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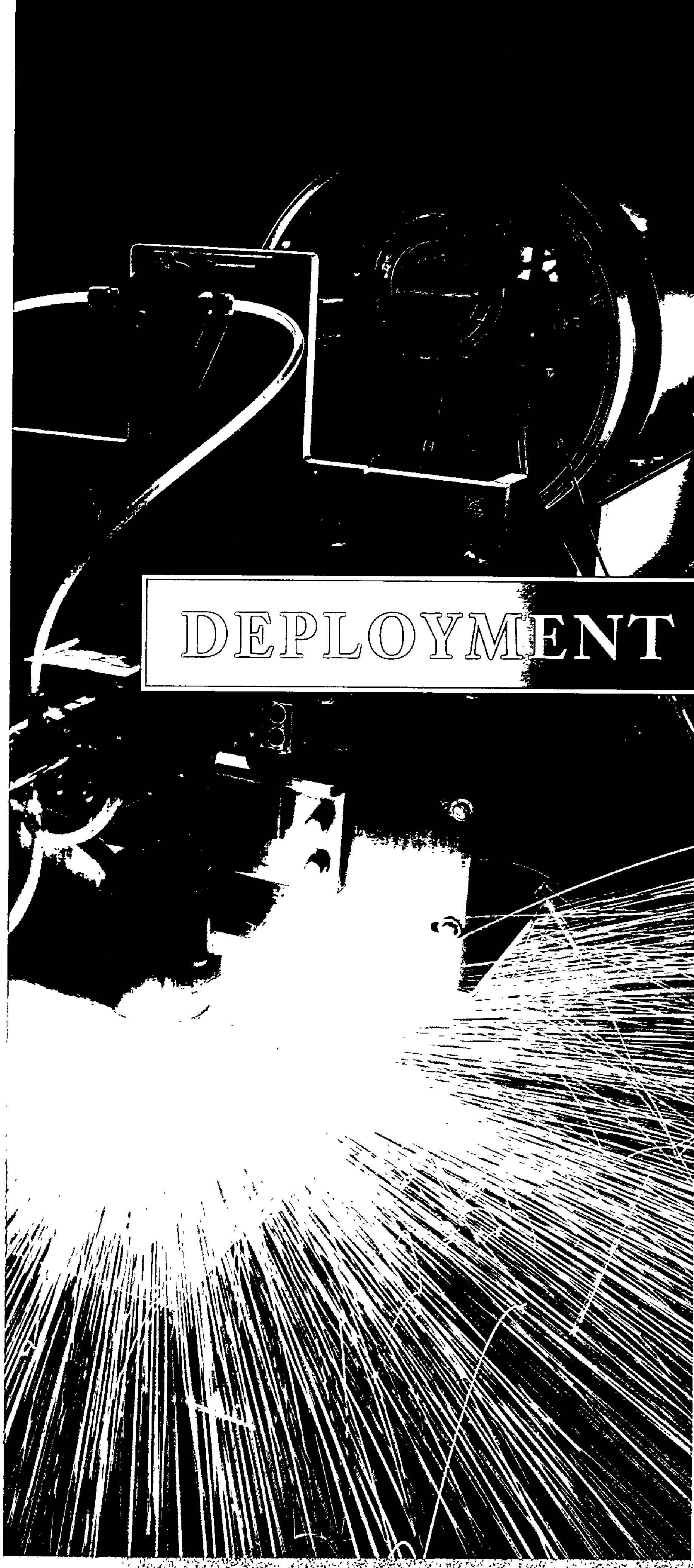


# Office of International Programs

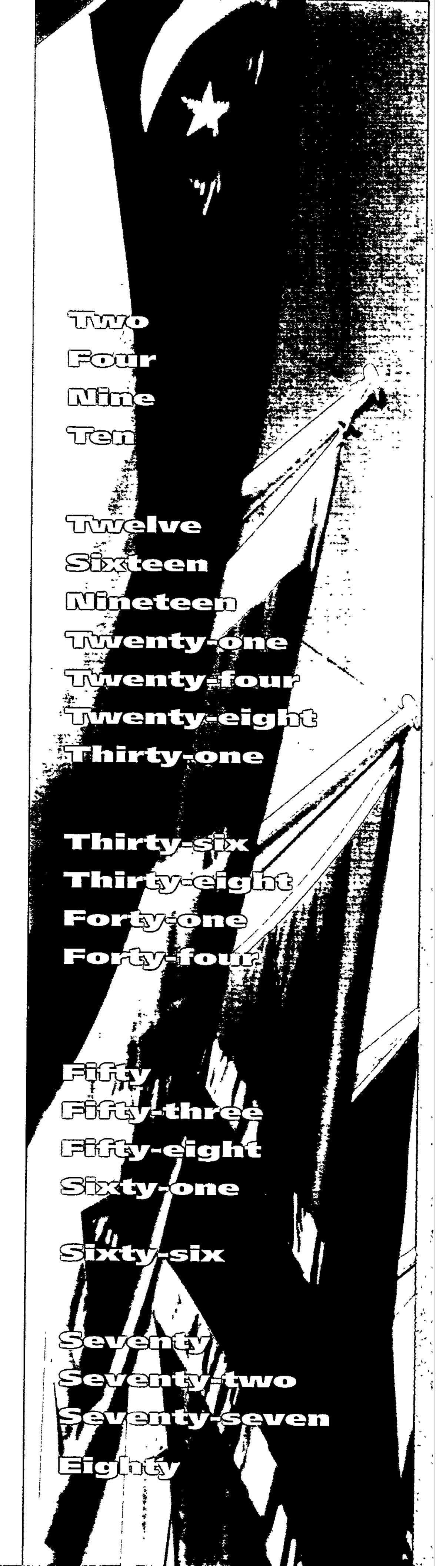
## DEPLOYMENT SUMMARY

FISCAL YEARS
1995-2000

The information in this book represents information available and current through July 2000.

# Table of Contents





# List of Acronyms

| | |
|---|---|
| **3-D** | Three Dimensional |
| **AECL** | Atomic Energy of Canada Limited |
| **ALARA** | As Low As Reasonably Achievable |
| **ANL** | Argonne National Laboratory |
| **ASTD** | Accelerated Site Technology Deployment Program |
| **BNFL** | British Nuclear Fuels Laboratory |
| **BVEST** | Bethel Valley Evaporator Service Tank |
| **CERCLA** | Comprehensive Environmental Response, Compensation, and Liability Act |
| **CMST** | Characterization, Monitoring, and Sensor Technology |
| **D&D** | Deactivation and Decommissioning |
| **DDFA** | Deactivation and Decommissioning Focus Area |
| **DISPIM™** | Decommissioning In-Situ Plutonium Inventory Monitor |
| **DNAPL** | Dense Non-Aqueous Phase Liquids |
| **DOD** | Department of Defense |
| **DOE** | Department of Energy |
| **EDTA** | Ethylenediaminetetracetic Acid |
| **EM** | Office of Environmental Management |
| **EPA** | Environmental Protection Agency |
| **ESC** | Expedited Site Characterization |
| **FEMP** | Fernald Environmental Management Project |
| **FY** | Fiscal Year |
| **GAAT** | Gunite and Associated Tanks |
| **HLW** | High-Level Waste |
| **IDW** | Investigation Derived Wastes |
| **IETU** | Institute for Ecology of Industrial Areas of the Republic of Poland |
| **INEEL** | Idaho National Engineering and Environmental Laboratory |
| **IP** | Office of International Programs |
| **JCC** | Joint Coordinating Committee |
| **JCCEM** | Joint Coordinating Committee for Restoration and Waste Management |
| **JCCES** | Joint Coordinating Committee for Environmental Systems |
| **JCCRM** | Joint Coordinating Committee for Radioactive and Mixed Waste |
| **JCCST** | Joint Coordinating Committee for Science and Technology |

