Project. Bench-, pilot- and engineering-scale testing with a nonradioactive simulant of the Tank 48 contents has resulted in greater than 99.99% destruction of the organics.

Wet Air Oxidation (WAO) has also been in use for more than 50 years to treat petrochemical, chemical, pharmaceutical, and other wastes. WAO uses oxygen in air at elevated temperatures and pressures to oxidize the organics, resulting in a product that can be returned to the SRS waste tanks for continued processing. A bench-scale test in the 1990s successfully treated actual radioactive waste at the Hanford Site, destroying greater than 98% of the organics. In 1993, WAO was utilized to treat organic-laden waste contaminated with low levels of radionuclides, and destroyed greater than 99.5% of the target organic. Bench-scale testing with Tank 48 simulant showed greater than 99.99% destruction. Both technologies have potential for application at other sites with a need to treat or destroy organic compounds in wastes. WAO could also potentially be used across the DOE complex in the Sludge Mass Reduction Program to more rapidly dissolve aluminum in sludges.

Fernald Site Closure

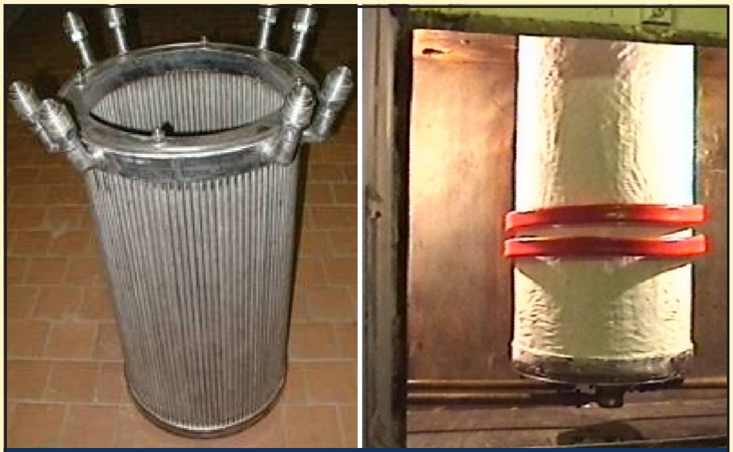
A wide variety of innovative technologies and approaches promoted cleanup at the 1,050 acre DOE Fernald Site 12 years ahead of schedule and $7.8 B less than the projected budget. Cleanup at the former uranium processing facility located near Cincinnati, Ohio, was formally declared complete on January 22, 2007. This was the result of timely insertion of critical technologies, including retrieval, treatment, and packaging of waste in the silos, radioactive characterization of contaminated soils to support excavation, and effective groundwater treatment. These successes accomplished by the DOE site contractor, Fluor Fernald, resulted from successful collaboration with a number of entities including the Oak Ridge National Laboratory (ORNL), the Institute for Clean Energy Technology (ICET) at Mississippi State University, Idaho National Laboratory, North Dakota State University, and various industrial entities.

Of particular note was the integrated effort to retrieve, treat, and package the 8,900 cubic yards of low-level radium-bearing waste and 5,100 cubic yards of low-level thorium-bearing waste generated during processing of uranium ore and stored in three 80-foot diameter silos for approximately 50 years. Using technologies such as sluicing and pneumatic removal, this waste was retrieved for treatment with grout and fly ash and then packaged with a remote-handling system for transportation to a licensed, off-site repository. This project required significant integration of technologies, engineering, and technical expertise, which involved expert panel reviews and recommendations, followed by four years of testing from laboratory to full-scale. Testing was conducted primarily at ORNL and ICET prior to on-site full-scale testing. These tests were directed at waste retrieval systems, development of grout formulations, and monitoring instrumentation with a goal of establishing the performance and reliability of each of the system components, as well as integrated system testing at full scale. The results of the testing significantly reduced project risks by providing validation data that supported selection of instrumentation and equipment and equipment operation. Without such testing, closure of the site according to the newly proposed schedule would not have been possible.

The Integrated Test Stand at the Silos 1 and 2 Project successfully verified the waste retrieval process and operations.

