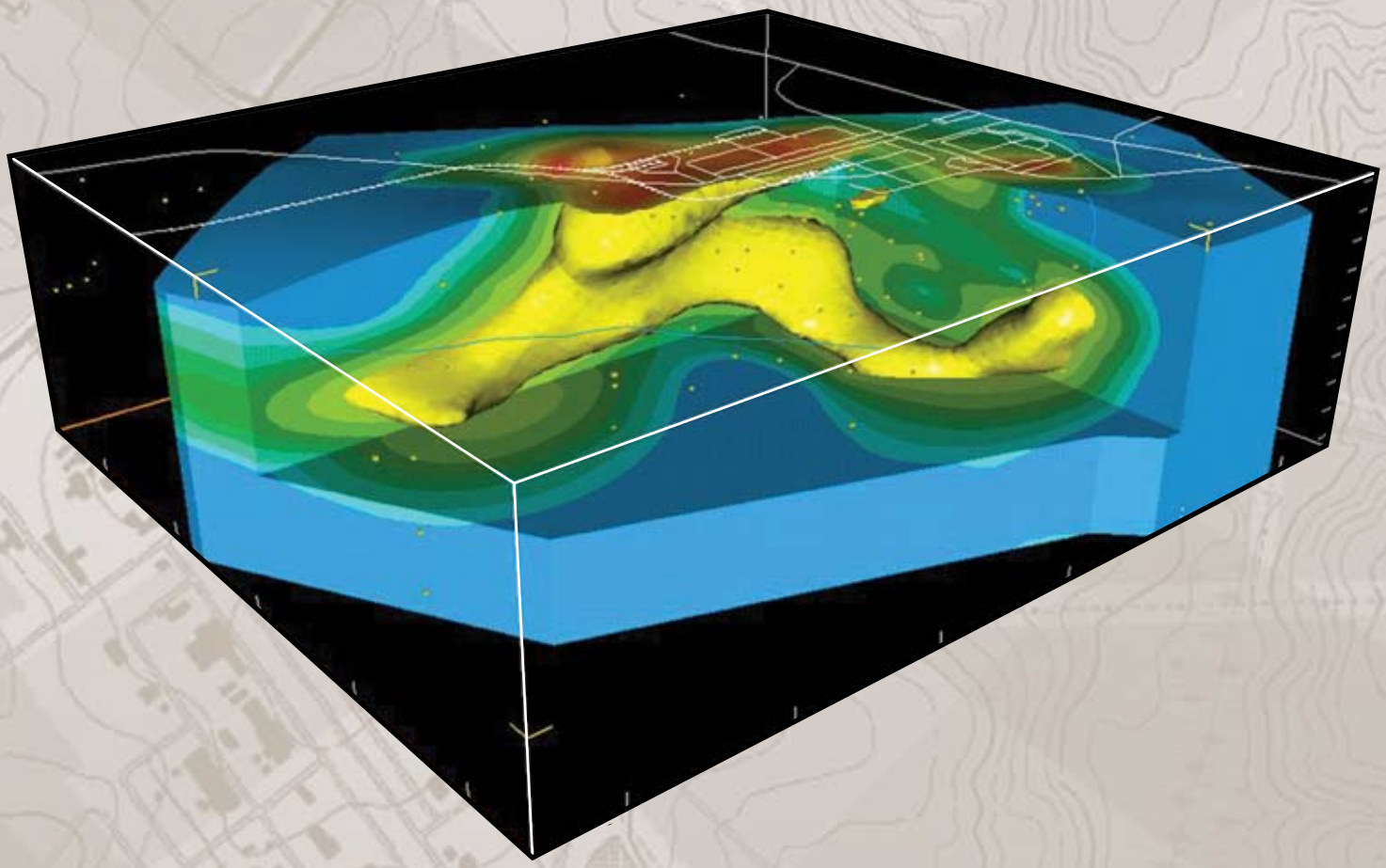
2008 – Vol. 2 – No. 1

SAVANNAH RIVER NATIONAL LABORATORY

SCIENCE AT WORK



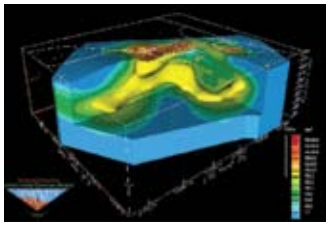
Nature-Based Remedies for Chlorinated Contamination

Also in this issue:

Digital Radiography for X-Ray Vision

Producing Hydrogen with Nuclear Energy

SRNL is a Key Partner in Ethanol Fuel Project



On the Cover

Three-dimensional visualization of subsurface contaminant plume beneath the Savannah River Site (see "Nature-Based Remedies for Chlorinated Solvents in the Environment").

About Science At Work

Science at Work is the flagship publication of the Savannah River National Laboratory (SRNL). It is designed to provide our Department of Energy customer, members of the scientific community, and the general public highlights of SRNL programs to put science to work in high-value R&D to serve urgent national needs.

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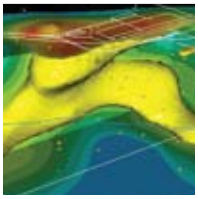

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Key South Carolina Partnership Formed to Convert Regional Plants to Biofuel

The Savannah River National Laboratory (SRNL) is a key player in a partnership to use South Carolina's agricultural resources to help the state and the nation decrease their dependence on fossil fuels.

SRNL, Clemson University, South Carolina State University, and SC Bio formed the South Carolina Bioenergy Research Collaborative to develop and demonstrate the economic feasibility of using cellulosic material (stems, leaves, wood, etc.) from regional plants such as switchgrass, short-rotation trees and sorghum to make ethanol. The research collaborative has expanded to include key industrial partners: Fagen Inc., one of the nation's leaders in designing and constructing ethanol plants; Dyadic Inc., a leader in the development of novel enzymes for breaking down cellulose; and Spinx Corp., one of the leading distributors of biodiesel and ethanol gasoline blends in the South. This Research Collaborative is going to take a holistic systems approach to developing commercially viable cellulosic ethanol technology from feedstocks to market delivery.

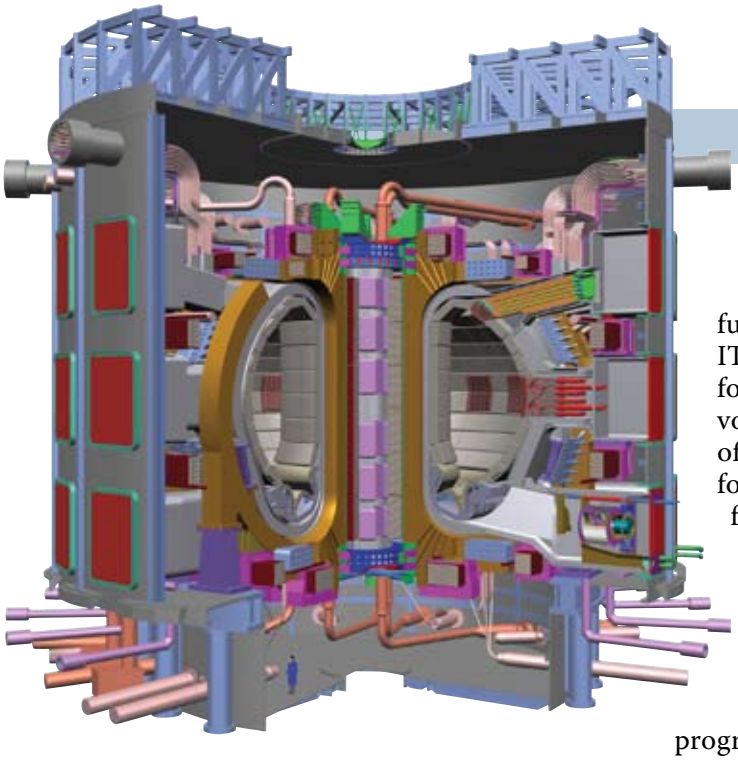
Cellulosic ethanol has the potential to be a highly efficient energy source. It is estimated that this approach could produce 800 to 1,000 gallons of ethanol per acre, compared to 416 gallons per acre for ethanol produced from corn. Even more striking, the energy content, which is the ratio of energy delivered to customer compared to the fossil energy used, could be as high as 10, compared with 0.81 for gasoline and 1.36 for corn-based ethanol.

Among the technical challenges being addressed by this collaborative effort is the development of energy crops with high biomass yield per acre, which require low water consumption, and are compatible with less productive lands. The other major challenge is the development of technology that economically digests the lignin and hemi-cellulose outer walls protecting the sugars of the plant. The various partners each bring to the project existing novel technology that can be expanded into this field, including application of signaled transgenic plants, novel conversion enzyme targets, and chemical technologies to convert residual and row crops into ethanol.

SRNL is bringing its environmental and biological research and development capabilities to this program, including its expertise in microbial and enzyme technologies designed to degrade various chemical and related compounds. SRNL is playing a lead role in research including pretreatment of biomass materials prior to hydrolysis or fermentation and in the discovery of effective novel cellulose enzymes.

The Research Collaborative plans to construct a cellulosic bioethanol pilot plant at Clemson University's Restoration Institute in North Charleston, S.C., using a combination of public and private funds. The goal for this pilot plant is to become a multi-purpose user facility that would enable energy producers interested in energy crop bases in the Southeast to scale up new and innovative processes and ultimately build regional ethanol production facilities.

In addition to the environmental benefits – analyses have shown that carbon emissions from cellulosic ethanol can be 85 percent less than from gasoline – this endeavor could lead to significant economic development for the region. South Carolinians consume over 2.5 billion gallons of gasoline every year, all of which is imported from out of state. Producing enough cellulosic ethanol to replace just 20 percent of the state's gasoline usage would create 10,000 new jobs and add $2 billion to the local economy.



SRNL to Support International Energy Project

The Department of Energy's (DOE) Savannah River National Laboratory (SRNL) was selected as a partner laboratory by the U.S. ITER Project Office. SRNL will add its technological expertise in support of the ITER program, an international project to demonstrate the scientific and technological feasibility of a full-scale fusion power reactor. ITER, which is Latin for "the way," will involve construction of a tokamak reactor for the production of fusion energy and research on self-heated reactor-scale plasma. Currently, seven parties are participating in the ITER program: the European Union, the United States, Japan, Russia, India, China and South Korea. The project is being constructed in Cadarache, France.

SRNL's role is the design, fabrication, assembly, testing, and shipment of the Tokamak Exhaust Processing (TEP) system, working in collaboration with DOE's Los Alamos National Laboratory.

SRNL's development of the TEP system will provide a technically mature, robust, and cost-effective solution for the separation of hydrogen isotopes from the Tokamak exhaust stream — a critical element in the ITER project. U.S. ITER Project Manager Ned Sauthoff said, "The U.S. ITER Project and the international ITER Organization are very pleased to have the Savannah River National Laboratory as a member of the ITER team. The ITER Project draws on the best in the world in addressing a global energy challenge by an unparalleled international partnership to create 'star-stuff' on Earth, to demonstrate the scientific and technological feasibility of fusion energy. SRNL's experience and expertise in large-scale tritium processing systems and its track record of effective project execution form a unique combination that is key to the success of this unique project."

SRNL Establishes EM Technical Integration Office

In 2007, SRNL's role as the U.S. Department of Energy Office of Environmental Management's (EM) Corporate Laboratory included working closely with the EM Office of Engineering and Technology and Deputy Assistant Secretary Mark Gilbertson to establish and staff EM's Technical Integration Office. This office is charged with managing the implementation of EM's Engineering and Technology Roadmap.

SRNL supported EM in the development of this Roadmap, along with its Implementation Plan and Process. The Roadmap identifies technology risks – those technical issues that could prevent project success – and strategic initiatives addressing these risks. The 13 initiatives address risks in the areas of Waste Processing, Groundwater & Soil Remediation, Deactivation & Decommissioning, DOE Spent Nuclear Fuel, Challenging Materials, and Integration & Cost-Cutting. The Technical Integration Office, which includes staff from EM, SRNL, Pacific Northwest National Laboratory, Idaho National Laboratory, Oak Ridge National Laboratory, and other organizations supporting EM, is organized into these same six key program areas.