## DISCLAIMER

# DISCLAIMER

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

# List of Acronyms

| | |
|---|---|
| **LANL** | Los Alamos National Laboratory |
| **LCD** | Liquid Crystal Display |
| **LDUA** | Light Duty Utility Arm |
| **LIF** | Laser Induced Fluorescence |
| **LIFI** | Laser Induced Fluorescence Imaging |
| **LIFS** | Laser Induced Fluorescence Spectroscopy |
| **LRAD** | Long Range Alpha Detector |
| **LSDDP** | Large Scale Demonstration and Deployment Project |
| **MLDUA** | Modified Light Duty Utility Arm |
| **MVST-TRU** | Melton Valley Storage Tanks-Transuranic |
| **ORNL** | Oak Ridge National Laboratory |
| **OSDF** | On-site Disposal Facility |
| **OST** | Office of Science and Technology |
| **PCE** | Tetrachloroethylene |
| **PPE** | Personal Protective Equipment |
| **R&D** | Research and Development |
| **RCA** | Radiological Controlled Area |
| **RCRA** | Resource Conservation and Recovery Act |
| **REM** | Roentgen Equivalent Man |
| **RTDF** | Remediation Technologies Development Forum |
| **RTIEE** | Robotic Tank Inspection End Effector |
| **RUCS** | Remote Underwater Characterization System |
| **SCM/SIMS** | Surface Contamination Monitor & Survey Information Management System |
| **SRS** | Savannah River Site |
| **STREAM** | System for Tracking, Remediation, Exposure, Activities and Materials |
| **TCE** | Trichloroethylene |
| **TMS** | Technology Management System |
| **TRU** | Transuranic |
| **UK** | United Kingdom |
| **US** | United States |
| **VOC** | Volatile Organic Compound |
| **WSRC** | Westinghouse Savannah River Company |

# Introduction

As a result of the nuclear arms race during the 50-year Cold War, the United States (U.S.) created one of the world's largest inventories of radioactive and hazardous waste. Although the U.S. instituted waste management systems to convert and store waste, significant discharges into the environment occurred. Among the many dangers posed by past waste management practices are widespread contamination of soil and groundwater, leaking or deteriorating containment vessels seeping radioactive and/or chemical wastes into the soil and groundwater, and the escape and transport of airborne contaminants. These and related issues demanded attention and illustrated the need to redirect resources from weapons production to environmental restoration and waste management.

## Office of Environmental Management

In 1989, the U.S. Department of Energy (DOE) responded to these concerns by establishing the Office of Environmental Management (EM) and delegated this office with the responsibility of cleaning up the U.S. nuclear weapons complex. EM's mission has three primary objectives: 1) to assess, remediate, and monitor contaminated sites and facilities; 2) to store, treat, and dispose of waste from past and current operations; and 3) to develop and implement innovative technologies for environmental cleanup.

EM faces a challenging job. A 1997 DOE report entitled *Linking Legacies* stated that DOE manages 36 million cubic meters of waste comprised of seven fundamental waste categories: high-level, low-level, transuranic (TRU), and mixed low-level radioactive waste as well as hazardous, byproduct material, and "other" waste. In addition, EM has oversight of more than 5,100 contaminated buildings and facilities awaiting decontamination, decommissioning, and dismantling. This challenge requires the identification of technologies and scientific expertise from a variety of sources including industry, academia, national laboratories, and the international community.

## EM Office of Science and Technology

The Office of Environmental Management established the Office of Science and Technology (OST) to conduct an aggressive program for the deployment of innovative solutions to address DOE's environmental remediation needs. OST investments provide the scientific foundation for new approaches and technologies that bring about significant reduction in risk, cost, and schedule for EM mission completion.

The mission of OST is to provide the full range of science and technology resources needed to deliver and support fully developed deployable technological solutions to the environmental remediation problems faced by EM. These resources include providing basic and applied research, technology demonstrations, and technical assistance for deploying technologies.

# Introduction

OST programs establish, direct, and manage targeted intermediate-term research bridging the gap between broad fundamental research that has wide-ranging applications and needs-driven applied technology development. Through the integration of basic research and applied research and development (R&D), as conducted by the Focus Areas, Crosscutting Programs, University Programs, and the Technology Integration Program, OST expects to produce and deliver technology solutions for the major needs of its EM customers. The Focus Areas, Crosscutting Programs, University Programs, and the Technology Integration Program strive to engage private sector technology providers and commercial users in developing and improving technologies to address site needs. These programs also work with interested parties, stakeholders, and public interest groups in assessing the acceptability, availability, and use of improved technical solutions. They provide uniform guidance, facilitate technology transfer, and ensure that the needs of stakeholders are integrated into the decision-making process.

In 1994, OST identified five major problem areas to focus its technology development activities, and established Focus Areas to address these problems.

*By 1998, the Focus Areas were redefined and currently include:*

- **Deactivation and Decommissioning.** The Deactivation and Decommissioning Focus Area (DDFA) provides new or improved technologies to deactivate and decommission contaminated buildings. This includes decontaminating the metal and concrete within those buildings and disposing of over 180,000 metric tons of scrap metal. The DDFA through its Large Scale Demonstration and Deployment Project (LSDDP), incorporates improved technologies identified as responsive to high-priority needs. Such demonstrations also include existing commercial technologies to provide a basis for comparison of costs and effectiveness.

- **High-Level Tank Waste Remediation.** The Tanks Focus Area provides new or improved technologies to safely and efficiently remediate over 300 underground storage tanks that have been used to process and store more than 100 million gallons of high-level radioactive and hazardous chemical mixed waste. Technologies are needed to characterize, retrieve, and treat the waste before radioactive components are immobilized. Emphasis is placed on in situ or remotely handled processes and waste volume minimization. R&D of technologies in this area is aimed at enabling tank farm closure using safe and cost-efficient solutions that are acceptable to the public and fulfill the requirements of site regulatory agreements under the Federal Facility Compliance Act.

# Introduction

□ **Mixed Waste Characterization, Treatment and Disposal.** The Mixed Waste Characterization, Treatment, and Disposal Focus Area provides new or improved treatment systems for mixed radioactive and hazardous chemical waste, and processes for the disposal of low-level and TRU waste in a manner that meets regulatory requirements. There are over 167,000 cubic meters of mixed, low-level, and TRU wastes from over 1,400 mixed radioactive and hazardous chemical waste streams at 38 DOE sites. Emphasis is placed on developing a cost-effective monitoring system, waste volume reduction, and safe permanent disposal.

□ **Nuclear Materials.** The Nuclear Materials Focus Area (formerly the Plutonium Focus Area) provides new or improved technologies for safe and effective long-term storage of nuclear materials including impure plutonium oxides, interim storage of stabilized plutonium residues pending disposition to the Waste Isolation Pilot Plant, and safety surveillance for long-term plutonium and other long-lived nuclear material storage.

□ **Subsurface Contaminants.** The Subsurface Contaminants Focus Area provides new or improved technologies to address environmental problems associated with hazardous and radioactive contaminants in soil and groundwater. Over 600 billion gallons of groundwater and 50 million cubic meters of soil are contaminated at more than 5,700 locations on DOE sites. The contaminants include radionuclides, heavy metals, and hazardous organic compounds. The migration of certain contaminants threatens water resources and, in some cases, has already had an adverse effect on off-site locations. Emphasis is placed on the development of in situ technologies to minimize remediation costs and potential worker exposures, to improve capabilities for landfill containment, and to implement effective and reliable subsurface barriers to contaminant migration.

*Five major Crosscutting Programs address technology development needs that are common to the Focus Areas. The five Crosscutting Programs are:*

□ **Characterization, Monitoring, and Sensor Technology (CMST).** This program develops or improves sensors, monitors, and site and waste characterization technologies to improve worker safety, lower costs, and enable operations where no technology currently exists for use during cleanup activities and site remediation, waste treatment and disposal, and facility deactivation and decontamination.

□ **Efficient Separations and Processing.** This program was established to concentrate contaminants, and/or purify waste streams, or to down grade the waste to a form that requires less difficult and less expensive disposal.

□ **Industry Programs.** This program involves private-sector entities such as colleges, universities, not-for-profit institutions, and industry in developing, demonstrating, and implementing improved technologies that address the needs of the EM Focus Areas, through government contracting mechanisms and competitive procurement.

□ **Integrated Process Analysis.** This program provides reliable, defensible information on remediation, deactivation and decommissioning, and waste treatment systems of technologies and their integration in order to steer the course of current technology implementation and R&D thrusts in future years.

□ **Robotics Technology Development.** This program develops robotic systems to minimize worker exposure while providing proven, cost-effective, and in some cases, the only acceptable approach to problems.