Cold Crucible Induction Melter

One particularly promising example of EM's use of international collaborations to address DOE's cleanup needs is SRNL's work with Russia's Scientific and Industrial Association (SIA) Radon Institute to evaluate and adapt Russian cold crucible induction heated melter (CCIM) technology to enhance the disposition of HLW currently stored at the SRS. The SRS Defense Waste Processing Facility (DWPF) processes HLW by blending it with specially formulated glass frit to produce a stable glass form for permanent disposal. The goal of the US-Russian collaboration is to determine whether the CCIM can increase waste loading in the glass at the DWPF, thus reducing the number of cans of glass that would need to be produced. This exciting collaboration could potentially provide a solution to significantly accelerate the DWPF processing schedule.



From Left to Right: 1) Cold Crucible Melter at SIA Radon before insulation and 2) After insulation with induction heating coils.

Testing with simulated DWPF waste has shown that as much as 60 weight % waste loading may be possible using the CCIM, compared to the 38 weight % loading achieved by the DWPF. In addition, the glass durability was better than the reference Environmental Assessment glass used for repository acceptance.

Of particular note is the testing completed this summer to evaluate CCIM processing of a high-aluminum batch of DWPF waste, because aluminum typically limits glass waste loading and durability. The higher process temperatures afforded by the CCIM may alleviate some of the difficulties associated with processing high-aluminum feeds.

Development of a Safer Waste Form for Liquid Radioactive Wastes at the Idaho Cleanup Project

Testing has identified a sorbent capable of solidifying a variety of liquid wastes into a form suitable for safe permanent disposal. Buried waste drums exhumed from the Idaho Cleanup Project Subsurface Disposal Area at the Radioactive Waste Management Complex were found to contain bottles of liquid wastes generated during experiments and routine analytical laboratory activities at Rocky Flats. To ensure a safer waste form for permanent disposal of these wastes, MSE Technology Applications, Inc. identified and tested a variety of commercially available sorbents capable of solidifying these liquid wastes.

Sorbents were tested for a variety of chemicals including flammables, acids, bases, oxidizers, reducing agents, chlorinated solvents, peroxidizables, and cyanide and sulfide salts. A number of sorbents were blended to produce a single, robust form that could stabilize all types of liquids tested.

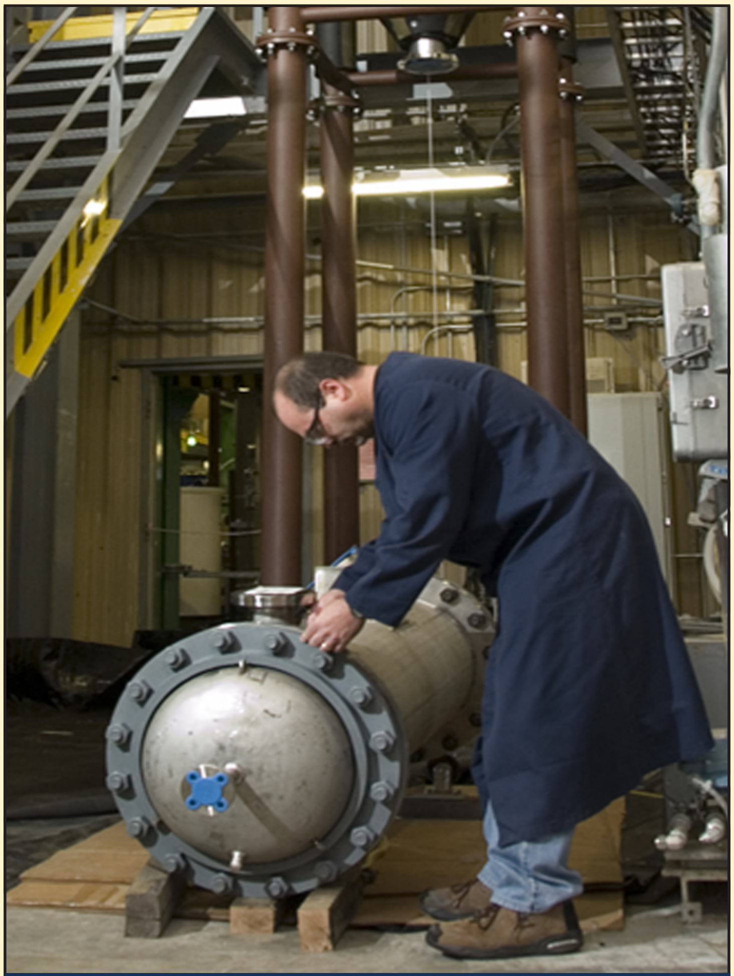
Testing of the new sorbent blend produced stabilized masses capable of withstanding conditions similar to those experienced during storage and burial, while controlling potential liquid release and limiting the reactivity for most of the solidified waste forms.