SRNL's support for EM as the Corporate Laboratory, under the leadership of Dr. John Marra, Associate Laboratory Director, Environmental and Chemical Process Technology, also included the development of draft guidelines for Expert Technical Reviews, as well as coordinating or leading several technical reviews in areas of importance to EM. In addition, SRNL led or supported several important workshops in the areas of cementitious materials, aluminum/chromium leaching, and reactor D&D.

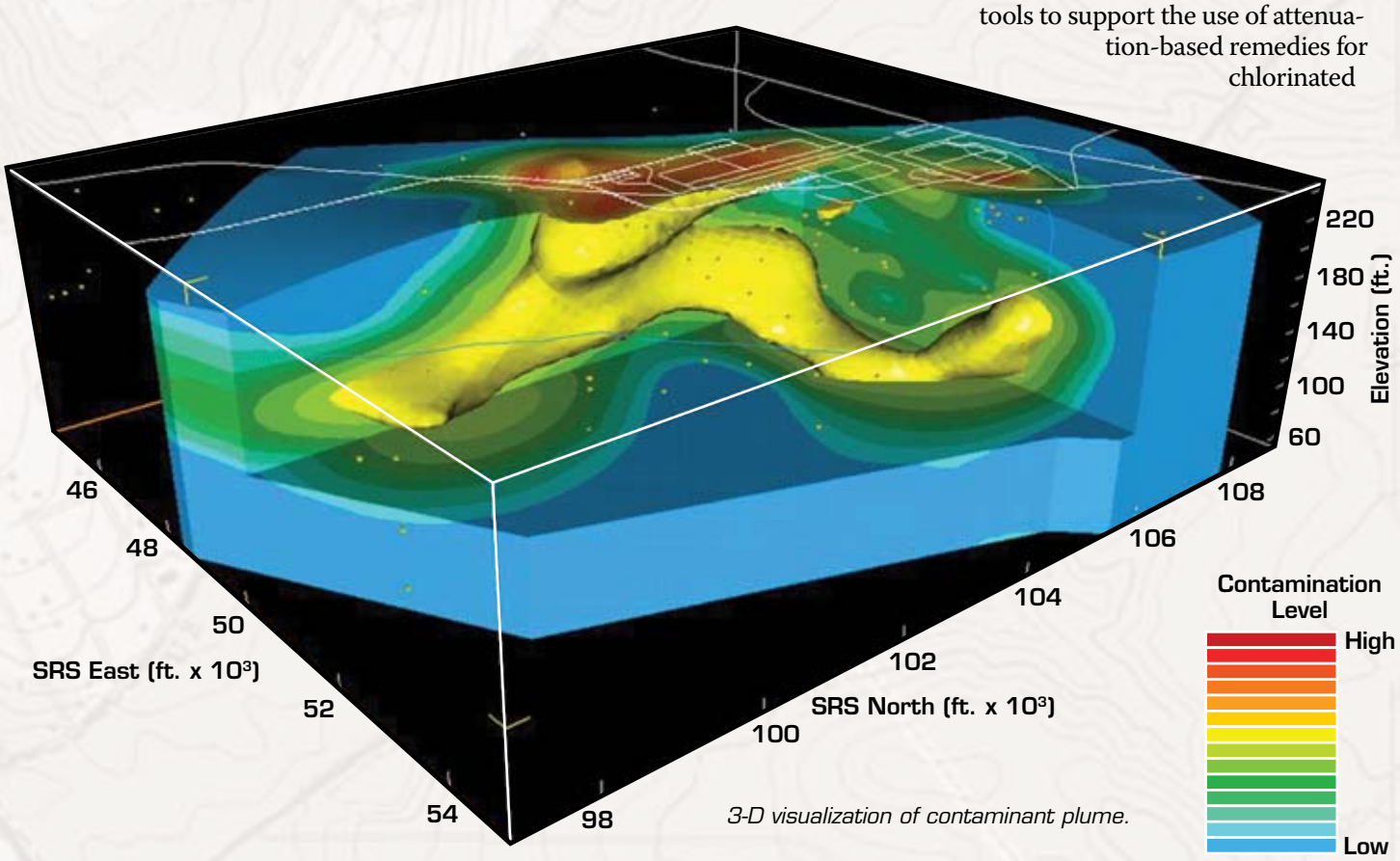
Dr. John Marra

Nature-Based Remedies for Chlorinated Solvents in the Environment

***Nature has its own ways of tackling some of the contamination that has been** imposed on it. Some of these methods work completely on their own, while others need a human "boost." A national team led by SRNL has completed a three-year, $6 million research project that examined and advanced various approaches and tools to support the use of nature-based remedies for chlorinated solvent contamination. Working with regulatory agencies to facilitate regulatory acceptance, the team also developed a process for determining when and how to transition to nature-based solutions.*

Nature has many ways of cleansing itself of the contamination that resulted from human activity. Sometimes the best method of environmental cleanup is to rely on nature, an approach known as Monitored Natural Attenuation or MNA. If nature needs a "boost," a new concept known as Enhanced Attenuation or EA may be appropriate.

The U.S. Department of Energy (DOE) has completed a three-year, $6 million research project that examined and advanced the various approaches and introduced new tools to support the use of attenuation-based remedies for chlorinated



3-D visualization of contaminant plume.

solvents. The effort built on the U.S. Environmental Protection Agency's 1999 Office of Solid Waste and Emergency Response Directive titled "Use of Monitored Natural Attenuation at Superfund, RCRA Corrective Action, and Underground Storage Tank Sites" and the 1998 Office of Research and Development's "Technical Protocol for Evaluating Natural Attenuation of Chlorinated Solvents in Groundwater." The Savannah River National Laboratory (SRNL) led this project, which was funded by the DOE Office of Environmental Management's Office of Cleanup Technologies. This project integrated the development of three key concepts, funded 14 research projects that supported the key concepts, and supported development of a technical regulatory document and training by the Interstate Technology Regulatory Council (ITRC).

"We have at our disposal a vast toolbox of methods for cleaning up contaminated groundwater," Dr. Brian Looney, SRNL, chairperson of the project's technical working group says. "Some contamination calls for very aggressive treatment using large amounts of energy and chemicals. At the other end of the spectrum, there are situations where the best approach is to stand back and allow natural mechanisms, like microbe-induced biological activity, to break down or isolate the contaminants. In those cases, the human's role is to monitor the process, to make sure that nothing is interfering with nature's ability to work," Dr. Looney continues. "That approach is called monitored natural attenuation.

"However, in transitioning from an aggressive treatment to MNA, there will be many instances in which nature will need a little assistance to reach a state where the natural attenuation mechanisms are sufficient to finish cleaning the environment. In those cases, an engineered action designed to move the site to where the natural attenuation mechanisms are then strong enough for the time needed to finish cleaning the environment will be required," Dr. Looney adds. "This is known as enhanced attenuation.

"The key," Dr. Looney explains, "is first to know which situations call for which approach, and then to assure the selected enhancements are sustainable."

"We're building on the very good science that already exists in this field," Karen Vangelas, the project's technical coordinator for SRNL, says. "We looked at the existing processes and technologies and determined where further advancements in research and development might be useful."

To assist in this work, a technical working group composed of nationally recognized scientists was assembled. In addition to Dr. Looney as chairperson, the group included Dr. Francis H. Chappelle, U.S. Geological Survey; Dr. Thomas Early, Oak Ridge National Laboratory;Tyler Gilmore, Pacific Northwest National Laboratory; Dr. Michael Heitkamp, SRNL; Dr. David Major, Geosyntec Consultants, Inc.; Dr. Jody Waugh, S.M. Stoller Corporation; Dr. Gary Wein, Savannah River Ecology Laboratory; Todd H. Wiedemeier, T.H. Wiedemeier and Associates; Mark Ankeny, Idaho National Laboratory; and Jeff Ross, Bechtel Savannah River Company, Inc. They provided the technical direction for the project and identified the major areas of study.

All project reports and products from this work can be found at two locations:

1) project website: www.mnaeacvocs.com
2) DOE Office of Scientific and Technical Information Website: www.osti.gov

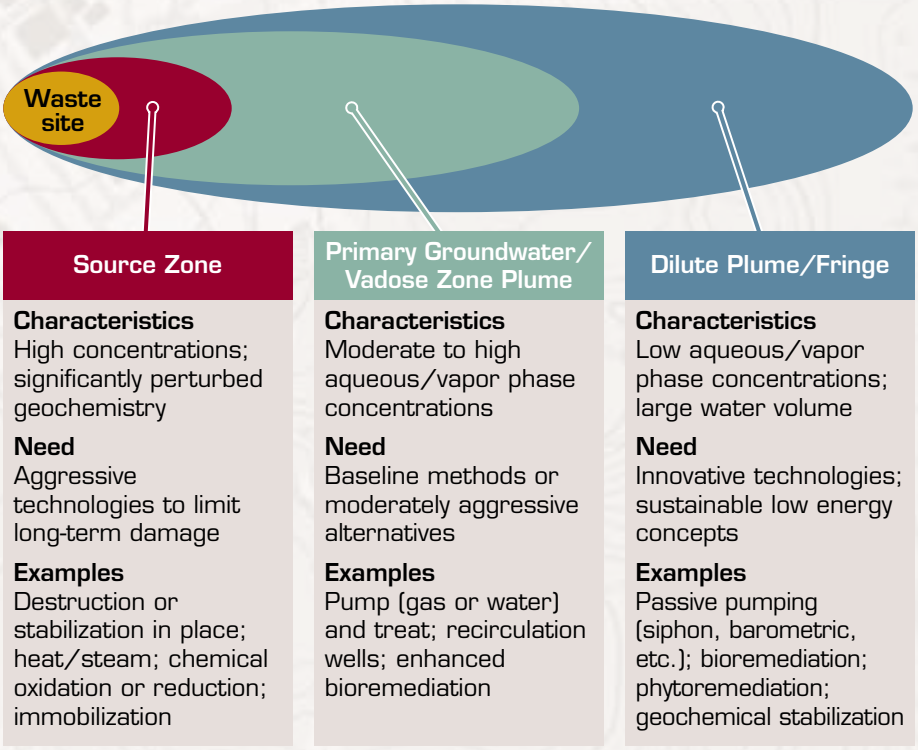


Figure 1. The various zones within a contaminated site and the different technologies that are applied to each zone for remediation. A contaminated site is best divided into three zones: a Source Zone, a Primary Groundwater/Vadose Zone Plume, and a Dilute Plume/Fringe.

Anatomy and Treatment of a Contaminated Site

To better understand how this project fits into the overall program of remediating contaminated sites, one needs to first understand the various zones within a contaminated site and the different technologies that are applied to each zone for remediation. A contaminated site is best divided into three zones: 1) Source zone, 2) Primary groundwater and/or vadose zone plume, and 3) Dilute plume or fringe zone (Figure 1).

The source zone contains high concentrations, typically at or close to the limit of solubility, of the contaminant. Aggressive technologies are used to limit long-term damage. These technologies include destruction or stabilization in place; volatilization with heat or steam; chemical oxidation or reduction; and immobilization.

The primary zone plume contains moderate to high concentrations of the contaminant in the dissolved phase. Baseline or moderately aggressive methods are used for treatment such as pump and treat, recirculation wells, and enhanced bioremediation.

The outer zone is the dilute plume or fringe where substantially lower energy concepts are needed and used. These include passive pumping, bioremediation, phytoremediation and geochemical stabilization.

It should be noted that Figure 1 greatly simplifies the actual picture since, in the real world, the plumes are three-dimensional and quite complex in shape (see 3-D visualization on page 4). In all cases a contaminant plume will expand, stabilize, and then shrink. The rate at which this occurs is based on a mass balance of the rate at which contaminants are entering the site and the rate those contaminants are being destroyed or removed from the entire site. These rates can be described in terms of contaminant flux, the mass of contaminant that moves across a plane per unit time. Engineered treatments are employed to minimize the expansion of the plume in both time and space. MNA is employed only when a plume has stabilized and will then shrink. Enhanced attenuation can be employed when a plume is close to being stabilized and a less energy intensive approach is determined to be viable to reach that stable and then shrinking state.