## OST Office of International Programs

Within OST, the Office of International Programs (IP) is responsible for the identification, evaluation, acquisition, and demonstration of international technologies that can accelerate DOE cleanup operations in conjunction with Focus Area activities. The goal of IP is to pursue collaborations among government organizations, educational institutions, and private industry to identify technologies that can address the environmental remediation needs of DOE. Through international agreements, OST engages in the cooperative exchange of information, technology, and data on technology development and demonstrations, as well as involvement with scientist exchanges.

IP seeks out and leverages foreign technology, data, and resources in keeping with EM's mandate to protect public health and the environment through the safe and cost effective remediation of the DOE's nuclear weapons sites. These international resources are used to manage the more urgent risks at DOE sites, secure a safe workplace, help build consensus on critical issues, and strengthen DOE's science and technology program.

## EM Joint Coordinating Committees

When DOE/EM engages in an international cooperative agreement, a Joint Coordinating Committee (JCC) is established to manage the activities conducted under the agreement. Each country appoints an equal number of representatives to serve on the JCC, which meets annually to evaluate the status of cooperation under the agreement. EM's participation in each JCC ensures that the areas of technical cooperation address the most critical needs of the EM Focus Areas.

Finally, IP supports four JCCs. The JCC for Environmental Restoration and Waste Management (JCCEM) was established in 1990 between DOE and the Ministry of Atomic Energy for the Russian Federation. Areas of cooperation under the JCCEM include: effi-

# Introduction

cient separations, contaminant transport and site characterization, mixed waste, high-level waste (HLW) tanks, TRU stabilization, deactivation and decommissioning (D&D), and scientist exchange.

The JCC for Science and Technology (JCCST) was established in March 1999 between DOE and the Russian Academy of Sciences. The main area of cooperation under the JCCST is subsurface contaminant remediation.

The JCC for Environmental Systems (JCCES) was established in 1995 between DOE and the Institute for Ecology of Industrial Areas (IETU) of the Republic of Poland. The JCCES focuses primarily on subsurface contaminant remediation.

The JCC for Radioactive and Mixed Waste Management (JCCRM) with Argentina was initiated in 1996 between DOE and the National Atomic Energy Commission of the Argentine Republic. Under the JCCRM, project areas include: D&D, contaminant transport and site characterization, HLW tank remediation, separations, mixed waste, plutonium stabilization and subsurface contamination.

*In addition to the four JCCs, EM supports partnerships with the following countries.*

- ☐ ***United Kingdom:*** Collaboration with the United Kingdom (U.K.) Atomic Energy Authority provides DOE immediate access to proven technologies in the areas of tanks remediation and D&D.

- ☐ ***Canada:*** DOE is in the process of developing a cooperative program with the Ontario Ministry of Environment for remediation and environmental restoration in the area of subsurface hazardous and radioactive contaminants. This collaboration will play a fundamental role in the initiative to establish a protocol for remediation of specific types of soil contamination.

- ☐ ***Mexico:*** Scientific information exchanges are being developed with the National Institute of Nuclear Research and the Monterrey Institute of Technology and Higher Education in characterization, modeling, and monitoring of subsurface contaminants at sites within the DOE complex and in Mexico. Discussions on long term monitoring of radioactive landfills in both countries are also being conducted.

- ☐ ***Japan:*** Current projects with the Japan Atomic Energy Research Institute include identifying and developing innovative D&D technologies. Additionally, performance assessments and experimental studies are being conducted with the Japan Nuclear Cycle Development Institute to understand the basic processes for nuclear waste disposal.

*More information about EM IP can be accessed at: http://www.eminternational.fsu.edu.*

# Purpose

In 1998, EM produced *Accelerating Cleanup: Paths to Closure*, a detailed complex-wide projection of the technical scope, cost, and schedule required to complete the DOE cleanup mission. Based on these projections, sites have identified specific science and technology needs that must be met to enable or improve cleanup, accelerate the schedule, or reduce cost. Through a Focus Area-centered approach, EM is now integrating science, technology, deployment activities, and cleanup projects to meet the short- and long-term needs of the EM clean up mission. IP is assisting the Focus Areas in incorporating international technologies to expedite cleanup of the DOE complex.

The purpose of IP's *Deployment Summary* publication is to summarize the progress made by IP in deploying innovative technologies for the environmental remediation of the DOE complex and for sites of its international collaborators.

## Definition Used for Technology Deployment

EM defines technology deployment as "the use of a technology or technology system toward accomplishment of one or more site-specific DOE Environmental Management program cleanup objectives as applied to the actual waste requiring management at the site." A deployment is counted as accomplished in the fiscal year (FY) in which it begins. This definition is consistent with contributing to the accomplishment of EM's performance measures and the application of technology to actual site wastes and cleanup activities.

## EM Technology Management System

EM continually works to improve the quality of deployment data. Starting in FY98, EM began constructing Deployment Fact Sheets for every technology deployment that occurred from FY95 through FY98. These Deployment Fact Sheets reside in EM's Technology Management System (TMS), with a corresponding OST Reference Number given to each technology entry. TMS is designed to provide access to data and information relevant to OST programs, technologies, and sites. TMS can be accessed at http://tms.em.doe.gov.

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# Deactivation & Decommissioning Focus Area


# BNFL IonSens™ Monitor (Long Range Alpha Detector–LRAD)

**OST Technology Management System Number:** 2382
**Domestic Deployment Sites:** Decontamination Facility, Savannah River Site, Aiken, South Carolina
**Country Developed:** United Kingdom
**Deployment Date:** FY99

## Technology Need

Many items, such as pipes, tools, fluorescent light bulbs, and small equipment, in contaminated areas may not become contaminated with radioactive materials during their normal use. However, these items may be classified as low-level radioactive waste unless they are proven to be free of contamination. For unrestricted release from a contamination area, these items must receive radiological surveys to prove radioactive contamination is not present on any surface of the item. For items in areas with alpha contamination, this becomes difficult because of the very short range and poor penetration of alpha radiation. Contamination on inaccessible surfaces, such as the internal surfaces of small diameter pipe, cannot be measured, and therefore the surfaces cannot be released for recycling or clean landfill disposal. The current baseline technologies used for these surveys is either a hand probe or the smear method. For the free release of materials, 100% of the surface area must be measured with an alpha scintillation probe to determine the total contamination (fixed and transferable). In addition, the surface area must be smeared to measure transferable contamination. The smears are counted on a calibrated gas flow proportional counter.

## Technology Description

The British Nuclear Fuels Laboratory (BNFL) IonSens™ Monitor is an application of the LRAD method and measures alpha contamination on surfaces by detecting the ionized air molecules produced by the alpha particles when they interact with ambient air. The monitor provides a method of measuring alpha contamination in areas that are inaccessible to the hand probe and smear baseline, but accessible to the flow of ambient air. The device includes three modular units: an input filter unit, a component chamber, and a detector unit. The component chamber can either be a Large Item Monitor (with an internal volume of about 1 cubic meter), or a Cut Pipe Monitor (about 2 meters long). Three Cut Pipe Modules can be used giving the ability to monitor pipes and scaffold tubes up to six meters in length. Air is drawn through the assembly, picking up the induced ions and delivering them to the detector unit, which counts the ions and converts them to a corresponding contamination level. A built-in calibration source and an onboard computer make operation simple and straightforward. The software creates a database that includes item identification, total activity, total activity standard error, time, and date.

## Collaboration/Technology Transfer

The LRAD was developed at Los Alamos National Laboratory (LANL), and commercialized by BNFL and named the IonSens™ Monitor.

## Technology Benefits

The BNFL IonSens™ Monitor technology provides several benefits over the manual hand probe and smear method used for free release surveys.

*These benefits include:*

□ Reduces costs for free release surveys.

□ Provides measurements on surfaces inaccessible to hand probes and smears.

□ Provides computer printout of measurement data.

□ Provides near real time analysis and display of contamination levels.

□ Involves shorter measurement times for large items.

□ Eliminates operator error and inconsistencies associated with baseline.

