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Advanced Remediation Technologies

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ABSTRACT

The United States Department of Energy (DOE), Office of Environmental Management (EM) is responsible for the cleanup of nation's nuclear weapons program legacy wastes, along with waste associated with nuclear energy programs and research. The EM cleanup efforts continue to progress, however the cleanup continues to be technologically complex, heavily regulated, long-term; and the effort also has a high life cycle cost estimate (LCCE) effort. Over the past few years, the EM program has undergone several changes to accelerate its cleanup efforts with varying degrees of success. This article will provide some insight into the Advanced Remediation Technologies (ART) projects that may enhance cleanup efforts and reduce life cycle costs.

INTRODUCTION

The EM program is responsible for addressing the environmental legacy of nuclear weapons research, production, and testing and of DOE-funded nuclear energy and basic science research in the United States. These activities collectively produced large volumes of nuclear materials, spent nuclear fuel, radioactive waste, and hazardous waste. Over the past few years EM refocused its environmental cleanup program by emphasizing: accelerated site closure and reduction in risk while continuing to improve safety performance.

Environmental Management Mission

EM's mission is one of the most ambitious and far-ranging within DOE—in short—dealing with the environmental legacy of the Cold War. The EM program is one of the largest, most diverse, and technically complex environmental cleanup programs in the world, and includes responsibility for the cleanup of 114 sites across the country. This effort involves site closure activities, processing and disposing of nuclear materials and wastes, and the technology deployment necessary to facilitate these activities. Progress has been made in the EM cleanup mission—most notably the closure of major sites at Rocky Flats and Fernald; however, future success at sites with complex nuclear waste and materials issues—such as Hanford and Savannah Rive—will hinge on the success of a number of new technologies.

Some of theses technologies are not yet fully tested out and others are yet to be developed. It is the mission of the Engineering and Technology program identify vulnerabilities and reduce the technical risk and uncertainty associated with EM projects and programs. An important source of potential risk reduction strategies and technologies is the private sector—this is where the Advanced Remediation Technologies program (ART) fits in.

Project Criteria for Phase I and Phase II

The Advanced Remediation Technologies program (ART) is a competitive process initially mandated by Congress in FY 2005; they directed DOE "… to conduct a competitive evaluation of the various advanced remediation technologies available in the private sector." The project was structured into two phases. In Phase I, the selected projects were intended to develop a technical approach for demonstration; provide appropriate test results for their technology; develop scale-up plans and an implementation schedule; start detailed system design; estimate the cost for implementation of the technologies at selected DOE site or sites.

If Phase I results were promising, DOE will then consider a Phase II award(s). Phase II will require a pilot/full-scale demonstration of the technology, preferably at a DOE site. The demonstration of a characterization and monitoring technical approach is expected to conform to the site's management and operating contractor's Environmental Safety and Health (ES&H) requirements.

Improved and advanced technology needs, identified in the EM Engineering and Technology Roadmap, will enable sites such as Hanford, Idaho and Savannah River Site (SRS) to accelerate their project schedules, reduce life cycle costs, and improve worker safety. Where treatment plants and processing facilities exist, or are already well into design or construction, the technologies are intended to complement the current facilities with minimum disruption.

Phase I Projects

The Department received 39 proposals for performing work under Phase I of the contract. A total of twelve (12) six-month, fixed price contracts were awarded in 2006. These awards provided $3.3 million to support the development of technologies that have the potential to reduce cleanup costs and increase the safety and efficiency of treating and disposing of radioactive waste. These contracts provide funding to both small and large businesses, in addition to a university, to develop technologies.

The contractors and the focus of their advanced remediation technology work were as follows. There was one award to an academic institution; the University of Texas performed work on strontium immobilization in groundwater. Four small businesses won Phase I awards, these included: ARES Corporation for single-shell heel removal, TMR Associates for tank heel removal, North Wind for subsurface characterization, and Commodore Advanced Sciences, Inc., for metals separation. Finally, five large businesses were awarded contracts: Cogema Inc., (2 awards) for cold crucible induction melter technology and tank waste alumina recovery; THOR Treatment Technologies for treatment of Hanford and

Savannah River site high level waste, through steam reforming; Parsons Inc., (2 awards) for cesium removal and aluminum and chromium removal; Gas Technology Institute for submerged combustion melting; and ARCADIS G&M Inc., for groundwater remediation.

Upon completion of the six-month contract period the projects were re-evaluated for continuation into a Phase II efforts, based upon those deemed to provide the greatest benefit to the Department's cleanup mission.

Phase II Projects

On September 25, 2007 five Advanced Remediation Technology (ART) projects were selected for Phase II. These projects will address cleanup of waste stored in High Level Waste (HLW) tanks, Groundwater/Soils remediation and contamination, and vitrification of HLW at Hanford, Savannah River, Idaho and other DOE sites. The five selected projects for continuation are for an estimated value of $24.4 M and are as follows.