The technical working group used this model and understanding to develop the major targets for the project. The three

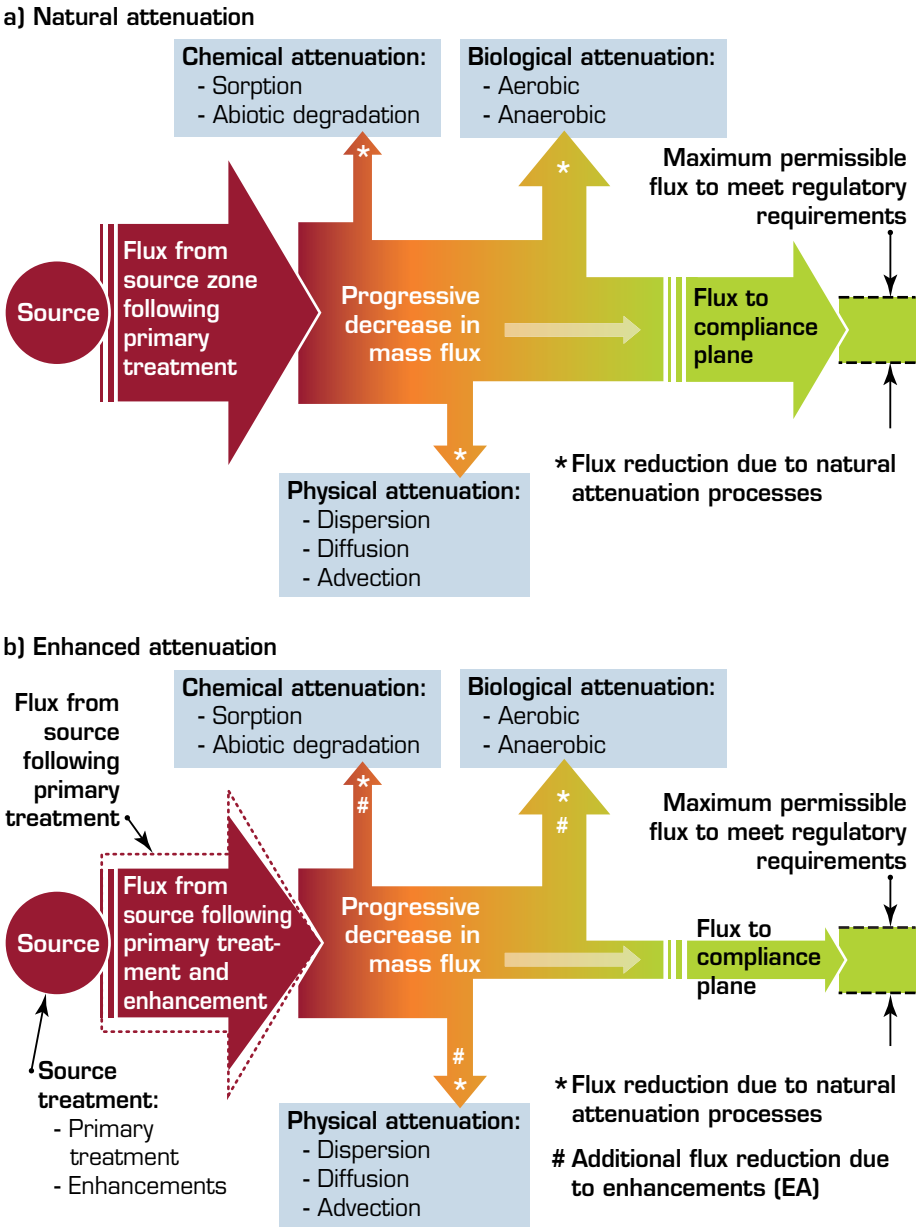


Figure 2. Processes that occur during (a) Natural Attenuation and (b) Enhanced Attenuation.

major targets they identified for improvement were: 1) Understanding natural attenuation and quantifying its capacity (mass balance), 2) Enhanced attenuation concepts, and 3) Strategies for characterization and monitoring.

Monitored Natural Attenuation (MNA)

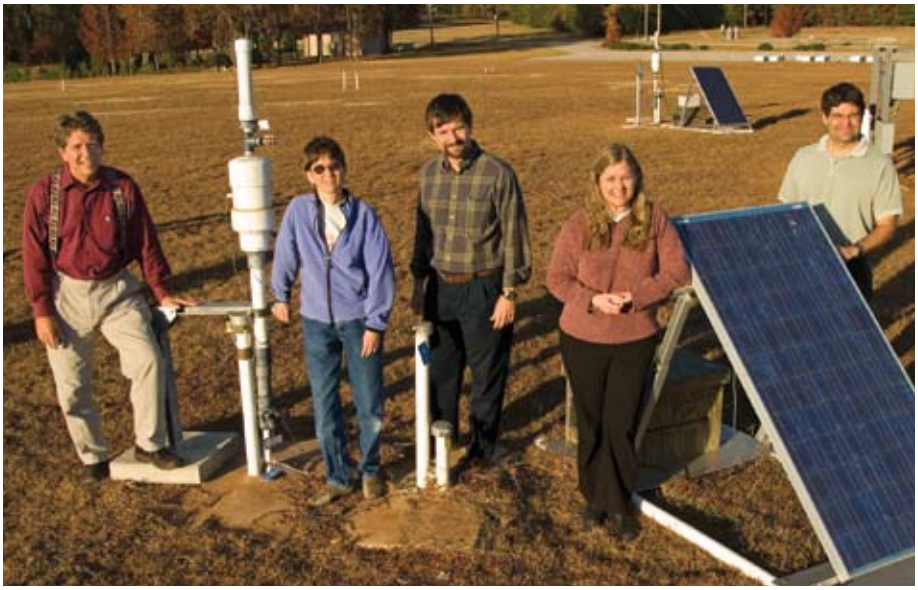
MNA has been very successful when it has been applied to petroleum-contaminated sites. However, the success with chlorinated solvents has been more variable. That is because chlorinated solvents tend to be more stable and less susceptible to the direct breakdown processes that occur with petroleum hydrocarbons. The processes that may be active during natural attenuation are shown in Figure 2(a). They include physical attenuation (by dispersion, diffusion and advection), chemical attenuation (by sorption and abiotic degradation), and biological attenuation (by aerobic and anaerobic biodegradation). The strongest and most studied mechanism, anaerobic reductive dechlorination (anerobic biodegradation), requires groundwater that contains very low concentrations of oxygen and specific geochemical conditions. Many groundwater environments on DOE sites do not meet these conditions on a scale suitable for this mechanism to have a sufficient impact on the plume. However, as shown in Figure 2(a), there are other natural mechanisms that contribute to the attenuation of a chlorinated solvent contaminant plume and must be understood and measured to be included in the mass balance of the contaminant plume. For many DOE sites, aerobic biodegradation processes may be important destruction mechanisms.

Enhanced Attenuation (EA)

Enhanced Attenuation is a strategy that supports the transition from active to passive (MNA) treatment and vice versa. Many technologies that can be used as EA technologies are presently designed and implemented as active treatments. To be implemented as an EA technology, the design of the treatment is based on reaching a state where the attenuation mechanism(s) are sustainable for the time needed to reach remediation goals with minimal intervention. An example of a technology that can be used as an active treatment or an EA treatment is biostimulation. As an active treatment, biostimulation is designed to remove a set amount of mass in a short time period with multiple injections of biostimulant. As an EA treatment, biostimulation is designed to "boost" the rate of the existing attenuation mechanisms with as few injections as possible so the mechanisms can work at a rate that can be sustained so that the contaminant concentration does not exceed remediation goals at the point of compliance.

The design of EA technologies is based on reducing the "loading" from the source, and/or enhancing the existing natural attenuation capacity through interventions (Figure 2(b)). Hydraulic manipulation techniques are often used to reduce source loading. These include interception and diversion of surface runoff and storm flow water, covers or caps, and diffusion barriers. Another approach is passive residual source reduction such as vapor extraction from the vadose zone using baroballs.

In addition to the source loading reduction, the natural biological attenuation processes can be enhanced through biostimulation, bio-augmentation, and plant-based methods. These include injection of appropriate nutrients into the soil or planting of the proper plants in the proper locations. Abiotic (non-biological) processes can also be enhanced with the addition of reduced iron and sulfur phases, sorption agents, and reactive barriers.



Some of the SRNL project participants gather around a microblower at the SRS T Area. The microblower removes chlorinated solvents from soil using solar power. (Left to right) Dr. Brian Looney, Karen Vangelas, Jeff Ross, Maggie Millings, and Dr. Chris Yeager.

Characterization and Monitoring Supporting MNA/EA

A major part of attenuation-based remedies is characterization and monitoring of those mechanisms that are the center of the remediation. To aid those responsible for characterization and monitoring activities, a four-phased approach was developed by the technical working group. This approach provides a process that supports initial screening to identify which mechanisms will be most likely, and then more detailed characterization to identify the rates and extent of those dominant mechanisms. For example, if the phase one screening determined that a site had high oxygen levels, the phase two characterization would focus on mechanisms that use oxygen. No effort would be made to determine the rates of anærobic mechanisms—which take place in the absence of oxygen—because they would not be important.

The final two phases of the approach support monitoring, which is often one of the most expensive elements of environmental remediation. This new approach advocates using traditional monitoring at the beginning of the monitoring cycle and then moving toward non-traditional methods, such as ecological monitors and remote sensing. In the final phase of monitoring, the non-traditional methods are the primary metrics used to demonstrate environmental protection. For these non-traditional methods to be viable, they must provide reliable monitoring of the sustainability of the attenuation

Technologies in the News

Smart Latch™ Named Among World's Best Technologies

For the third year in a row, a technology developed at the Savannah River National Laboratory has been named among the top 25 of the World's Best Technologies for the year. The Smart Latch™ acoustic door latch detector, invented by SRNL's Bob Eakle and built with the help of Charlie Fulghum and Larry Feutral, was one of the featured inventions at the World's Best Technologies for 2007 (WBT07) Showcase.

WBTshowcase
world's best technologies

This was the second time in three years that one of Eakle's inventions has been selected as one of the top 25 technologies in the WBT Showcase. In 2005, the Floating Plasma Screen Mount, which he co-invented with SRNL's Don Pak, was featured.

The Smart Latch™ device is designed to verify that doors are latched properly, providing an alert if a door does not latch. It would be useful anywhere that a properly closed and latched door is needed for security and safety, including offices, industrial facilities, or homes with children or elderly residents. The battery-operated device occupies only one cubic inch of space, meaning that it could be easily incorporated into many lockset designs.

It works by using state-of-the-art neural network technology to acoustically analyze the lock's performance. The device memorizes the precise sound – the acoustic "signature" – of the door closing properly. Once this signature is memorized, the device gives a visual and/or audible alarm if the door remains open for too long or is not properly latched. Existing technologies use simple limit switches, which do not actually sense the latching event and can be defeated in various ways.

The WBT07 is an international competition showcasing seed-stage technologies and licensing opportunities from top universities, federal laboratories, federal agencies, research institutions, and private companies. Each year, up to 75 exhibitors are selected by a seasoned screening panel of investors and commercialization experts on the basis of having the greatest potential for high growth commercial enterprises. From those 75, the top 25 are selected for special attention. The event is produced in cooperation with The National Association of Seed and Venture Funds and the Federal Laboratory Consortium for Technology Transfer.

mechanisms and do so at a cost that is less than the traditional methods.

Critical in this phased approach is periodic re-examination of the site and implementation of contingencies if the risks are increasing and the contamination is not behaving as expected.

Part of this project was to advance the state of characterization and monitoring techniques. Several techniques were investigated during this project that will support characterization and monitoring of MNA and EA, as well as providing input for a mass balance evaluation. These include emerging bioassessment techniques, new field tests to measure reaction rates, geochemical conditions (e.g., sensors), flux monitors and estimation methods, biological and ecological indicators, and remote geophysics and aerial sensing.

Integrating Science and Regulation

An invaluable partnership was formed during this project with the ITRC and their Enhanced Attenuation: Chlorinated Organics (EACO) team. The ITRC is a consensus-based organization led by state regulators with the goal of advancing the use of novel concepts and technologies to move environmental cleanup forward. The partnership has led to the incorporation of the scientific advances of the SRNL-led team into a decision-framework developed by the EACO team that complies with existing environmental regulations. The goal in developing this framework, shown in Figure 3, was to provide a process to tie together source treatment, MNA, EA and the concepts of mass balance and sustainability in an efficient, protective and scientifically defensible process.

This process will be described in detail in the ITRC guidance document on Enhanced Attenuation that is scheduled for publication in mid- to late-2008 and Web-based training that will be initiated once the guidance document is published.