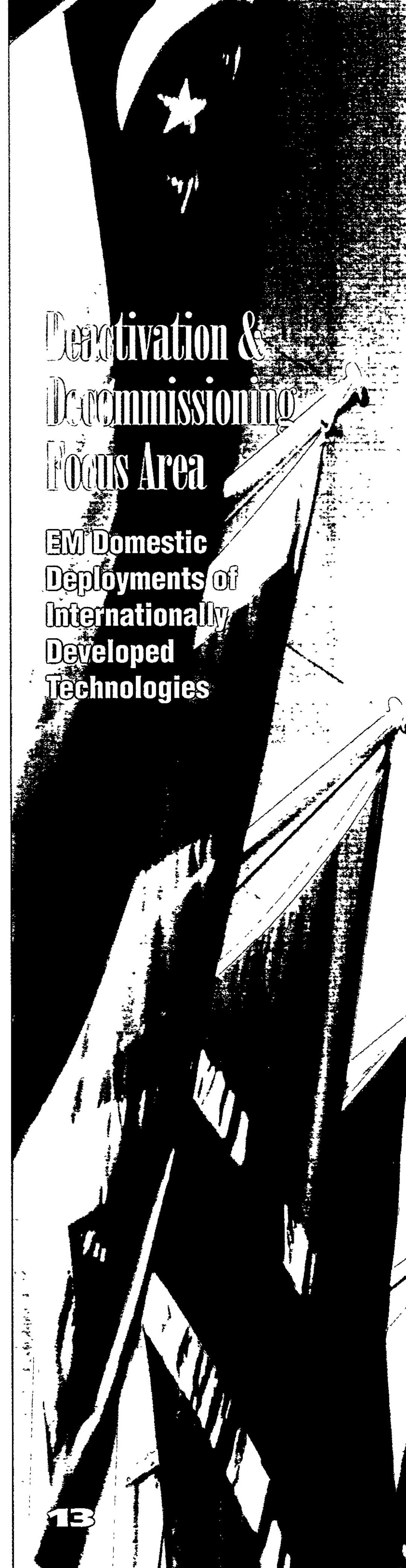
## Technology Capabilities/Limitations

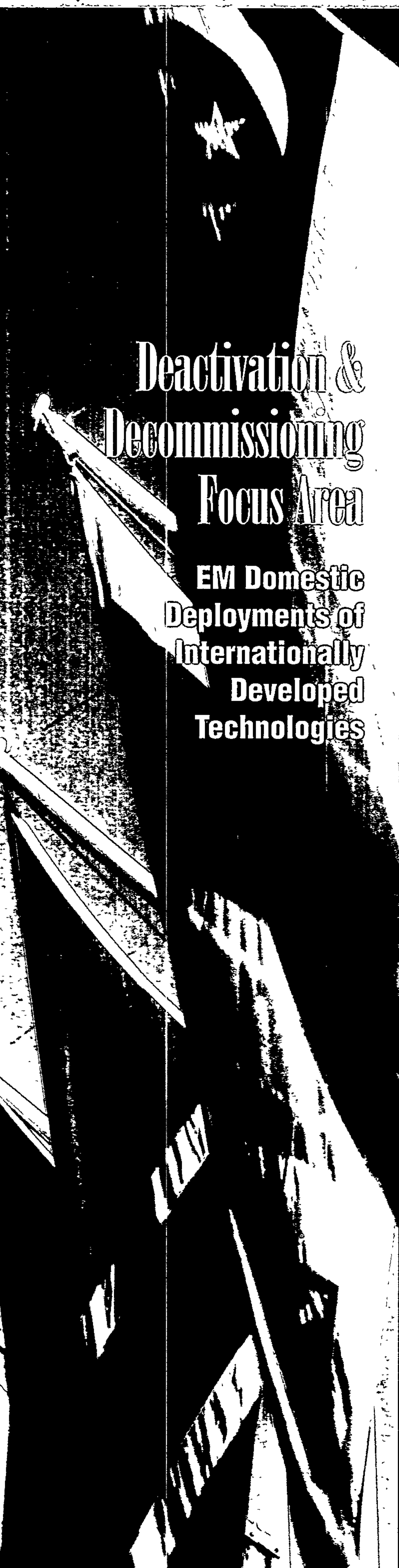
The technology has potential for use at any DOE facility that has alpha producing radionuclides and the need to dispose suspect contaminated tools and materials. The IonSens™ technology removes the inaccuracies and inconsistencies of probing and smearing because the automated detection process completely eliminates error resulting from operator technique. The detection levels are within the range of the uranium limits.

The IonSens™ monitoring system measures alpha contamination on any surface accessible to the free flow of air. Measurement times are not dependent on the amount of surface area and are equal for small or large surfaces. A small item [e.g., 2 inches (in.), 5 centimeters (cm) diameter rod, 1foot (ft) (30.5 cm) in length] requires the same measurement time as a 18 in. (45.7 cm) diameter valve body. The man-hours for probes and smears for the valve body would be much longer than those for the small rod. In general, the IonSens™ system becomes more economical for larger items, or batches of small items.

The IonSens™ monitoring system measures the total alpha contamination present on all surfaces of monitored items. The contamination level reported by the software is a total reading and not a reading per unit area.

It should be noted that the pipe measurement chambers were designed for pipe sections and not small tools and items. A measurement chamber that would give optimum results for multiple small items could be designed if needed.






*Limitations on this technology include:*

- □ Cannot measure beta/gamma contamination.
- □ Cannot measure components with a surface charge, e.g., plastic materials.
- □ Cannot measure surfaces inaccessible to the free flow of air.
- □ Limits for other TRU radionuclides are lower and may be below the detection level of the detector.
- □ Calculations of surface area of items being monitored must be done separately by the operator.

## Technology Cost Savings Data

This cost analysis compares the innovative IonSens™ Monitor, used to survey alpha activity, to baseline technologies used for radiological surveying at DOE-Savannah River Site (SRS). The IonSens™ surveyed 403 items with an approximate weight of 2,000 pounds, for the LSDDP located at building 321 - M at SRS. The baseline technology surveyed 132 items from the same location.

The cost analysis considers only the purchase of the innovative technology equipment and contract personnel performing the demonstration; no training costs were required. The analysis includes mobilization, survey activities, and demobilization.

The IonSens™ has a higher production rate than the baseline technology (2.3 times faster than manual surveys). The innovative technology offers a 50% cost savings over the baseline technology for bulk items of characterization work performed during the demonstration. The capital cost of equipment is assumed to be amortized over a ten-year period and adds little to the cost to survey per item (approx. $0.30/item or $1.49 per cycle). The IonSens™ Monitor is more costly for equipment, mobilization, and demobilization than the baseline technology. The probe and smear method is less costly for equipment, but more costly when bulk counting of items and when monitoring cut pipe (which cannot be done manually).

The cost of burial of low-level waste at SRS is $106.00 per cubic foot. One cubic foot is approximately equal in cost to one multiple survey by the IonSens™ Monitor. Cut pipe and similar objects with inaccessible internal voids could be measured and cleared by the device, thus, the IonSens™ Monitor would be beneficial in reducing contaminated waste.

The cost to survey a single item with the IonSens™ Monitor may be greater for small items, but the difference decreases when large items are surveyed, which require more time for hand surveying.

**Table 1: Cost Comparisons**

| Technology | Labor Cost | Equipment Cost | Total Cost |
|---|---|---|---|
| Probe and Smear Method | $3.30/item | N/A | $3.30/item |
| IonSens™ (Bulk items) | $1.40/item | $0.30/item | $1.70/item |
| IonSens™ (Single items) | $7.00/item | $1.49/item | $8.49/item |

## Accomplishments and Ongoing Work

The IonSens™ Monitor has been successfully deployed at the Decontamination Facility at SRS to characterize small tools, pipes, and light bulbs contaminated with alpha radiation. The characterization process identified these pieces which could be released and which ones needed to be designated as low-level waste.

## Regulatory Acceptance Information

There are no Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) or other regulatory considerations related to this technology.

The use of the IonSens™ Monitor as an alternative to the baseline requires approval by responsible site or facility health physics departments.