Fractional Crystallization for Pretreatment of High Level Waste at Hanford Moves to Pilot Scale Testing

Successful laboratory and engineering-scale testing of fractional crystallization by Areva and Georgia Tech has established a scientific and engineering basis to design a pilot testing facility for supplemental pretreatment of Hanford's HLW. Successful implementation of this pretreatment technology could result in significant reduction in the volume of HLW to be treated, reducing the HLW vitrification plant projected operations by 20-30 years, with a life-cycle cost savings of more than $1 billion. Additional cost savings would also be incurred, because of a smaller volume of HLW requiring off-site transportation and disposal.

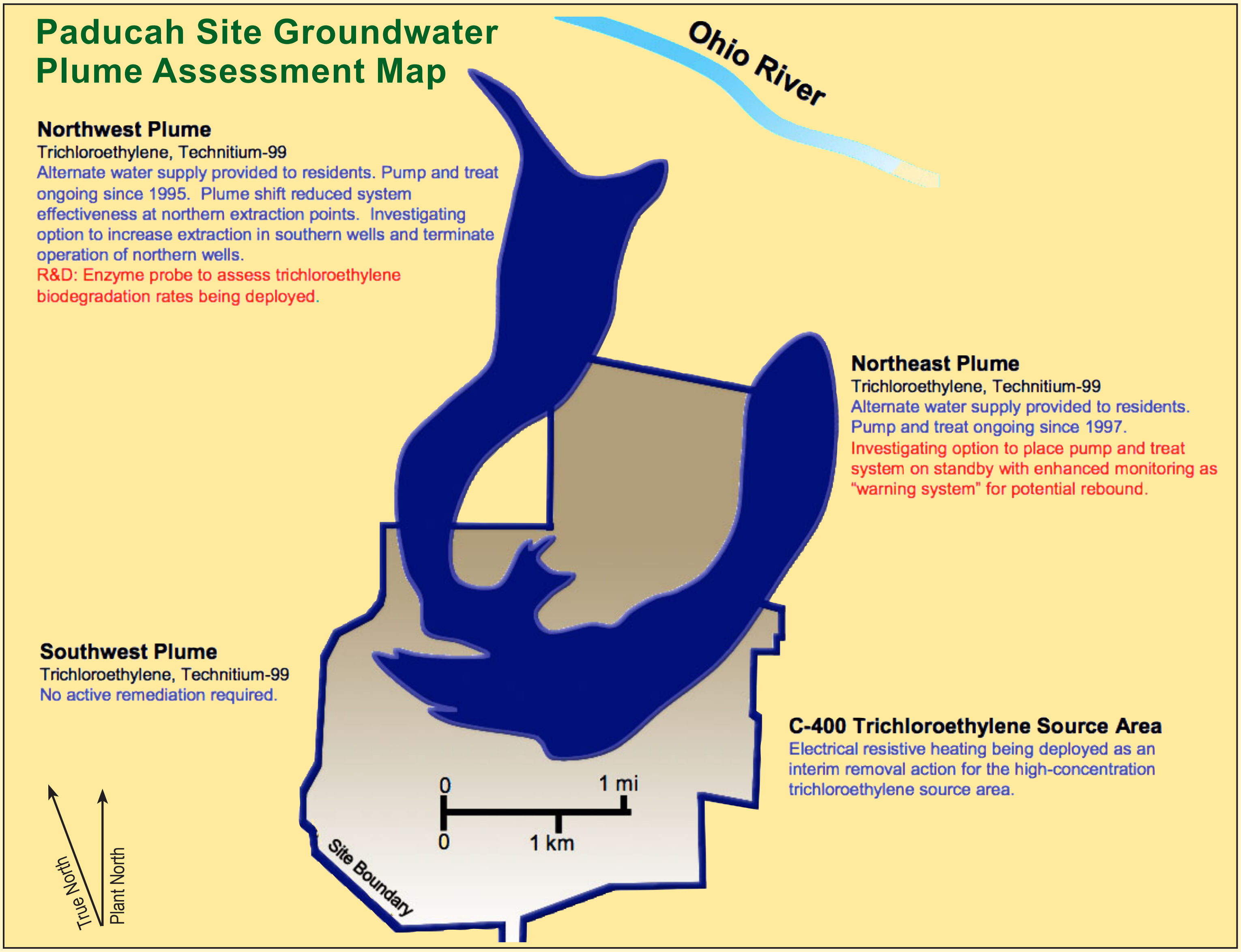
Radioactive wastes from 177 underground storage tanks at the Hanford Site in Washington State will be retrieved, treated, and stored in a permanent repository. DOE is currently planning on separating the wastes into two fractions, HLW and low activity waste (LAW), which would be treated and disposed in separate facilities. Fractional crystallization is currently being tested to remove the LAW sodium salts, thus significantly reducing the volume of HLW to be fed to the HLW vitrification facility. The one-fifth scale pilot testing facility is currently under construction at the SRNL.