Another important point associated with the framework is that it supports a paradigm shift from evaluating and treating zones of a plume towards evaluating and selecting treatments of each zone as a part of the entire system. In other words, one must think about how the actions in one zone will impact actions in another zone.

Next Steps

"While a lot has been accomplished by this project," concludes Vangelas, "we need to start focusing on the next steps. These include an active outreach program and training to communicate all this valuable information and technologies, support for future EPA and state policy development activities, and the application of these EA developments to metal and radionuclide contaminants."

These efforts have begun in earnest with the completion of two national workshops as well as a training course at EPA Region IV in Atlanta. The response has been very positive with future requests for other EPA regions, the military, and Internet-based training.

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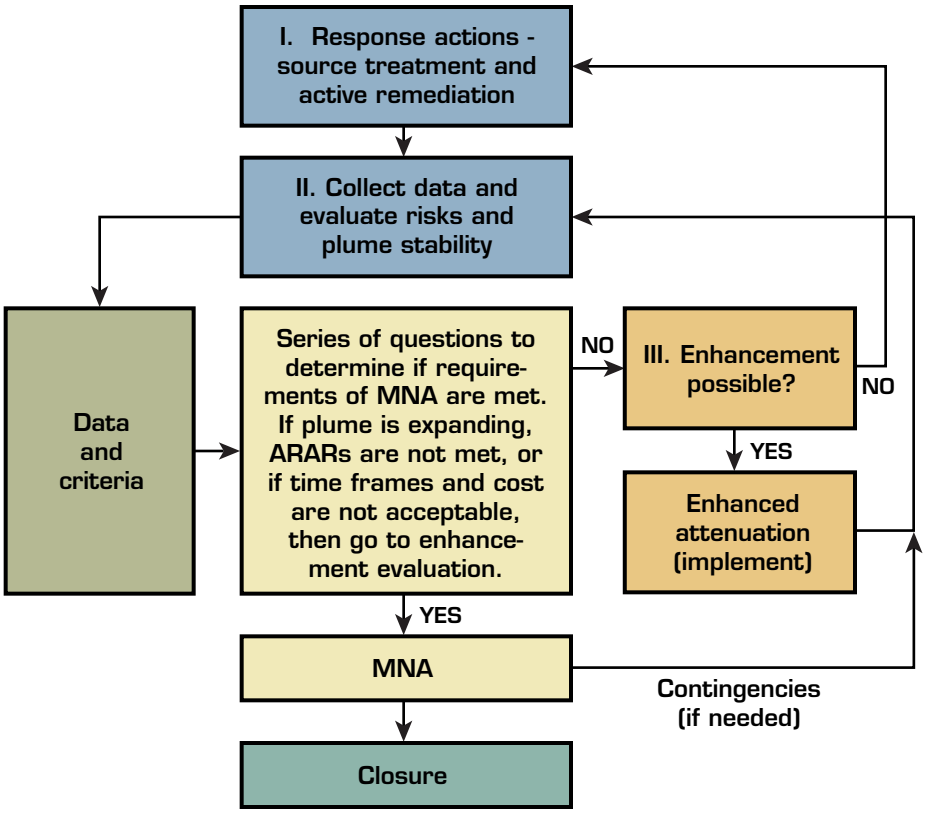


Figure 3. Decision framework developed by EACO team for determining when EA and MNA are appropriate.

Contributing to the Nation's Hydrogen Future

***SRNL is playing a key role in a national effort to investigate the use of** nuclear energy to produce hydrogen for use as a fuel. Hydrogen is one of the most abundant elements on the planet, but most of it is chemically bound as part of water or other compounds, so the goal is to find the most energy-efficient method of splitting it from these compounds so it can be used. Using nuclear energy to obtain hydrogen avoids the use of fossil fuels and greenhouse gas emissions. SRNL is championing the hybrid sulfur process, an approach that combines thermochemical and electrochemical steps, using the heat and energy from a nuclear reactor. This approach offers a very high level of efficiency while simplifying process steps.*

Hydrogen has attracted a lot of interest recently as a replacement for fossil fuels because it can be made from a variety of domestic energy resources, is environmentally benign, and can provide very high efficiency when used in fuel cell generators. Hydrogen burns cleanly to produce only water vapor as a by-product. While hydrogen is one of the most abundant elements on the planet, it is, unfortunately, chemically bound as water, hydrocarbons and other compounds. Therefore, energy must be expended to split hydrogen from other compounds to be able to use it as a fuel. The Department of Energy (DOE) is sponsoring research to identify the most energy-efficient methods of achieving that split.

The Savannah River National Laboratory (SRNL) is contributing to this national effort by leading the development of one technique for using nuclear energy to produce hydrogen. The advantage of using nuclear energy is that it avoids the use of fossil fuels and greenhouse gas emissions. Electrical and/or heat energy from the nuclear reactor is used to split water and separate the resulting hydrogen and oxygen. To achieve this separation, electrolysis, thermochemical, and hybrid thermochemical-electrochemical cycles are being investigated.

While the major driver for the DOE hydrogen program is for use in transportation, there currently exists a large hydrogen demand of about 32,000 metric tons of hydrogen per day in U.S. industry, equivalent to the energy output of nearly 50 nuclear power plants. This includes the use of hydrogen to produce ammonia for fertilizers and to "sweeten" and lighten heavy crude oils for cleaner-burning fuels. These large centralized hydrogen users

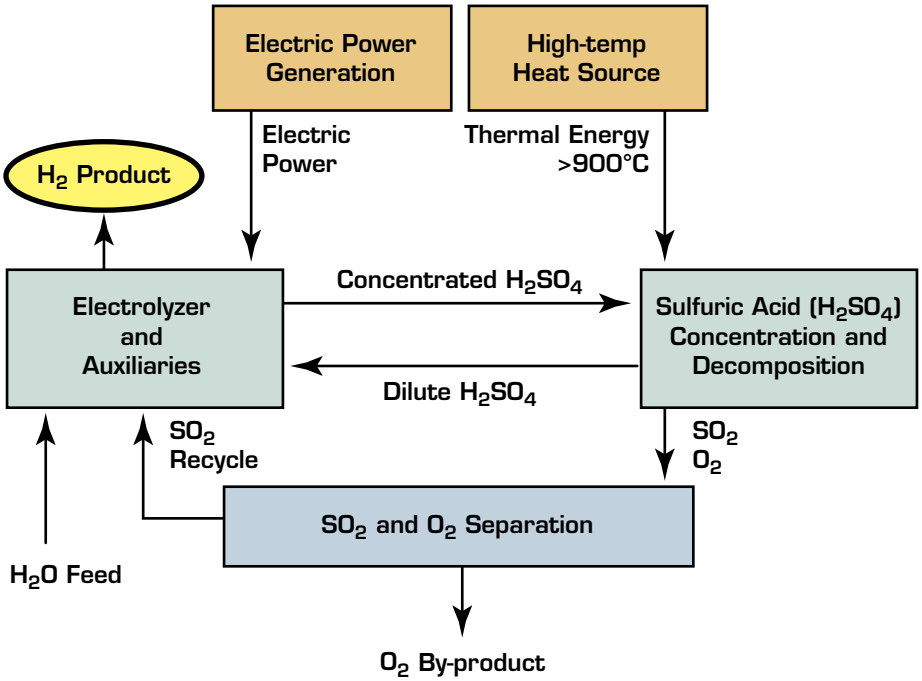


Figure 1. The hybrid sulfur cycle.

may provide a pathway for commercialization of hydrogen production using nuclear energy.

The Hybrid Sulfur Cycle (HyS)

One of the major contenders for hydrogen production is the hybrid sulfur (HyS) process, which is currently being studied and championed by SRNL. The HyS process has the highest process efficiency of proven thermochemical cycles. The HyS process was invented by Westinghouse Electric Corporation in the early 1970s, when it was known as the Westinghouse Sulfur Cycle. "The HyS process offers significant advantages and simplifications compared to other processes," says Dr. Bill Summers, manager for SRNL's Hydrogen Production Program. "It offers high thermal efficiency while simplifying material considerations and minimizing chemical separation steps because it involves only hydrogen, oxygen and sulfur in the process steps."

"Hybrid" cycles for the production of hydrogen involve combining an electrolysis step in a thermochemical cycle. The two-step HyS cycle consists of the following reactions:

$$H_2SO_4 \leftrightarrow SO_2 + H_2O + {}^1/_2\, O_2$$

Thermochemical, 800–900°C

$$2H_2O + SO_2 \leftrightarrow H_2SO_4 + H_2$$

Electrochemical, 100–120°C

The major processing steps for the HyS process are shown in Figure 1. The process requires both electrical and thermal energy. Using a nuclear reactor, approximately one-fourth of the energy would be supplied as electrical energy and three-fourths as high-temperature thermal energy.

A lot of work was done previously on this process to advance the technology. In 1978, Westinghouse successfully demonstrated a bench-scale integrated process that produced 120 liters of hydrogen per hour. SRNL is now involved in further advancing the technology. Much of this effort is focused on the electrochemical step.

The advantage of the HyS process is that a significant portion of the electrical energy needed for electrolysis can be replaced by direct use of thermal energy, resulting in a large efficiency improvement. While direct electrolysis of water has a reversible cell potential of 1.23 volts at 25°C, the reversible cell potential for SO_2 anode-depolarized electrolysis in the HyS process is only 0.158 volts. This translates to a theoretical reduction of 87% in electrical energy requirements. The overall efficiency of the HyS process is calculated to be around 52–54%, compared to a room temperature electrolysis

efficiency of 25–35% and an High Temperature Electrolysis (HTE) efficiency of 45–50%.

Sulfur Dioxide Depolarized Electrolyzer

The proof-of-concept of the SO_2 electrolysis for the HyS process is a major target of the DOE Nuclear Hydrogen Thermochemical Program. SRNL is pursuing a sulfur dioxide depolarized electrolyzer (SDE) which uses liquid-phase SO_2 feed for this process, while the University of South Carolina is pursuing the gas-phase option. The liquid phase being tested is concentrated sulfuric acid containing dissolved sulfur dioxide as the anode feed.

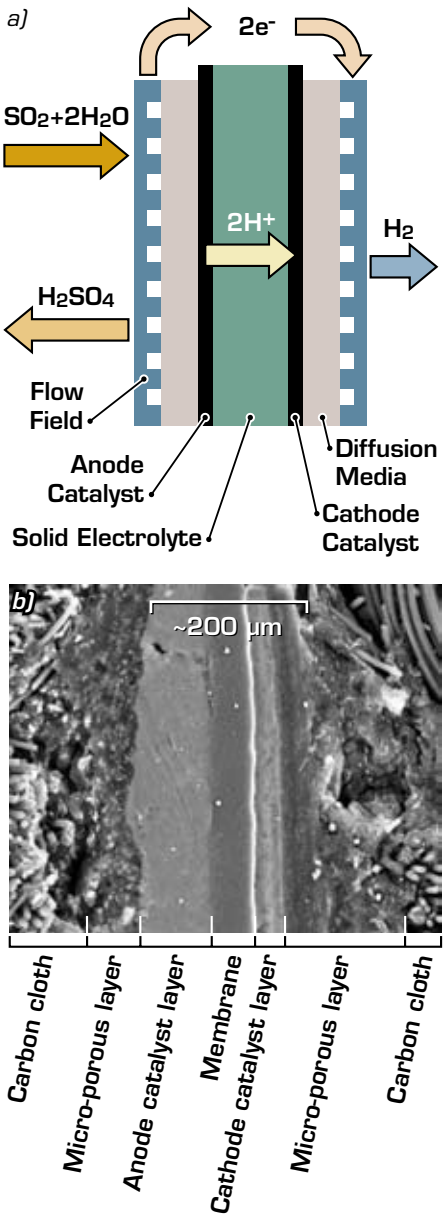


Figure 2. (a) Sulfur dioxide depolarized electrolyzer. (b) Electron micrograph of SDE cross-section.

SRNL demonstrated the proof-of-concept for the liquid phase electrolyzer using a low-temperature proton exchange membrane (PEM) in FY05. This design concept features high electrochemical efficiency and a small footprint, which are important in the commercial implementation of the technology. Ongoing research work for automotive fuel cells can be leveraged since PEM cells are also being developed for that application.