## Contact Information

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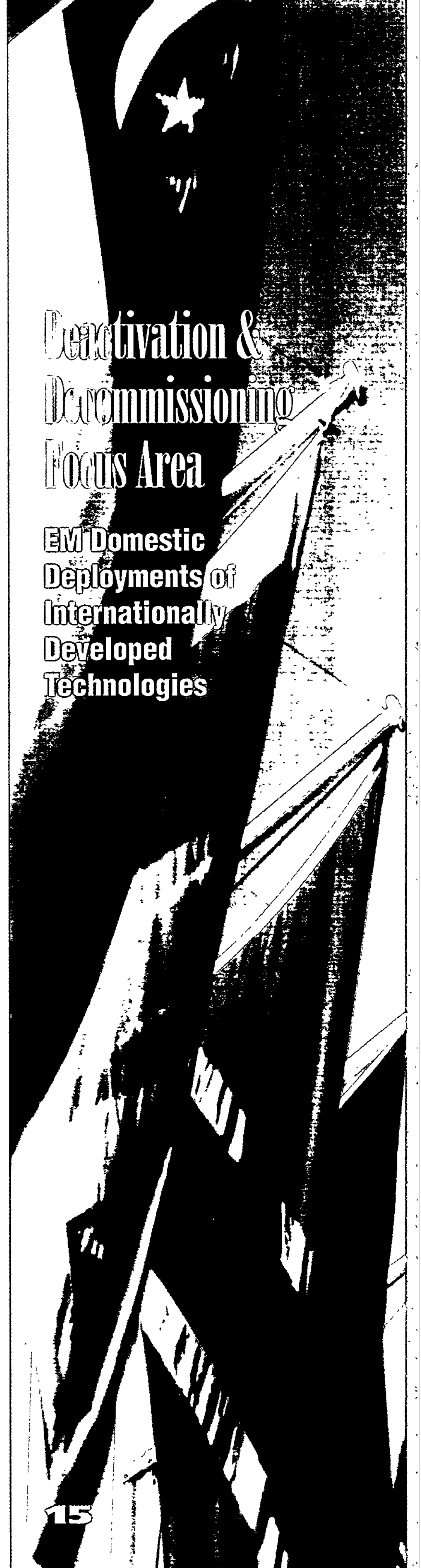



# Remote Underwater Characterization System (RUCS)

**OST Technology Management System Number:** 2151
**Domestic Deployment Site:** Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho
**Country Developed:** Canada
**Deployment Date:** FY98, FY99

## Technology Need

Most DOE facilities with waste canals or pools have requirements for visual inspection of equipment and materials mounted or stored in water when preparing for D&D. Radiological characterization of items in the pools or canals must be performed to dispose of wastes properly and understand the hazards to personnel. Inspection and characterization of water-cooled and moderated nuclear reactors and fuel storage pools requires equipment capable of operating underwater. This equipment is often required to operate at depths exceeding 20 feet and in relatively confined spaces. The typical baseline technologies consist of radiation detectors and underwater cameras mounted on long poles, or stationary cameras with pan and tilt features mounted on the sides of the underwater facility. In some cases, the only method of underwater viewing during characterization has been a plexiglass window floating on the surface of the water.

## Technology Description

The RUCS is an underwater characterization system designed to perform tasks such as characterization and small parts retrieval. It is based on a small, commercially available submersible vehicle. The small size of the vehicle allows it to operate in areas where access is tight or where maneuvering room is limited. The vehicle has underwater lights, a front color camera, and a rear black and white camera. It is operated over a 125 foot neutrally buoyant tether and is capable of operating at depths up to 100 feet. The Robotics Crosscutting Program has added an on-board compass, a depth sensor, and a gamma radiation detector. An "auto-depth" control feature has also been implemented to allow the vehicle to "hover" at a user-selected depth. A second version includes a small manipulator and an ultrasonic probe.

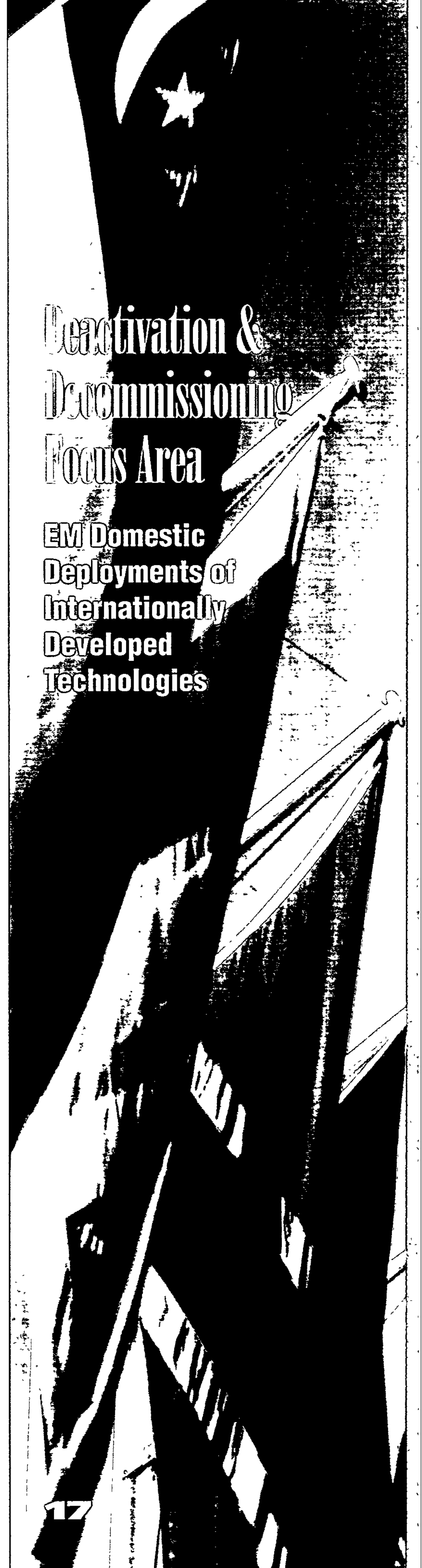
## Collaboration/Technology Transfer

This technology was developed under the DOE Robotics Crosscutting Program and Inuktun Services, Ltd. in Cedar, British Columbia, Canada, primarily at the Idaho National Engineering and Environmental Laboratory (INEEL).

## Technology Benefits

*Benefits of the RUCS system include:*

- Reduce overall costs by approximately 60% when compared to baseline technology.




□ Increase in worker safety because fewer personnel need to be present in the contamination/canal area.

□ More effectively characterize several areas over the baseline technology because of the RUCS' ability to "fly" directly up to objects and its ability to access some areas inaccessible to the baseline technology.

□ Reduce waste because less personal protective equipment (PPE) is required to perform the work.

## Technology Capabilities/Limitations

The RUCS is designed to perform visual inspection and gamma radiation characterization, even in confined or limited access areas. It utilizes a forward-looking tilt color camera and a Geiger Mueller tube radiation detector to get "on-the-spot" information needed to perform D&D intelligently and safely.

The only significant technology limitation is the inability of the system to gather radiological characterization data from inside vertical pipes and tubes. This is due to the fixed horizontal orientation of RUCS' radiation detector and the overall size of the vehicle. This limitation could not be easily remedied.

## Technology Cost Savings Data

The cost to use the innovative technology is approximately 60% of the cost of using the baseline technology. The bulk of the savings is due to the reduced labor requirements of the RUCS. Typically the RUCS system requires one fewer radiological control technician for the work crew; however, the crew configurations will vary from site to site, thus affecting the overall cost savings. In some cases, the RUCS system may actually cost more than the baseline technology. This analysis assumed only one technology operator on the baseline crew.

The production rates for the innovative technology and the baseline technologies are approximately equal. Any variation for site-specific conditions on production rates should not have a significant impact in the overall cost. The innovative and baseline technologies do not differ in their impact to worker heat stress, fatigue, and stay-time. The productivity loss for the innovative technology differs from the baseline because the loss is applied for one worker rather than for two workers. Mobilization and demobilization costs will depend on the distance that the equipment must be moved between the storage area and the work area. There was no substantial difference between the RUCS system and the baseline technology in the amount of water generated, but in most cases the innovative technology should generate less PPE waste because of one fewer worker is needed in typically contaminated areas. The reduction in PPE will reduce the overall waste remediation costs.


## Accomplishments and Ongoing Work

The demonstration, which became a deployment, took place in a canal containing two defueled test reactors at the INEEL TRA-660 facility in FY98. The RUCS was used to visually survey the canal and its contents, and also to gather radiological characterization data on the reactors and equipment on the floor of the canal. The RUCS was simpler to deploy than the baseline approach of mounting underwater cameras or underwater radiation detectors to a cable or a long (15 foot - 20 foot) reach rod. Its small size and maneuverability allowed the RUCS to operate beneath overhead structures and behind the reactors, and it measured radiation levels 50% higher than previously known because of its ability to "fly" right up to objects. The RUCS was successfully deployed again at the INEEL facility in FY99.