A variety of anticipated HLW feed formulations from the various tanks has been modeled thermodynamically and tested in the laboratory. A quality crystalline product that can be readily separated from the liquid waste stream has been produced. Phase I and II testing has confirmed that radionuclides (cesium, iodine, and technetium) in the waste feed can be separated into the HLW stream, while the LAW waste stream is maintained at an appropriate level for handling in the supplemental treatment facility. Engineering-scale tests of the crystallizer design and operation have confirmed the laboratory results, and solid liquid separation of the produced crystals has been demonstrated to be an effective process.



Equipment installation is under way at the SRNL Pilot Test Facility where Fractional Crystallization will be tested in 2008.

The EM technology and engineering organization has convened two expert panels that have reviewed the results of the testing at the end of each phase of technology development. Most recently, the expert panel provided recommendations to enhance the pilot testing, which is scheduled to begin in 2008. As a result of this successful technology development project, fractional crystallization has demonstrated great potential to provide a cost-effective solution to support the treatment and disposal of HLW at Hanford.



Groundwater and Soil Remediation

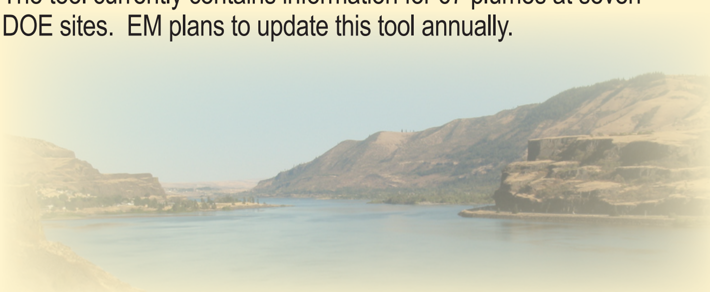
Groundwater Plume Assessment and Mapping Tool

DOE-EM Office of Engineering and Technology has developed a groundwater plume assessment and mapping tool that can be used to help identify and prioritize technology needs across the DOE Complex. Because DOE has one of the largest groundwater contamination problems and cleanup responsibilities in the world, this tool was developed to provide DOE-EM management, project managers, and other interested parties with information to assess and compare major groundwater contaminant plumes and associated remedial approaches at DOE sites across the US. It can be used to help with identifying and prioritizing technology and external review needs across the DOE complex.

The tool, containing both mapping and assessment functions, provides information on the type and extent of contamination at a particular location as well as the associated remedial approaches currently under way.

- The plume map function provides a visual representation of groundwater information for a specific plume. Maps provide location and extent of contamination, types of contaminants, current remedial activities, as well as current research and development projects.
- The plume assessment function provides details on plume location and size, contractor performing the work, major contaminants, source, status (relative to offsite migration), regulatory status, treatment status, and an evaluation of groundwater contamination and treatment needs.

The tool currently contains information for 67 plumes at seven DOE sites. EM plans to update this tool annually.