In FY06, SRNL built and tested an electrolyzer and test facility capable of operation at increased temperature up to 80°C and pressure to 90 pounds per square inch. During FY07, the electrolyzer performance has been improved and the cells have been operated for longer periods. To date, cell voltages of less than 0.5 volts were measured at low current densities, and 0.77 volts were achieved at the desired current density of 500 milliamps per square centimeter or higher. These cell voltages are about 75% lower than those for direct electrolysis. Further performance improvements are expected when the cell temperature and pressure are increased next year.

SRNL has evaluated numerous components for the electrolyzer cell over the past couple of years. "Nafion 115 and hydrocarbon (SDAPP) membranes have shown the most promise in our electrolyzer cell tests," says Dr. Hector Colon–Mercado, one of several SRNL researchers working on the project. "We have also selected platinum/carbon as the anode and cathode electro-catalysts," he adds. Tests on single-cell SDEs have been performed up to 80°C, 6 atmospheres, and 30–50 wt% sulfuric acid. A cross-section of the SRNL cell construction is shown in Figures 2a and 2b. However, these conditions will have to be increased to 80–120°C, 20 atmospheres, and 50–60 wt% sulfuric acid to meet the target design objectives.

Also, long-duration, single-cell tests are planned to help address lifetime issues and material concerns. In 2007, SRNL successfully completed a 100-hour-long demonstration of the SDE, one month ahead of schedule, meeting an important milestone for DOE's Hydrogen Fuel Initiative. This demonstration showed that the electrolyzer can successfully operate continuously without significant loss of performance.

In addition to optimizing the electrolyzer design and materials of construction, one of the biggest challenges is the crossover of sulfur dioxide from the anode compartment to the cathode to form elemental sulfur. This could poison the electro-catalyst or cause physical blockage. SRNL is actively pursuing resolutions to this problem, including the development of better cell membranes, modified cell designs, and operational methods to continuously remove the sulfur. Additionally, Sandia National Laboratories (SNL) and an industrial partner are working with SRNL to seek ways to resolve the sulfur-crossover problem.

SRNL has established a partnership with Giner Electrochemical Systems LLC for the design and construction of a larger, multi-cell stack to leverage existing PEM water electrolyzer technology and to make maximum use of existing components and hardware. A three-cell, 100-liters-per-hour of

hydrogen production stack design was completed in August. This multi-cell stack can be combined with a sulfuric acid decomposition system developed by SNL to complete the HyS cycle and permit closed-cycle test operations. These combined systems will form the basis for the Hybrid Sulfur Integrated Laboratory-Scale Experiment, which is scheduled for 2008.

Aternative Hydrogen Production Processes

In addition to the HyS hybrid process, the U.S. DOE Hydrogen Program is also pursuing several other approaches:

1) High Temperature Electrolysis (HTE)

The most direct method of hydrogen production is electrolysis of water. This can be accomplished at room temperature or at high temperatures. A temperature of 800–1000°C reduces the electrical energy demand and improves the chemical reaction kinetics.

This effort is being led by Idaho National Laboratory (INL) and Ceramatec. Results to date have demonstrated efficient small-scale hydrogen production and appear

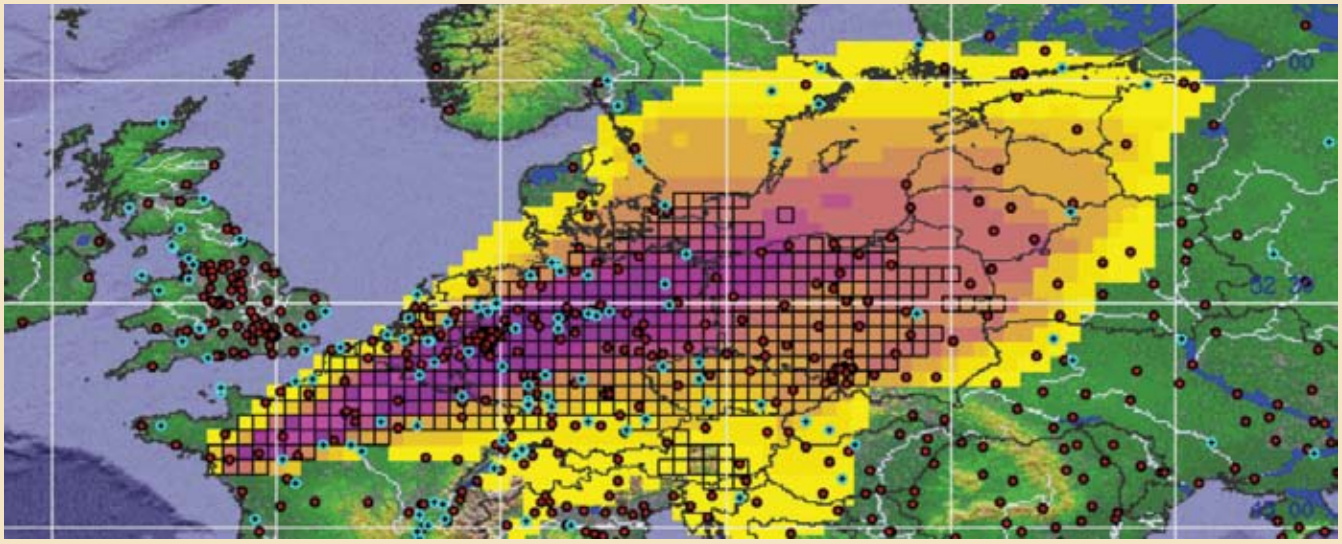
Technologies in the News

International Program Improves Ability to Predict How Plumes Move

Predicting how a potential release from a nuclear facility will disperse and be transported in the atmosphere is critical to emergency response planning. Differences in the forecast wind fields generated by various meteorological agencies, differences in the transport and diffusion models themselves, as well as differences in the way these models treat the release source term, all may result in differences in the projected location and magnitude of the contaminant plume. For the past six years, SRNL has participated in a European Union sponsored ENSEMBLE project to demonstrate the advantages of the ensemble approach to predicting the plume behavior.

In the past, most agencies relied on single forecasts and single models to arrive at their projected radioactive plumes. In the ensemble approach, many different atmospheric transport and diffusion models are used, coupled to prognostic atmospheric fields from several different forecast centers. This approach shows more clearly the uncertainty in forecasting plume transport and growth as a result of differences in the models (see Figure). Ensemble modeling increases the understanding of plume behavior and enables decision-makers to improve their emergency responses.

The ENSEMBLE project has had a positive effect on SRNL modeling and consequence assessment capabilities. Although ensemble modeling has been used for a number of years to improve U.S. meteorological predictions, the atmospheric community is now beginning to see the advantages of ensemble modeling techniques for plume transport as a result of the ENSEMBLE project.



Agreement on threshold level for time-integrated surface concentration for a hypothetical six-hour release of Cs-137 from Nantes, France. The agreement between models is indicated by the shading, where pink and purple colors denote a majority of the 16 models used in this ensemble agree on the plume location and intensity at this time, while light yellow shading represents only one or two models predicting concentrations at these locations. The cross-hatched area represents the SRNL prediction.

to be a viable means for hydrogen production using nuclear energy. The technology is based on solid oxide fuel cells running in reverse, with water and electricity as inputs and hydrogen and oxygen as products. The solid oxide electrolyte in the cells requires operation at 800–1000°C.

2) Thermochemical water-splitting cycles

Several hundred thermochemical cycles have been proposed worldwide on thermochemical water-splitting reactions. The DOE effort has focused on the sulfur–iodine (S–I) cycle and the HyS cycle as the baseline processes. Other alternative cycles, which are not as well developed but are promising, are also being evaluated.

The S–I cycle is an all-thermal cycle with three major reaction steps. A laboratory-scale process in Japan has successfully produced 50 liters per hour of hydrogen using the S–I process. A laboratory-scale process is under construction in California by General Atomics, SNL and the French national laboratory, CEA. The process offers high-efficiency conversion of heat energy to hydrogen energy, but it requires considerably more processing equipment than either the HyS cycle or HTE.

Alternative thermochemical processes are being evaluated that offer higher efficiency, lower temperatures, and/or reduced complexity and corrosivity. Among them are the low-temperature copper–chlorine cycle and the calcium–bromine cycle being developed by Argonne National Laboratory. Other cycles being considered are the magnesium–iodine, the copper–sulphate, and the hybrid chlorine cycles. These are all at early stages of development.

Nuclear Reactors for Hydrogen Production

Since energy must be expended to split hydrogen from its naturally occurring compounds, hydrogen is considered an energy carrier, not an energy source. Nuclear reactors are an excellent means to provide this energy input because they avoid using fossil fuels and emit no greenhouse gases during regular operations. SRNL is an important player in supporting DOE's efforts in this area.

The SRNL research team displaying the three-cell sulfur dioxide depolarized electrolyzer. (Left to right) Dr. David Hobbs, Dr. Hector Colon-Mercado, Tim Steeper, Dr. Bill Summers, Dr. John Steimke, David Herman, Dr. Mark Elvington, Dr. Max Gorensek.

The DOE Generation IV Nuclear Reactor Program and Next Generation Nuclear Plant Project are DOE collaborations, working with governments, industry, and the research community worldwide, to develop the next generation of advanced nuclear reactors. One advanced reactor concept, called the High Temperature Gas-Cooled Reactor (HTGR), is being developed specifically for use as a high-temperature thermal energy provider for water-splitting hydrogen production processes or other downstream users of high-temperature heat. The HTGR, which may employ a pebble-bed or prismatic nuclear core, is especially suited for this purpose because it is capable of supplying hundreds of MW of thermal power at an outlet temperature of up to 950°C, which is an excellent match for the HyS Cycle or other thermally driven hydrogen production cycles. The HTGR designs under consideration also have the advantage of being passively safe, in that no operator intervention or powered systems are needed to prevent damage to the nuclear core in the event of an accident. HTGRs are also capable of generating electricity at high efficiencies using gas-driven, steam-driven, or combined-cycle power generation cycles.

The coupling of a high-temperature nuclear reactor with a thermochemical, hybrid, or HTE hydrogen production process is performed using an intermediate heat transfer loop. An intermediate heat transfer loop consists of high-temperature heat exchangers and at least one long-distance loop using either compressed helium gas or a molten salt as a heat transfer fluid. Though slightly less efficient than a direct coupling, using an intermediate loop allows for clear separation of the nuclear and non-nuclear portions of the combined plant and

helps prevent the potential contamination of the hydrogen plant with nuclear materials.

SRNL is actively engaged in collaborative research and development on the intermediate loop technologies and is playing a program leadership role for the DOE Nuclear Hydrogen Initiative (NHI) in this area. SRNL work in 2008 includes the definition of high-temperature heat exchanger testing requirements and testing facilities, the development of loop and hydrogen plant component maturity assessment tools, and work in the hydrogen plant safety and tritium areas.

Other sources of energy are also being evaluated for hydrogen production. For example, solar energy is being investigated for smaller volume applications. As with a nuclear heat source, a solar heat source would also require a thermal energy transfer coupling, and the work already under way on intermediate heat transfer loops is also applicable to solar systems.

Next steps

The next step in the DOE Nuclear Hydrogen Program is the laboratory-scale demonstrations of the HyS process, along with other processes under consideration. These include the HTE and S–I processes. "Successful laboratory-scale demonstrations will lay the foundation to scale up the demonstrations to one-megawatt pilot-scale tests," says Dr. Summers, "I believe the HyS process will continue to show promise." Finally, it is planned that one of these processes will be demonstrated using the Next Generation Nuclear Plant project as the nuclear heat source at the INL by 2018.

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Technologies in the News

New SRNL-Developed Containers to Serve Variety of Radioactive Packaging Needs

A new generation of radioactive materials container, which was conceptualized, designed, and tested by the Savannah River National Laboratory (SRNL) in cooperation with the Kansas City Plant, is now certified for packaging and transportation of radioactive materials.

The package, which will initially be used to transport two specific types of Radioisotope Thermoelectric Generators and Heat Source materials, is positioned to become a replacement package for the fleet of outdated Department of Transportation 6M type containers across the Department of Energy complex. The 6M certificate will expire at the end of September 2008, meaning that it will no longer be authorized for shipment of radioactive material after that time.

SRNL designed the "9977," as it is called, to be lighter and easier to use than previous designs. It incorporates proven SRNL containment technology, and can be configured to include shielding features necessary to meet regulatory dose limits.