## Regulatory Acceptance Information

There are no known regulations associated with the use of the RUCS. Its use under the INEEL LSDDP was covered by a test plan, a radiological work permit, and a safe work permit. It is not known whether data gathered from RUCS is suitable for regulatory purposes. The data is taken with a calibrated detector, but given that the data is taken underwater and remotely, it may or may not be acceptable to regulators.

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# BNFL Decommissioning In situ Plutonium Inventory Monitor (DISPIM™)

**OST Technology Management System Number:** 2241
**Domestic Deployment Site:** Rocky Flats Environmental Site, Building 771, Golden, Colorado
**Country Developed:** United Kingdom
**Deployment Date:** FY98

## Technology Need

Accurate methods of determining concentrations of plutonium contamination in gloveboxes and vessels are needed to assist in work planning during dismantlement and size reduction activities. Such work planning includes the selection of PPE, contamination control, and TRU/low-level waste segregation. In the course of the Rocky Flats Closure Project, approximately one thousand gloveboxes and hundreds of process vessels have been identified as contaminated with plutonium. This equipment must be removed, size-reduced, and disposed of as radioactively-contaminated waste.

The baseline method of in situ plutonium assay of this type of equipment is by manual gamma-scan equipment. Using the gamma-scan equipment, the most useful radioactive emissions are quickly absorbed by both in-box machinery and lead shielding. Therefore, depending on the gamma modeling technique used, a potential exists to significantly over- or under-estimate the plutonium content of the item being measured.

## Technology Description

The BNFL DISPIM™ uses passive neutron counting and 3-dimensional (3-D) imaging to perform an in situ assay of plutonium-contaminated equipment. The DISPIM™ system has lower sensitivity and greater accuracy than current on-site systems. Through the Accelerated Site Technology Deployment (ASTD) program, the DISPIM™ system will be deployed at the Rocky Flats Environmental Site to provide a means to map accurately plutonium hold-up in process equipment awaiting D&D.

## Collaboration/Technology Transfer

This technology was primarily developed by British Nuclear Fuels Laboratory, Inc.

## Technology Benefits

*Benefits of this technology include:*

- Lower sensitivity and greater accuracy than current on-site systems.
- Provides a means to accurately map plutonium hold-up in process equipment awaiting D&D.
- Offers incentives in terms of time-savings, reduced TRU waste volume, and maintaining worker exposure levels to as low as reasonably achievable (ALARA).


## Technology Capabilities/Limitations

*Some primary capabilities of DISPIM™ include:*

□ Identify glovebox hot spots.

□ More efficiently plan and implement size reduction strategy.

□ More efficiently segregate TRU vs. low-level waste, reducing disposal requirements and cost.

□ Maintain exposure levels to ALARA.

□ Establish staff and PPE requirements.

## Technology Cost Savings Data

Cost savings will be realized as a result of the DISPIM™ more efficiently segregating TRU and low-level wastes and reducing requirement costs. A more detailed cost analysis will be completed at a later date.

## Accomplishments and Ongoing Work

The DISPIM™ was used to assay three items in FY98: a carpenter crate holding glovebox J-40, glovebox SR-14, and a raschig ring filled tank. Based on the results, the DISPIM™ was purchased for continued deployment in FY99. The system will be used primarily as a D&D planning tool, but additional applications are being considered. The DISPIM™ is also being used at the BNFL Sellafield site and at other European nuclear facilities.

## Regulatory Acceptance Information

There are no regulatory concerns regarding this technology.

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# System for Tracking, Remediation, Exposure, Activities and Materials (STREAM)

**OST Technology Management System Number:** 1947
**International Deployment Site:** Unit 4 Shelter Project, Chernobyl, Ukraine
**Deployment Date:** FY98

## Technology Need

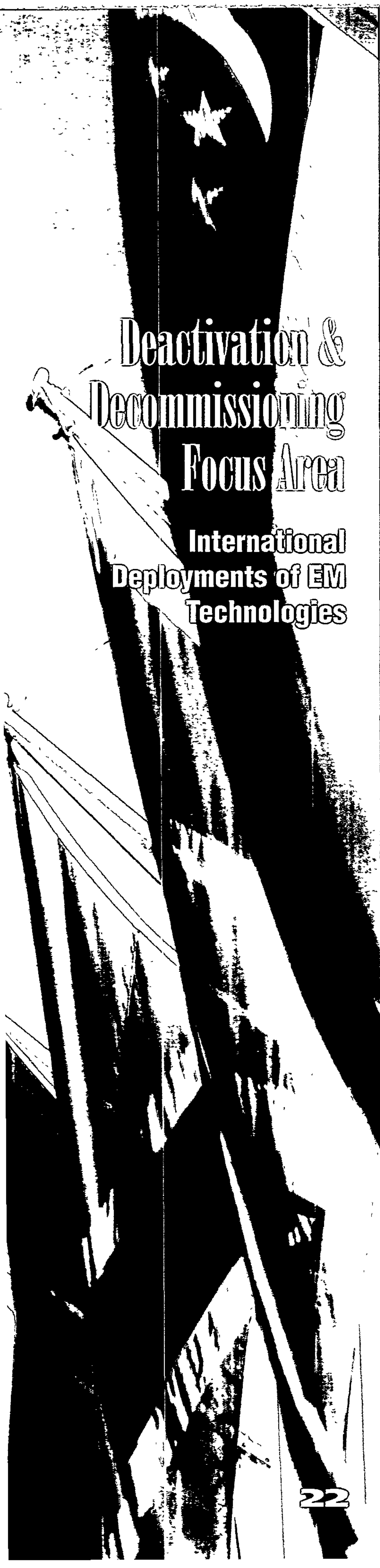
Several areas and facilities on DOE sites have the need for a technology that can manage and sort large volumes of information on areas where access may be limited due to high levels of radioactive waste contamination. This information needs to be gathered and analyzed in order to facilitate more effective D&D activities. The Unit Shelter 4 Project, in Chernobyl faces many of these same problems found throughout the DOE complex, particularly in the D&D of the 105-C Reactor at Hanford and the Heavy Water Component Test Reactor at SRS. The reactor at Chernobyl is an extreme example of a reactor needing thorough and effective D&D (as compared to the reactors at Hanford and SRS), and STREAM was deployed at the Chernobyl site to assist in the decommissioning planning of the damaged reactor.

## Technology Description

The STREAM technology is a multi-media database that consolidates project information into a single, easily accessible source for day-to-day work performance and management tracking. Information inputs can range from procedures, reports, and references to waste generation logs and manifests to photographs and contaminant survey maps. Key features of the system allow for easy information organization and retrieval, versatile information display options, and a variety of visual imaging methods. These elements enhance productivity, safety, and compliance as well as facilitate communications with project staff, clients, and regulators. Use of STREAM also gives visual access to contaminated areas, reducing the number of physical entries and promoting safety and ALARA principles. The STREAM system can be customized to focus on the information needs of a specific project, and provides a capability and work process improvement well beyond the usual collection of paperwork and independent databases. Especially when incorporated early in project planning and implemented to the fullest extent, it is a systematic and cost-effective tool for controlling and using project information.

## Technology Benefits

The system represents an innovative technology that can be effectively used on any project where there are large volumes of information, particularly visual information. The system is particularly useful for decommissioning, maintenance, and remedial action activities in cases where: access may be limited due to hazards, waste tracking is complex, quick




and easy reference to large amounts of reference information is desirable, it is important to track hours/material use, or it is important to document information for historical reference or follow-on activities.

## Technology Capabilities/Limitations

*The key capabilities of STREAM are:*

- Consolidates large amounts of information and various types of project information (photographs, videos, survey maps, waste management tracking and disposition information, procedures, reports, and similar data) into one electronic location.
- Provides easy location, retrieval, and viewing of information. Information can be sorted in various ways and viewed at any STREAM workstation, printed in black and white or color, and/or projected.
- Allows engineers, planners, and craft workers to "see" contaminated areas before entry, reducing frequency and duration of entries.
- Displays data in tables, reports, and chart formats, thus allowing easy understanding of progress and trends.
- Simplifies waste tracking and allows direct download of waste data to various organizations.
- Provides a comprehensive legacy document for historical purposes.
- Connects up to 50 separate computer workstations and assorted visual aids.