In-Situ Groundwater Remediation with Enhanced Anaerobic Reductive Precipitation/Enhanced Reductive Dechlorination (ARCADIS G & M Inc., Durham, NC)

This technology is an in situ bioreductive process to immobilize contaminant metals and radionuclides within the subsurface at Hanford. The technique involves the injection of a biodegradable substrate into the subsurface to stimulate the activity of native microorganisms present in the subsurface that will couple the oxidation of the degradable substrate to the production of reduced iron and sulfur species. The reduced iron and sulfur species are known to both chemically reduce and precipitate metal and radionuclide contaminants thereby producing less soluble, and therefore less mobile forms, of these contaminants. This bioremediation technique has been successfully deployed at many locations for a variety of metal contaminants. This ART Phase II demonstration focuses on deployment for use in immobilization of DOE contaminants of concern, such as radionuclides.

Cold Crucible Induction Melter (CCIM, AREVA NC, Bethesda, MD)

CCIM is an alternative vitrification technology that, when successfully deployed, could accelerate the High Level Waste (HLW) vitrification program schedule, reduce lifecycle cost and mitigate technical risks at Savannah River. The technology has the potential to be a retrofit replacement of the Joule Heated Melter (JHM) technology currently installed at the Defense Waste Processing Facility (DWPF) using lessons learned from the retrofit of the JHM at Marcoule, France, currently scheduled to complete in 2010. Extensive testing in France has resulted in the decision by CEA, the French government equivalent of the Department of Energy, to adopt the CCIM technology for use in their HLW vitrification facilities in Marcoule and La Hague. Deployment of the CCIM technology offers several potential advantages over the current JHM technology including: higher operating temperatures that support higher waste loadings resulting in fewer canisters produced; glass pool stirrer that ensures homogeneity of the glass; longer melter life based on the cold shell "skull" created on the melter interior surface that prevents erosion and corrosion of internal structure; and replaceable key ancillary equipment. Successful demonstration and adoption of the CCIM technology at Savannah River could potentially benefit the Hanford Waste Treatment Plant; it could reduce the number of HLW canisters that may have to be produced, thus improving both lifecycle cost and schedule.

Near Tank Cesium Removal (Parsons Infrastructure and Technology Group, Inc., Aiken, SC)

This project is a technology demonstration to provide a portable, modular, and shielded, near-tank system for removal of cesium from Hanford tank supernates and dissolved saltcake by 2012, well before the Waste Pretreatment Facility (WPF) is presently scheduled to be available in 2019. Once the cesium is removed, the low activity waste stream can be vitrified. The ART Phase II technology demonstration is based upon the elutable (re-usable) ion exchange process using the Spherical Resorcinol Formaldehyde resin also planned for cesium removal in the WPF. Successful deployment of this technology will also provide a pilot plant opportunity for the WPF ion exchange technology. After cesium removal, the decontaminated tank farm wastes are likely to be suitable for processing in the Low Activity Waste melters or alternative immobilization processes.

Near Tank Continuous Sludge Leaching (Parsons Infrastructure and Technology Group, Inc., Aiken, SC)

Advancement of this technology will reduce the uncertainty and risk to process tank waste sludge which is becoming an increasing concern due to the projections of metal oxides leading to a higher number of HLW canisters. This technology demonstration involves a process to dissolve aluminum and chromium compounds from sludge tanks using 100 deg C temperatures, 200 minute residence times and caustic sodium hydroxide, with concurrent use of cross-flow filtration for separation, thereby reducing HLW volume which requires vitrification. Deployment of this technology could assist in early mission completion at Hanford through a reduction in total number of cans processed.

Steam Reforming Process (THOR Treatment Technologies, Inc., Aiken, SC)

This project is a technology demonstration to produce final disposition waste forms for waste streams at Hanford and Savannah River. The implementation of this process would complement the current treatment utilizing vitrification and will demonstrate several potential advantages over current technologies: the process is low temperature compared to vitrification potentially allowing retention of key volatile radionuclides that are important to meeting regulatory requirements for groundwater; the final mineralized waste form is a monolith and has similar or better leaching characteristics compared to glass; the process results in no liquid or solid secondary waste streams and the fact that NOx is reduced to Nitrogen; and it is flexible and can treat various waste streams including those high in organics and sulfur. This technology has been previously tested for Idaho's sodium Bearing Waste and selected as the preferred technology.

Conclusion

In announcing the ART Phase II awards, Mr. James Rispoli, DOE Assistant Secretary for Environmental Management noted:

> **"These advanced remediation technologies will enable the Department to demonstrate and implement processes to accelerate high level waste and groundwater/soil cleanup missions across the Department's complex…"**

Project kickoff meetings were held at the Office of River Protection and Savannah River sites during the week of October 22, 2007. Each project's goals and objectives were presented and a site point of contract was identified. The immediate next steps for each project contractor will be to establish a rapport with the sites on their technology demonstration for successful implementation.

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