A sister container, the 9978, is also in the process of final review. The 9978 is essentially the same design as the 9977, but with a slightly smaller containment vessel for contents above the subcritical mass limits.

The flexibility provided in the designs of the 9977 and 9978 allows for various additional content configurations to be incorporated that will accommodate users throughout the DOE Complex. These content configurations minimize contamination, simplify handling, and facilitate storage.

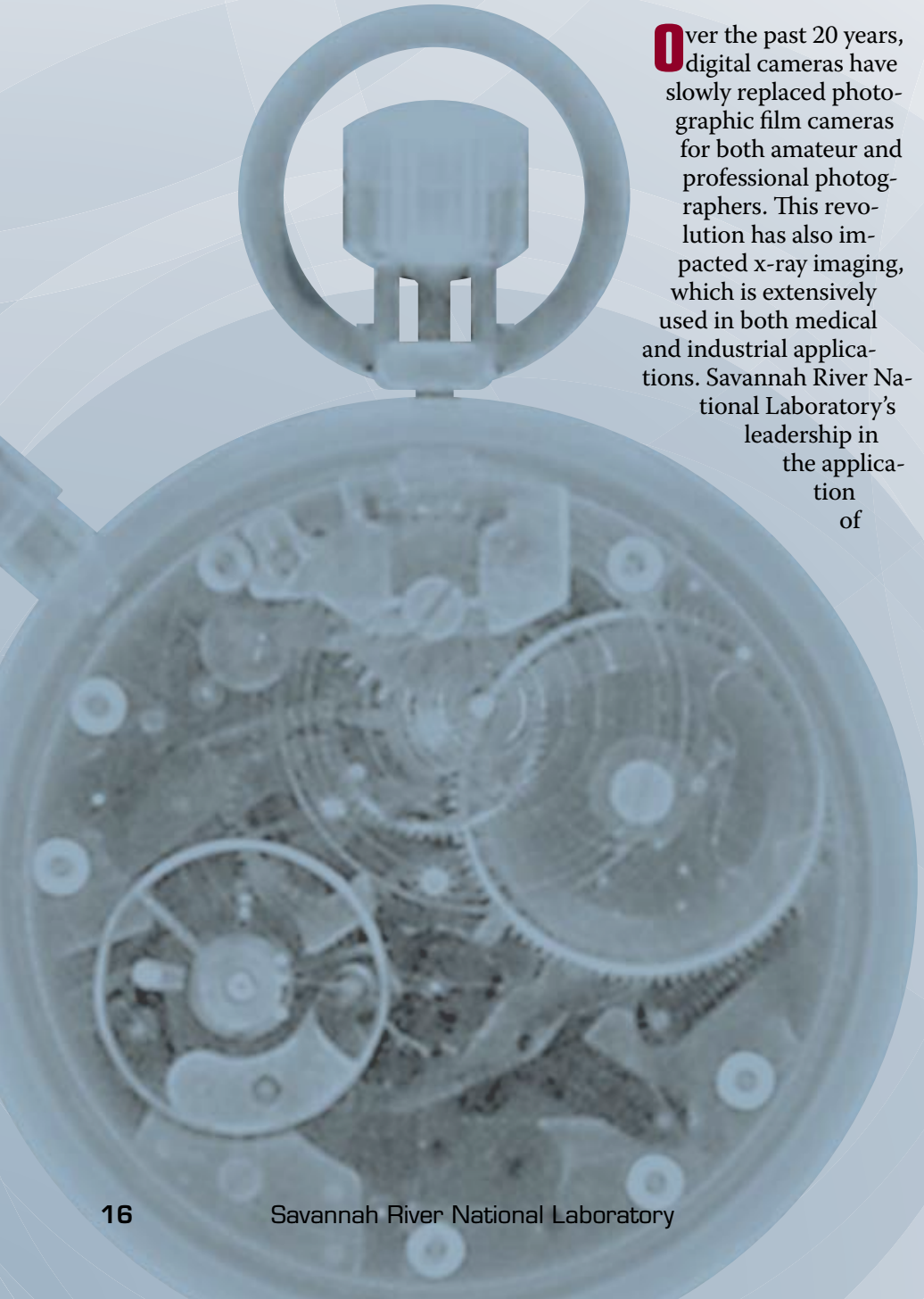
Obtaining certification for a radioactive materials package such as the 9977 involves a comprehensive series of tests and analyses to demonstrate that the package will maintain containment, shielding, and subcriticality under both normal conditions of transport and hypothetical accident conditions.

SRNL developed the packages at the direction of the National Nuclear Security Administration, in cooperation with the DOE Kansas City Plant.

Radioactive materials container "9977" undergoes testing by fire to demonstrate suitability for certification.

X-Ray Vision Using Digital Radiography

***The innovative application of Digital Radiography (DR) has enabled SRNL to** provide the National Nuclear Security Administration (NNSA) with a superior method for the inspection and analysis of pinch welds for weapons reservoirs and for evaluating the integrity of containers for radioactive materials. A number of other applications have been developed, including applications for industrial and medical use. SRNL is also leading NNSA's DR Thrust Area.*



Over the past 20 years, digital cameras have slowly replaced photographic film cameras for both amateur and professional photographers. This revolution has also impacted x-ray imaging, which is extensively used in both medical and industrial applications. Savannah River National Laboratory's leadership in the application of digital radiography (DR) has been beneficial for the National Nuclear Security Administration (NNSA) and the Lab's other customers. "The advantages of digital radiography over x-ray film are multifold," says Boyd Howard, one of several SRNL champions of DR since 1993. "We can achieve improved picture quality, lower cost, easier data storage, and the ability to image planes and 3-D volumes. DR gives us Superman's x-ray vision!"

"SRNL's strength in DR is in the application of the technique to unique measurement problems," adds Rick Poland of SRNL, who leads the NNSA DR Thrust Area. "We were the first in the weapons complex to replace film radiography with DR for the inspection and analysis of pinch welds in nuclear weapon reservoirs. We've also led the way in using DR in many radioactive container applications."

Digital Radiography (DR) Principle

In DR, the object to be examined is bombarded with x-rays or gamma rays and the resultant image converted to a visible image via a scintillator panel (Figure 1). The visible image on the scintillator is then captured by a DR detector such as a charge-coupled device (CCD) used in video and digital photography. A turning

mirror and a clear lead-glass shield are placed between the scintillator and the detector to protect the CCD from any x-rays which would introduce noise to the CCD. The digital image output from the CCD is then transferred to a computer for image processing, enhancement and evaluation.

Scintillators used by SRNL include terbium-doped glasses, gadolinium oxy-sulfide screens, and cesium iodide crystalline structures. In addition to CCD detectors, a number of new detector systems are being marketed. These include direct and indirect conversion (x-rays to electric charge) flat panel detectors using thin-film transistor technology.

Inspection of Pinch Welds

A joining technique called "pinch welding" is used to seal highly pressurized containers known in the Nuclear Weapons Complex as reservoirs. In a pinch weld process, two electrodes exert lateral force on either side of a metal tube while an electric current is passed between them to perform the weld. A pinch in the tube, or weld nugget, is formed to seal the material inside the reservoir (Figure 2). It is critical to the longevity and safety of the reservoir to ensure the integrity of that weld.

For several decades, pinch welds on nuclear weapon reservoirs were inspected using x-ray film radiography. In 1997, SRNL embarked on a program to improve on the existing radiographic film method by using DR. SRNL demonstrated that the new technique had an extended dynamic range and better contrast linearity (Figure 3). This reduces the "burn-off" of edges (narrowing of image) and provides the ability to see through the weld nugget to detect any anomalies that may be present. DR also provides more accurate, repeatable measurements at a reduced cost, with less waste, and improved data storage. After an extensive period of side-by-side evaluation, the use of DR with SRNL-developed measurement algorithms and process control software was qualified and replaced film radiography in 2004. The system automatically analyzes the digital radiographs to determine that as many as seven parameters are within required tolerances. SRNL's DR system was clearly shown to be a superior method for inspection and analysis of pinch welds for NNSA weapon components.

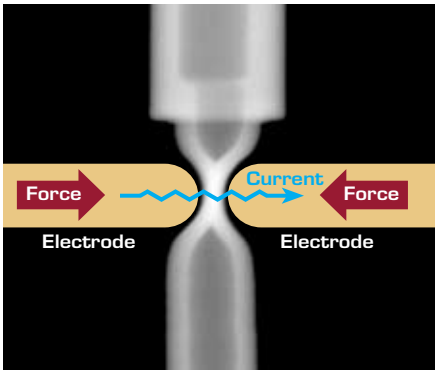


Figure 2. Pinch-welding process.

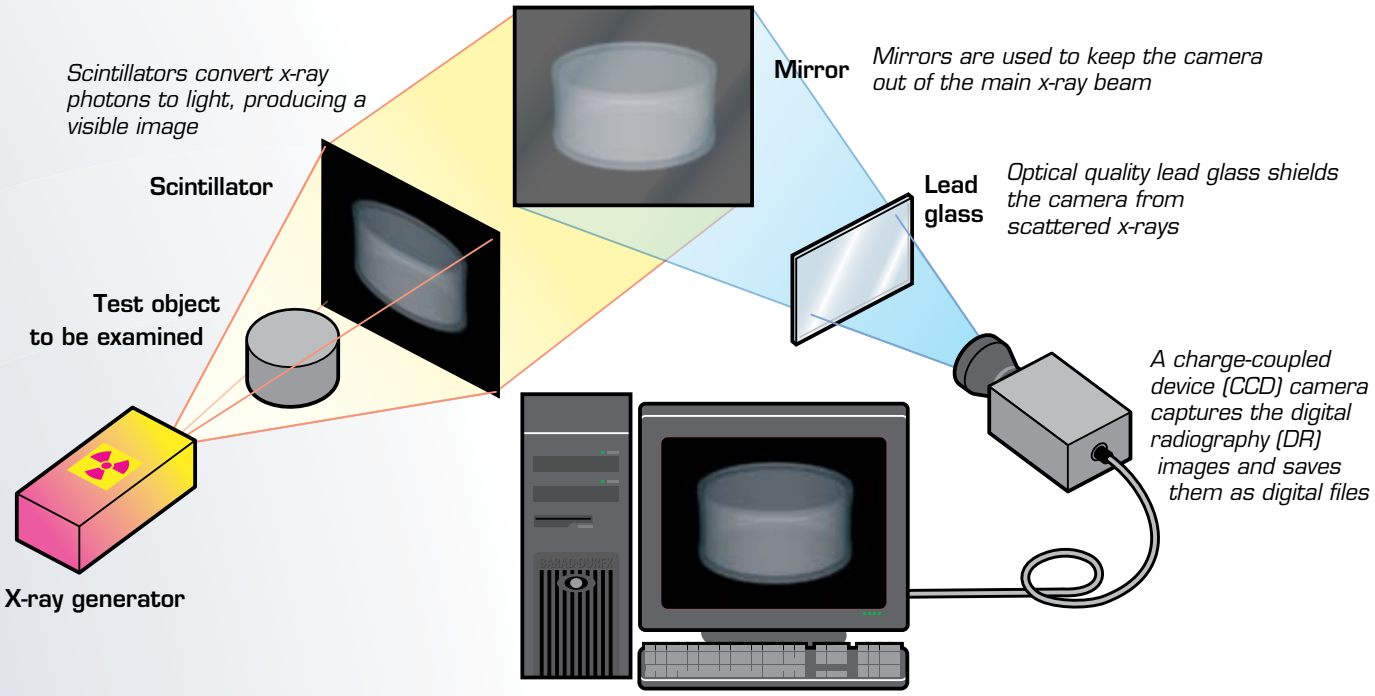


Figure 1. Typical digital radiography equipment setup.

Application to Radioactive Material Containers

DR has played a key role in the safe packaging, shipping and storage of plutonium-bearing materials for the Department of Energy (DOE). The 3013 container is a DOE standard for storing plutonium-bearing material across the Nuclear Weapons Complex. DR has been successfully used as a screening tool to evaluate the integrity of 3013 outer container closure welds. In addition, DR is able to track the pressure buildup during storage of the 3013 inner containers (called Bagless Transfer Cans or BTCs) by measuring the lid deflection. SRNL designed and deployed a DR imaging system for Hanford that can accurately measure lid deflection to <0.2 mils. More than 1,000 BTC lids have been radiographed in Hanford's Plutonium Finishing Plant to establish baseline lid deflections. DR is then used as a surveillance tool during storage of the material to measure internal pressure buildup by measuring the current lid deflection and comparing it to the baseline measurement. Deflections are converted to pressure using a correlation curve (Figure 4).