The primary limitation with STREAM is the inability to electronically export information for use with other word processing software.

## Technology Cost Savings Data

*Specific ways in which STREAM provides a cost benefit include:*

- Work package development effort was reduced by using STREAM as a source of data for the report and using photographs to avoid drawing/drafting costs.
- Work package reviews and approvals were conducted more effectively by reviewing the document in a STREAM-based review meeting.
- Facility entry and associated exposure (as measured in man-rem; 1 rem = 1 x $10^6$ man-rem; annually, the average natural background radiation exposure for humans is 360 millirems or 360,000 man-rem) for the purpose of gathering data for work packages and operational readiness review was avoided using STREAM.

□ Compared to baseline costs, STREAM saved approximately $30K at a site demonstration in 1998 at the C Reactor ISS project at Hanford (activities in costs calculations included support preparation and approval of working packages, waste tracking, and preparation of presentations).

## Accomplishments and Ongoing Work

STREAM was successfully deployed at the Chernobyl site in Ukraine in FY98, and at Hanford and SRS in FY97. The deployment at the Chernobyl site has managed and tracked D&D projects in a more organized, efficient, and effective manner while ensuring worker safety, understanding, and satisfaction.

## Regulatory Acceptance Information

There are no regulatory permits required to use STREAM, and no changes in regulatory requirements are anticipated that would require permitting.

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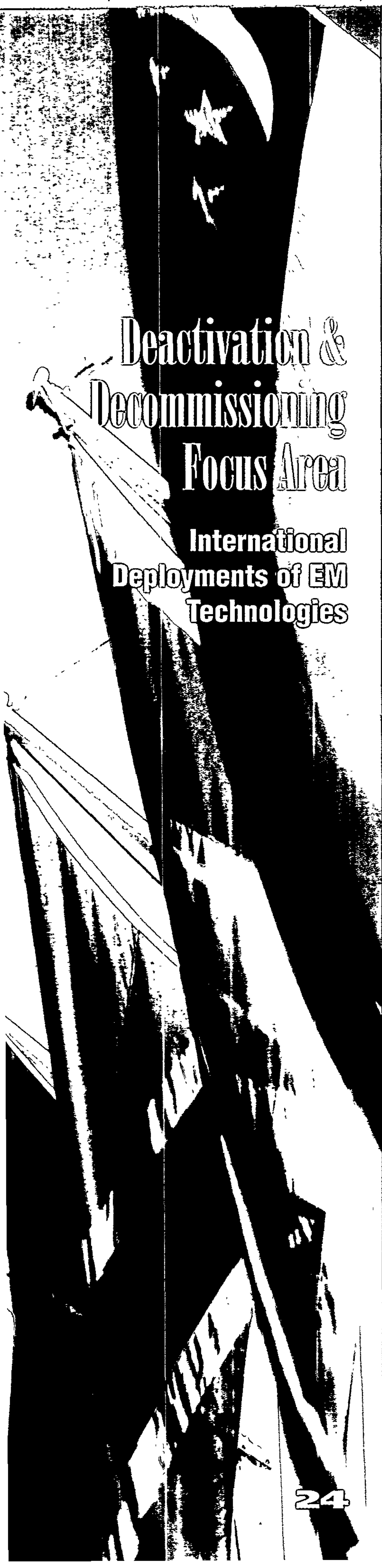


# Oxy-Gasoline Torch

**OST Technology Management System Number:** 1847
**International Deployment Site:** Russia, Kazakhstan
**Deployment Date:** FY97

## Technology Need

Under the D&D Implementation Plan of the DOE Fernald Environmental Management Project (FEMP), non-recyclable process components and debris that are removed from buildings undergoing D&D are disposed of in an on-site disposal facility (OSDF). Critical to the design and operation of the FEMP's OSDF are provisions to protect against subsidence of the OSDF's cap. Subsidence of the cap could occur if void spaces within the OSDF were to collapse under the overburden of debris and the OSDF cap. Subsidence may create significant depressions in the OSDF's cap in which rainwater could collect and eventually seep into the OSDF. DOE requires a technology that can perform in situ component segmentation for size-reducing D&D debris in preparation for disposal, including placement in an OSDF, and to minimize voids in the OSDF.

The current baseline technology used in the DOE complex is the oxy-acetylene cutting torch. The torch is fueled by a combination of oxygen and acetylene. The oxygen and acetylene are combined in the mixer in the head of the torch. The mixed fuel then travels to the tip of the torch where it is lit. While the oxy-acetylene torch has performed satisfactorily, improvements are sought in areas of productivity, airborne contamination, safety, and cost.

## Technology Description

The Oxy-Gasoline Safety Torch was developed by Petrogen International Ltd., Richmond, California. The Oxy-Gasoline Torch burns at a temperature of over 5,000° F and the force of the expanding gasoline flame allows for cutting under adverse conditions (dirty, rusty, cement coatings or backing, stacks of deformed plate, 5 percent chrome steel, 9 percent nickel steel, etc.). The torch deployed is a hand-held torch with a 2.5-gallon gasoline tank and a manifold tank system for the liquid oxygen. The Petrogen Oxy-Gasoline Torch is also available as a machine torch, which can be mounted on track machines, pipe cutters, and rail cutters.

## Collaboration/Technology Transfer

Petrogen International, LTD., the major developer of this technology, has patented the oxy-gasoline torch with patent number 1,036,590.

## Technology Benefits

The oxy-gasoline torch is similar in operation to the oxy-acetylene torch, but uses gasoline instead of acetylene as the fuel. The oxy-gasoline cutting technique has been around for many years, but it was not considered a safe method because earlier technology charged a gasoline tank with oxygen and piped this volatile vapor to the cutting torch. A backflash often resulted in explosion. This current technology system is a safe, reliable design, which makes backflash impossible. An additional advantage of the Oxy-Gasoline Torch is the evaporation of gasoline, which acts as a refrigeration process making the torch run cooler than conventional torches, thereby greatly extending tip life.

*Additional benefits of the oxy-gasoline torch include:*

- Increases cutting speed, particularly for metal thickness greater than 1 inch.
- Reduces airborne contamination.
- Readily available and less expensive fuel.
- Increases worker safety.
- Reduces cost of operation.

## Technology Capabilities/Limitations

*The key capabilities of the oxy-gasoline torch are:*

- Can be used to cut steel that is in direct contact with concrete without the risk of the concrete shattering and causing a projectile hazard.
- Cuts through carbon steel, including rusted steel surfaces, from 0.5 inches to 4.5 inches thick.
- Will perform effectively at coupling distances up to 2 inches allowing for greater flexibility when cutting steel under unusual conditions.
- Does not produce any hazardous airborne contaminants. It only produces carbon dioxide and water during cutting.

Based on its demonstrated good performance, the oxy-gasoline torch does not appear to require any further development.

A limitation of the oxy-gasoline torch is that it will not readily cut through stainless steel due to its high resistance to oxidation. The oxy-gasoline torch will cut through thin stainless steel up to a quarter inch thick mostly by melting through it. At greater thickness, the oxy-gasoline torch will cut through some forms with varying degrees of success. The oxy-gasoline torch also cannot cut cast iron.


## Technology Cost Savings Data

The oxy-gasoline torch shows a cost savings when compared to the baseline technology, the oxy-acetylene torch. The data presented here is based on the demonstration of these two technologies at FEMP's OSDF. The data strive to develop realistic estimates that are representative of work performed within the DOE-complex. However, the DOE-complex represents a wide range of working conditions at each site that directly affect the manner in which D&D work is performed and, consequently, the costs related to each job.

*At the FEMP site, the demonstration yielded the following cost data:*

- Mobilization costs were insignificant for both technologies.
- The cost of performing D&D work was lower for the oxy-gasoline torch due to its lower fuel cost and its higher productivity.
- Neither torch generated secondary wastes other than PPE.
- Demobilization costs were insignificant for both torches.
- Total PPE costs were identical for both torches; however, unit PPE costs were lower for the oxy-gasoline torch because of its higher productivity.