Deactivation and Decommissioning

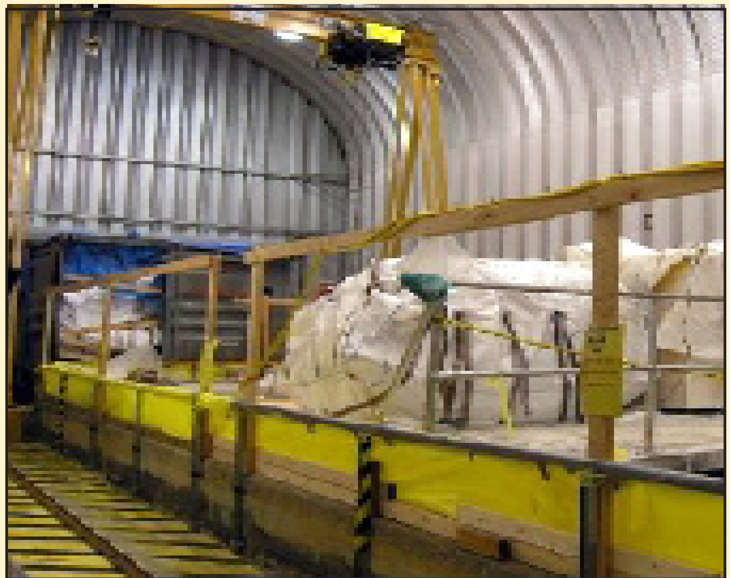
Chemical Decontamination Improves Safety, Reduces Transuranic Waste

Innovative technologies developed for decontaminating gloveboxes and tanks reduced the Rocky Flats Closure Project's life-cycle estimates for transuranic waste by nearly 30 percent – from an estimated 17,500 cubic meters to 12,500 cubic meters. The single most significant decommissioning innovation, chemical decontamination, slashed months from the site's accelerated closure date. More significantly, the use of these new chemical decontamination technologies – rather than traditional size-reduction methods – avoided thousands of hours of worker exposure to high airborne radioactivity, exertion and industrial hazards.

Rocky Flats had more than 900 gloveboxes that had been used for processing various radioactive isotopes, along with hundreds of tanks that had stored plutonium and actinide liquids. These items, which were contaminated with transuranic materials, were too large to be packaged into the 1.9-cubic meter Standard Waste Box or the 55-gallon drum required by the acceptance criteria at the Waste Isolation Pilot Plant (WIPP); (the largest glovebox was 64 feet long, and the largest tank had a capacity of 20,000 gallons). Size-reduction activities posed numerous safety and radiological hazards. Decontaminating the items to reach the Department of Transportation's surface contaminated objects criteria allowed the items to be packaged in 38-cubic meter cargo containers, reducing the need for size-reduction.

At a recent meeting of the Nuclear and Radiation Studies Board of the National Academy of Sciences, Dr. David Maloney, Director of Nuclear Technology for CH2M Hill, indicated that EM provided about $30 million in funding over eight years to address technology development needs and also encouraged the contractor to tap the expertise in EM's technology development organization. There was an estimated 30:1 return on this investment in terms of cost savings to the cleanup program. Dr. Maloney concluded by acknowledging that the Rocky Flats closure schedule and cost targets could not have been met without the continuous improvements made possible through the development and use of new technologies.

Gloveboxes prior to chemical decontamination at Rocky Flats.



Inside the Brookhaven Graphite Research Reactor (BGRR). The BGRR , the first reactor built soley for peaceful research, began operations in 1950 and performed its last scientific operation in June 1988; early D&D began in 1997.

Brookhaven Graphic Reactor Technical Exchange Workshop

Expertise gained from decommissioning graphite reactors in both the U.S. and the U.K. is benefiting Brookhaven Science Associates (BSA), as it undertakes the disassembly of the Brookhaven Graphite Research Reactor (BGRR) in New York.

The BGRR, the first reactor built soley for peaceful research began operations in 1950 and performed its last scientific operation in June 1968; early deactivation and decommissioning (D&D) began in 1997. The fuel has been removed from the reactor, leaving behind approximately 60,000 blocks of contaminated graphite (formerly the reactor core), and a steel and concrete "bio-shield."

EM Engineering & Technology's Office of Deactivation & Decommissioning (D&D) and Facility Engineering brought together a panel of subject matter experts with extensive experience in U.K. graphite reactor D&D, as well as the D&D of the Fort St. Vrain graphite reactor in Colorado, the first commercial nuclear generating plant in the U.S. to be decommissioned, for a workshop with BSA personnel and DOE and contractor staff.

The subject matter experts made a number of recommendations for modeling, process mock-ups, planning, and suggested graphic block removal and bio-shield cutting technologies, which the BSA team intends to incorporate into their D&D plans.

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