Another interesting application was the development, in less than three months, of a unique imaging system for uranium-233 containers stored at Oak Ridge National Laboratory. The challenge in this case was the extremely high radiation field (300R/hr at contact) coming from the material in the container. The image-fogging caused by the high radiation field was digitally subtracted using custom-developed software to produce a usable, enhanced image. An iridium-192 gamma source was used in place of an x-ray source to provide a monochromatic source spectrum to improve background subtraction and to facilitate maintenance.

The SRNL DR team has developed applications of DR to numerous other problems, assisting their customers in NNSA, Environmental Management (EM), other DOE offices, other federal agencies, and medical and commercial fields. The team found that DR has clear advantages over conventional radiography where: 1) the object being examined is a source of radiation, 2) specimens have considerable thickness variations, 3) computed tomograms (sections through the object) are necessary, and 4) quantitative information must be tracked.

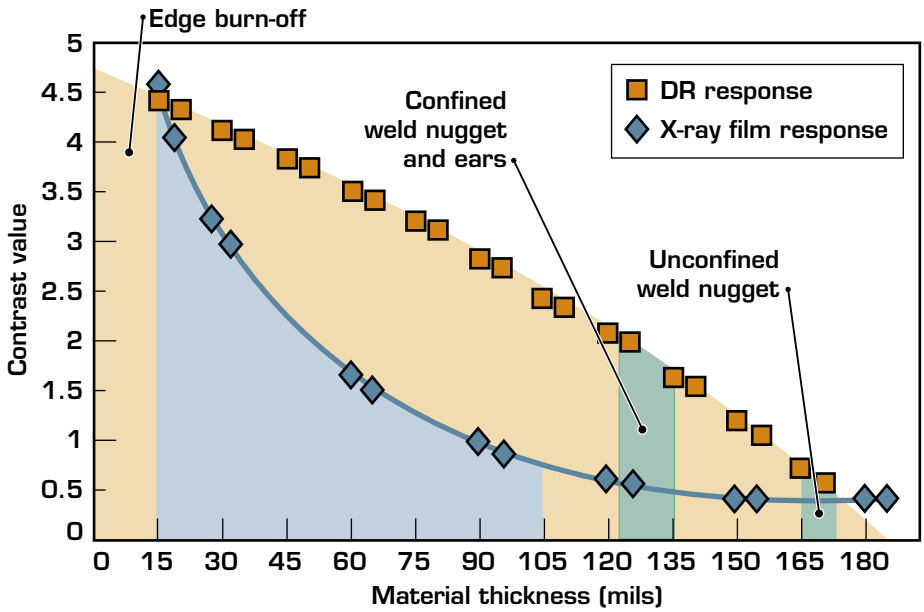
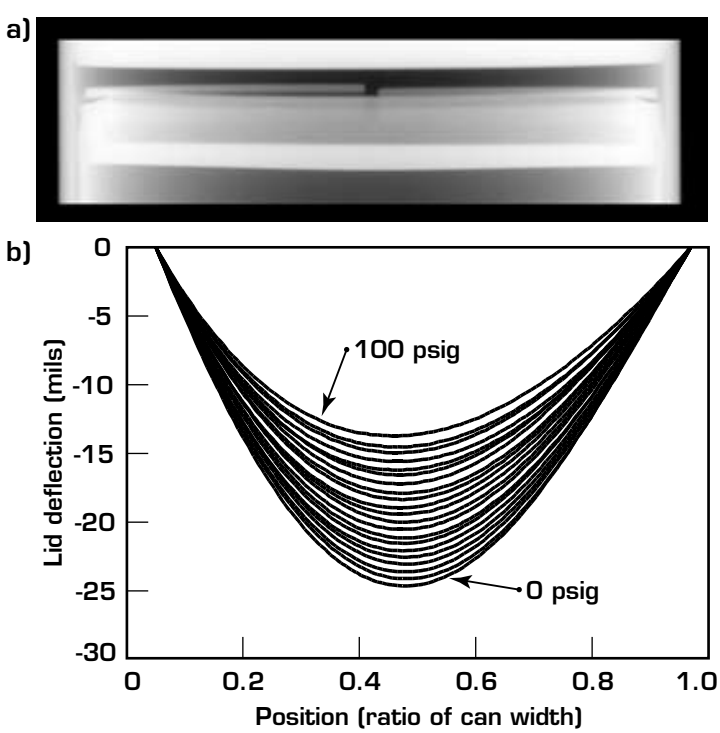


Figure 3 (top). Comparison of x-ray film to DR image response.

Figure 4. (a) DR of 3013 BTC lid. (b) Lid deflection vs. pressure-correlation curves.



Tomosynthesis

One of the advantages of DR is the ability to obtain volumetric information of an object and then reconstruct any x-ray image plane. To obtain that information, multiple images must be recorded at different angles between the source and the detector (Figure 5). Computer software is then able to take that digital information and convert it to 3-D views or specific horizontal or vertical slices through the object (tomosynthesis). SRNL has applied tomosynthesis to human body phantoms, printed circuit boards, ammunition, weld seams, and biomedical samples (Figure 6).

Future Work

The importance of DR work is reflected in the formation of a DR Thrust Area by NNSA comprising representatives from each site in the Nuclear Weapons Complex. "This is a collaborative effort among the various sites to share information and to advance DR technology to benefit NNSA," says Poland.

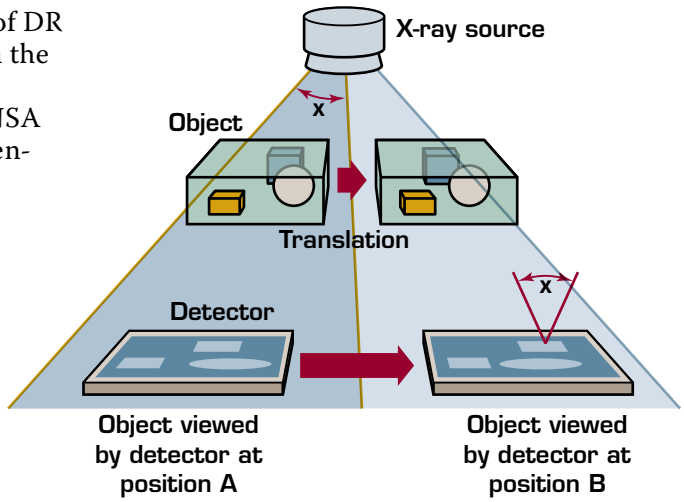


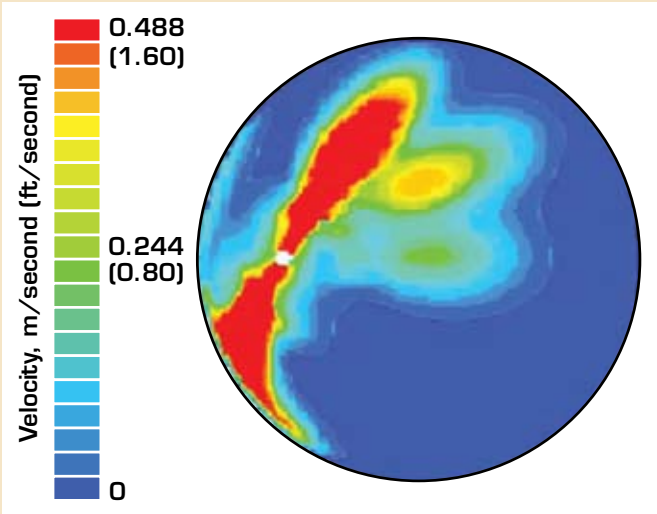
Figure 5. Object translation for tomosynthesis. Translation is equivalent to a rotation by angle "x."

Technologies in the News

Computational Methods Save Customers Time and Money

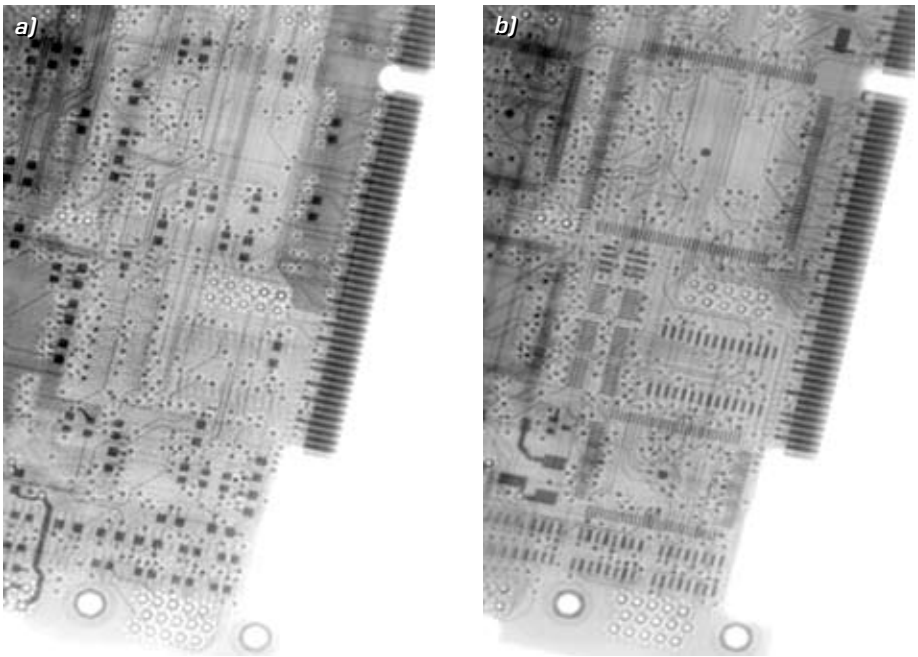
In recent years, SRNL has led their Savannah River Site (SRS) customers to increased use of computational fluid dynamics (CFD) methods to save both time and money in addressing design, operations, and safety issues related to waste tank performance. SRNL has developed CFD models and solutions to address waste tank and other SRS issues that are either too big or too expensive to address with physical experiments. CFD has helped customers in numerous applications including erosion models for Defense Waste Processing Facility process tanks; jet mixing models for sludge recovery in waste tanks; vapor space mixing models to evaluate ventilation systems in the waste tanks and Saltstone (a tailored grout waste form); water and air jet behavior for waste tank operations; and solids suspension in liquid flows for supernate decant operations as well as sludge recovery. "The analyses performed by SRNL resulted in millions of dollars of savings to SRS by directing design or demonstrating the adequacy of existing designs and avoiding unnecessary modifications to existing systems," said Dr. Si Young Lee and Dr. Richard Dimenna of SRNL, developers of the CFD models and solutions.

All of this modeling has been confirmed with actual field data – either taken from the literature or measured by SRNL. In a recent example, flow evolution models were developed to evaluate the performance of the new advanced design mixer pump for sludge mixing and removal operations with high-velocity liquid jets in one of the large-scale SRS waste tanks, Tank 18. A three-dimensional CFD model was developed to simulate sludge removal operations. The computational scheme and the two-equation turbulence closure models were validated with onsite test data and literature data. The model was then extended to actual conditions in Tank 18 through a velocity criterion to predict the ability of the new pump design to suspend settled sludge. A qualitative comparison with actual sludge removal operations in Tank 18 showed a reasonably good comparison with final results, subject to significant uncertainties in actual sludge properties. Final results from this work were published and extended the literature for far-field performance of water jets.



Test facility flow pattern one minute after pump startup with counterclockwise rotation.

DR researchers (left to right); Rick Poland, David Immel and Timothy Smail.



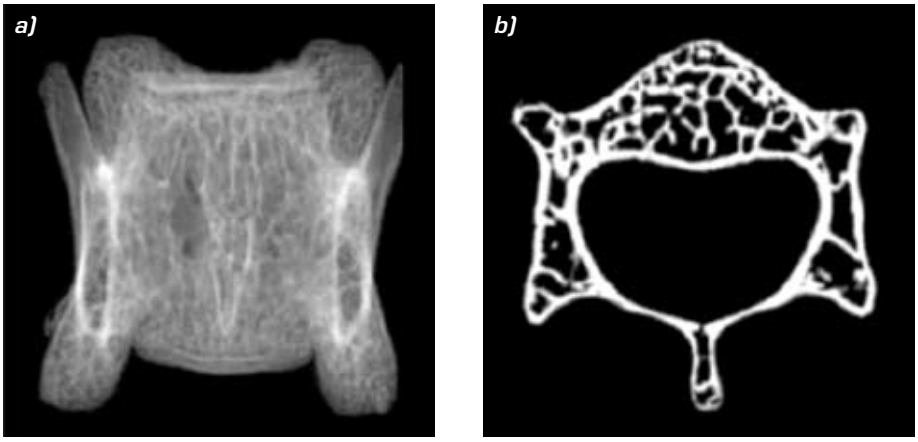


Figure 6 (top). Tomosynthesis views through a printed circuit board. (a) Bottom layer. (b) Top layer.

Figure 7. (a) Digital radiograph of a mouse vertebra. (b) Computed tomography reconstruction of a horizontal slice through the vertebra.

"We are working on several critical areas of need such as high-energy, high-resolution scintillators and flat panel imagers, and improved image algorithms and software," he adds. SRNL is also leading an NNSA effort to implement an international standard (DICONDE) for nondestructive evaluation data exchange and archiving to ensure long term integrity and retrievability.

In addition, SRNL researchers are working with medical and commercial partners to develop new DR applications and to advance the technology. "We are working with the Medical College of Georgia to develop unique imaging methods for aging bone studies and soft tissues, and to produce image data that are DICOM (Digital Imaging and Communication in Medicine) compatible for data archival and transmission," explains David Immel. "We are also working with a commercial partner on a portal image acquisition prototype system."

The future for SRNL's DR team is exciting with a number of new opportunities to expand the impact of DR technology. These include partnerships with the medical and academic community to perform unique analyses to determine the impact of disease and aging on bones and soft tissue such as muscles and the brain. The team is also designing new imaging detectors and scintillators for high energy x-ray imaging for NNSA.

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Technologies in the News

SRNL, Russia Collaborate to Advance Melter Technology

In one particularly promising example of the use of international collaborations to address the Department of Energy's cleanup needs, SRNL is working with Russia's SIA Radon Institute to evaluate and adapt Russian cold crucible induction heated melter (CCIM) technology for the disposition of high-level radioactive waste currently stored at the Savannah River Site (SRS). The work is part of the DOE Office of Environmental Management's International Program, under the auspices of the DOE EM Office of Engineering and Technology.

The SRS Defense Waste Processing Facility (DWPF) processes SRS high-level waste by blending it with specially formulated glass frit to produce a stable glass form for disposal. The U.S.-Russian research effort is evaluating whether incorporating the CCIM technology into the DWPF can increase the percentage of waste that the glass/waste formula can hold. This would reduce the number of high-level waste canisters produced and thereby reduce, by billions of dollars, the cost of production, storage and disposal of the waste canisters. Also, if the CCIM can accelerate the rate at which the glass is produced, then additional savings in operational costs are possible.

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

During the summer of 2007, tests were conducted to evaluate CCIM processing of the next batch of DWPF waste, containing high levels of aluminum, which limits the waste loading and impacts the durability of the resulting glass. The higher process temperatures afforded by the CCIM may alleviate some of the difficulties associated with high aluminum feeds. Researchers have been characterizing the resulting glass, analyzing off-gas samples and analyzing process data.

This is one of three collaborative projects on radioactive waste issues that EM is currently conducting with institutions in the Russian Federation and the Ukraine; two others were completed last year.

Pouring of a molten glass/waste formulation from the large-scale CCIM at the SIA Radon facility in Russia.

Awards

Looney

Dr. Brian Looney

received an invitation from the National Research Council and the National Academies to serve as a member of the Committee on Cleaning Up of Radioactive Contamination: Russian Challenges and US Experience. The National Academies are made up of the National Research Council, National Academy of Sciences, National Academy of Engineering, and Institute of Medicine. They are private, nonprofit institutions that provide science, technology and health policy advice under a Congressional charter. The National Research Council is the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public and the scientific and engineering communities.

Dr. Looney is a member of SRNL's Environmental Science and Biotechnology Directorate, where he coordinates development and deployment of innovative environmental characterization and cleanup methods; he also serves as an adjunct professor in the Environmental Engineering Science Department at Clemson University.

He was invited to serve on this prestigious committee alongside Dr. Frank L. Parker, Distinguished Professor of Environmental and Water Resources Engineering at Vanderbilt University, and Dr. F. Ward Whicker, Professor and Head of the Department of Radiological Health Sciences at Colorado State University.

Beals

Donna M. Beals

won the 2007 ASTM International Harlan J. Anderson Award for her outstanding contributions to Committee C26 on the Nuclear Fuel Cycle.

ASTM International is a standards organization that develops and publishes technical standards for a wide range of materials, products, systems, and services.

Rhodes

Dr. William D. Rhodes

received the 2007 Robert E. Wilson Award from the Nuclear Engineering division of the American Institute of Chemical Engineers (AIChE). This is the oldest award presented by the AIChE. Dr. Rhodes is being recognized for "outstanding chemical engineering contributions to the nuclear industry spanning the Naval Nuclear Propulsion Program, Liquid-Metal Fast Breeder Reactor technology development, and leadership roles at the divisional and national levels within AIChE that promote the role of Chemical Engineers in addressing our Nation's Energy Security."

The award is given in memory of Dr. Robert E. Wilson, a noted chemical engineer, long time member of AIChE, board chairman of Standard Oil of Indiana, and member of the former U.S. Atomic Energy Commission (AEC). Previous award recipients include Crawford Greenewalt, President of E.I. DuPont de Nemours Corporation, for leading DuPont's efforts to build and startup the Hanford Project.

Trimm

Marvin Trimm

was elected Chairman of the Board, American Society for Nondestructive Testing (ASNT) following his one year term as President of the ASNT. The formal induction ceremony took place at the 2007 ASNT Fall Conference held during November 2007. The ASNT has a membership of over 9,000 NDT professionals with over 80 affiliated local sections worldwide.

Dr. Mac Louthan

Louthan

received the 2007 Alan Ray Putnam Service Award from ASM International, the professional society of materials scientists and engineers, for his "…continuing service to ASM International through education, training, and information transfer and by constantly demonstrating that understanding materials is so exciting that others are motivated to work in the materials area." Established in 1988, the Allan Ray Putnam Service Award recognizes the exemplary efforts of members of ASM International on behalf of the society to further its objectives and goals. He also received the 2007 Henry Clifton Sorby Award from The International Metallographic Society in recognition of lifetime achievement in the field of metallurgy. Recipients are acknowledged for 25 years or more of dedication to research, teaching, and/or laboratory sales and service.

Karthik Subramanian, Dr. Steve Wyrick, and Karen Graves

were awarded the Defense Programs Award of Excellence for "Significant Contribution to the Stockpile Stewardship Program" as members of the Readiness Campaign team providing critical technology for the National Nuclear Security Administration. Bob Manz and Mark Tyrrell, from the Savannah River Site Tritium Facilities, were also members of the award-winning team.

Dr. David T. Hobbs

Hobbs

received the Don Orth Award of Merit for 2007 from WSRC. He is widely recognized for his significant contributions in the chemistry of high level nuclear waste including criticality, corrosion, energetic compounds, waste retrieval and waste pretreatment. He is also recognized for his work in electrochemistry and chemical sorbents for medical applications.

Federal Laboratory Consortium Southeast Region 2007 Awards for Excellence in Technology Transfer

SRNL received two Federal Laboratory Consortium (FLC) Southeast Region 2007 Awards for Excellence in Technology Transfer. The FLC, with its mission of promoting and facilitating the rapid movement of federal laboratory research results and technologies into the mainstream of the U.S. economy, presents the Awards of Excellence to recognize laboratory employees who have accomplished outstanding work in transferring a technology developed by a federal laboratory.

The first award went to the commercialization team of **Eric Frickey, Dr. David Peeler and Johnetta George** for transferring the Protective Device Having One or More Optical Sheet Layers (ProTec Tear-Offs™), which protect the viewing windows of gloveboxes, shielded cells, etc. The second award went to the commercialization team of **Dale Haas, Dr. Ken Hofstetter, Kevin Huffman, Charles Fulghum, Donald Varble and Larry Harpring** for transferring the RadRope™ portable nuclear material detection system.

Award nominations are judged by representatives from other federal laboratories in the Southeast.

Patents

Radiation-Resistant Microorganism to Help Environmental Remediation

Patent Issued: US 7,160,715 B2
Dr. Carl Fliermans

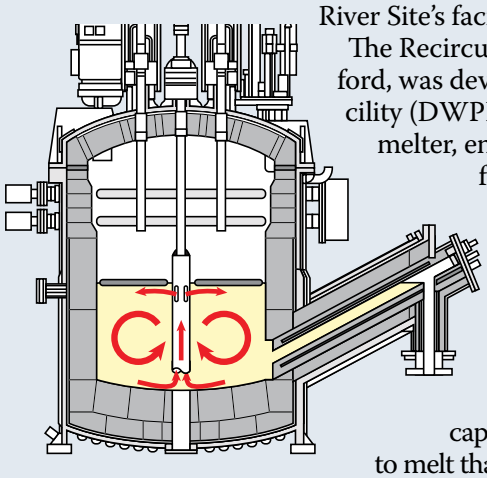
The patent, titled "Radiation-Resistant Microorganism," is for an isolated and purified bacterium from a high-level radioactive waste tank. The isolate has the ability to degrade a wide variety of organic contaminants while demonstrating high tolerance for ionizing radiation. The organism is suited to bioremediation of a variety of organic contaminants while in the presence of ionizing radiation.

SRNL Device Enhances Glass Melter Operations

Patent Issued: US 7,225,643
Dr. Hector Guerrero and Dennis Bickford

The patent, titled "Recirculation Bubbler for Glass Melter Apparatus," provides mixing of the molten glass and the feed materials to increase the production rates through a glass melter.

The invention has already proven itself highly valuable for enhancing operation of the Savannah River Site's facility for immobilizing high-level radioactive waste.



The Recirculation Bubbler for Glass Melter Apparatus, invented by Guerrero and Bickford, was developed in consultation with personnel at SRS's Defense Waste Processing Facility (DWPF). At the DWPF, radioactive waste is mixed with a special glass formula in a melter, encapsulating the waste in glass at the molecular level, resulting in a stable glass form that isolates the radioactive contaminants from the environment. The Recirculation Bubbler, which enables more efficient melting of the waste and mixing with the glass, was installed in the DWPF in 2004 and has allowed the facility to increase by as much as 10 percent the rate at which it converts radioactive waste to a stable glass form for permanent disposal. SRNL personnel conducted an extensive computer modeling and experimental program in developing the bubbler.

When waste is added to the molten glass in the melter, it tends to form a "cold cap" resting on top of the pool of glass. Key to efficient melter operation is the ability to melt that cap and mix it with the molten glass. That requires circulating the hot pool of glass, but glass does not circulate very well naturally because it is highly viscous—about the consistency of molasses. The Recirculation Bubbler is essentially a lift pump, in which gas bubbles are injected inside a pipe open at both ends. This draws glass from the bottom of the melter and deposits it close to the cold cap for enhanced heat transfer.

Air bubblers in which air is bubbled at the end of a tube are currently used in commercial glass melters, but these generally mix only a local region of the pool, while the Recirculation Bubbler mobilizes the entire melt pool.

The U.S. Department of Energy was issued a patent on the device in 2007. Several sites across the DOE complex are either already using a vitrification (glass-making) process to stabilize various types of waste, or have plans to do so in the future. In addition, commercial firms use vitrification for a variety of purposes. The Recirculation Bubbler could potentially be useful in a number of these operations.

About Savannah River National Laboratory

The Savannah River National Laboratory is the U.S. Department of Energy's applied research and development laboratory at DOE's Savannah River Site. The Laboratory, established in the early 1950s to meet the Savannah River Site's technology needs, now serves DOE and the nation in three primary areas: National and Homeland Security, Energy Security, and Environmental Management. Today about half of the Laboratory's work is on behalf of the Savannah River Site, with the other half for a variety of customers in other offices of DOE, other federal agencies, and a limited number of commercial customers. One key area of responsibility is serving as the DOE Office of Environmental Management's Corporate Laboratory.

EM Office of Environmental Management

safety ❖ performance ❖ cleanup ❖ closure

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