The final unit cost ($/inch) associated with cutting 100 feet of 2-inch carbon steel were evaluated. Included in this estimate was the cost for mobilization, D&D work, demobilization, and PPE. The unit cost for the oxy-acetylene torch was $1.12/inch, compared to $0.64/inch for the oxy-gasoline torch. See Table 2 below for the breakdown of these figures:

**Table 2: Cost associated with cutting 100 ft. of 2-inch carbon steel**

| Cost Driver | Oxy-acetylene Torch | Oxy-gasoline Torch |
|---|---|---|
| Mobilization | $ 0.00 | $ 0.00 |
| D&D Work | | |
| Labor | $ 818.18 | $ 495.41 |
| Fuel | $ 121.18 | $ 20.20 |
| Amortized Capital Cost | $ 0.27 | $ 0.50 |
| Waste Disposal | $ 0.00 | $ 0.00 |
| Demobilization[1] | $ 0.00 | $ 0.00 |
| PPE | $ 408.00 | $ 247.05 |
| Total Cost | $1347.63 | $ 763.16 |
| Unit Cost ($/in) | $ 1.12 | $ 0.64 |

[1]These are costs that are independent of the quantity of D&D work performed.

## Accomplishments and Ongoing Work

The oxy-gasoline torch has been deployed at more than a dozen U.S. DOE sites and several non-DOE sites in the U.S. (2), Russia (1), and Kazakhstan (1).

## Regulatory Acceptance Information

Data not available.

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# Surface Contamination Monitor/Survey Information Management System (SCM/SIMS)

**OST Technology Management System Number:** 1942
**International Deployment Site:** Puerto Rico
**Deployment Date:** FY97

## Technology Need

In general, three types of radiation surveys are needed to support DOE D&D activities. The first consists of surveys of hallways and floors as part of standard Health Physics surveillance procedures within a facility. The second uses surveys to identify the amount and location of contamination for use by cleanup crews or by personnel planning decontamination efforts. This type of survey typically requires specific measurements of the contamination level and the location of these measurements on a layout of the area for use by personnel not involved in the original measurements. The third involves surveys and documentation to be used for free-release certification of a specific area. DOE is in search of technologies that will effectively survey and characterize contaminated wall and floor surfaces as well as generate data analysis of the survey. The baseline methodology to SCM is a manual survey by trained Health Physics Technicians.

## Technology Description

SCM/SIMS, developed by The Shonka Research Associates, Inc., is a motorized characterization and data analysis system for surveying contaminated floor and wall surfaces. Utilizing a position-sensitive, gas-proportional counter, 400 radiation measurements are taken in an area of 1 square meter. Survey data and sample location are logged electronically as well as displayed on a liquid crystal display (LCD) screen for the operator. The data from each survey is analyzed by the SIMS to obtain visual representations of the surfaces surveyed, to generate a data report detailing the actual numerical results, and to overlay the data into a computer aided design drawing.

## Collaboration/Technology Transfer

Data not available.

## Technology Benefits

SCM/SIMS is a complete system for surveying floors or surfaces for alpha and beta radiation contamination and can be applied to routine operational surveys, characterization surveys, and free release and site closure surveys. Any large nuclear site can make use of this technology. The SCM/SIMS has maximum utility in facilities that have large areas to survey; however, even in small facilities with relatively irregularly shaped rooms, the use of the SCM/SIMS should reduce costs and increase survey accuracy.

*Some of the key advantages of the SCM/SIMS include:*

- ☐ SCM in conjunction with the LCD display screen is an extremely useful tool for routine surveillance surveys.
- ☐ SIMS provides a unique tool for analyzing the data from SCM and for generating data reports that can meet regulatory requirements. In addition, the system is easy to use and to learn.
- ☐ The system generates automatic data reports with minimal operator intervention.
- ☐ The proportional counter on SCM can be easily changed so that the dimensions can be optimized for the area being scanned.
- ☐ The reliability of the measured data is significantly increased because the computer records all of the data. In addition, the system relieves the operator of much of the routine data recording and transcribing, which reduces operator fatigue and improves performance.

## Technology Capabilities/Limitations

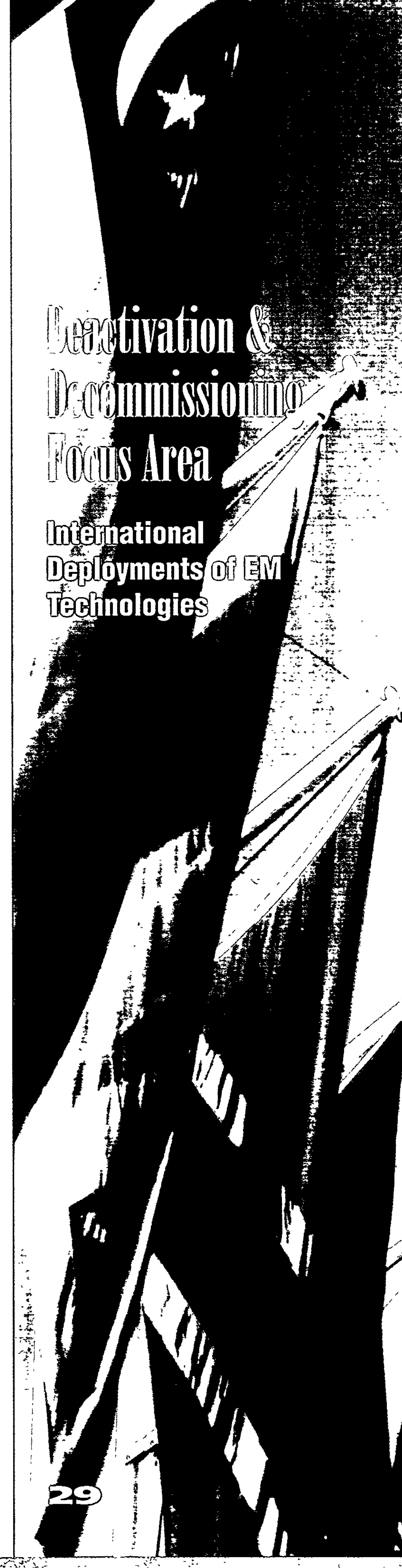
SIMS is primarily oriented toward handling large data sets generated by the SCM; however, SIMS can be applied to the integration of survey information from a wide variety of measuring devices. In fact, the more survey data a site generates, the more need there is for a system to manage it. SIMS is used for analysis and report generation and to assist in providing useful presentations of the data to other applications, such as electronic-based drawings and mapping systems.

While SCM/SIMS could in principle be used for minor surveys, use of the system is not recommended for areas of less than a few square meters or surveys with less than a hundred measurement points, since the visualization of the data becomes less useful for small data sets.

The major limitation of the system is in surveying small rooms with a large number of obstacles. It is possible that combining manual survey instrumentation with SIMS could reduce this problem.

## Technology Cost Savings Data

The cost to perform and document a floor radiation survey with conventional radiation monitoring equipment is considerable, depending on several factors: the complexity and size of the room or area to be surveyed, the level and type of contamination in the room or area, and the analysis requirements imposed on the survey end results, such as whether the survey is being conducted for characterization or for closure.




## Accomplishments and Ongoing Work

Data not available.

## Regulatory Acceptance Information

Since SCM/SIMS is designed for use when decontaminating structures, there is no regulatory requirement to apply CERCLA's nine evaluation criteria. However, some evaluation criteria required by CERCLA, such as protection of human health and community acceptance must be considered. With respect to safety issues, the SCM/SIMS involves the same considerations as those in standard gas proportional counter systems regularly used by health physicists. Most of these considerations involve the high-voltage of the system and the gas cylinder, and are typical of what is routinely encountered in an industrial environment.

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# GammaCam™ Radiation Imaging System

**OST Technology Management System Number:** 1840
**International Deployment Site:** Paldiski, Estonia
**Deployment Date:** FY95

## Technology Need

The DDFA is responsible for developing technologies to solve DOE's challenge of deactivating and decommissioning 7,000 contaminated buildings. A similar problem is being faced by the Estonian government, which recently acquired the former Soviet Union Naval Nuclear Submarine Training Facility, which is located in Paldiski, Estonia. The facility contains two nuclear reactors, which were shut down in 1989 for safety reasons. Building 307 is the site's above-ground solid waste storage facility that consists of ten separate storage cells. The contents of Cells 1 and 5, which display the most significant radiological fields are of main concern to the Estonian government. Records from the former managers of the facility are incomplete, and there is significant uncertainty as to the contents of the storage cells and how contaminated they are.

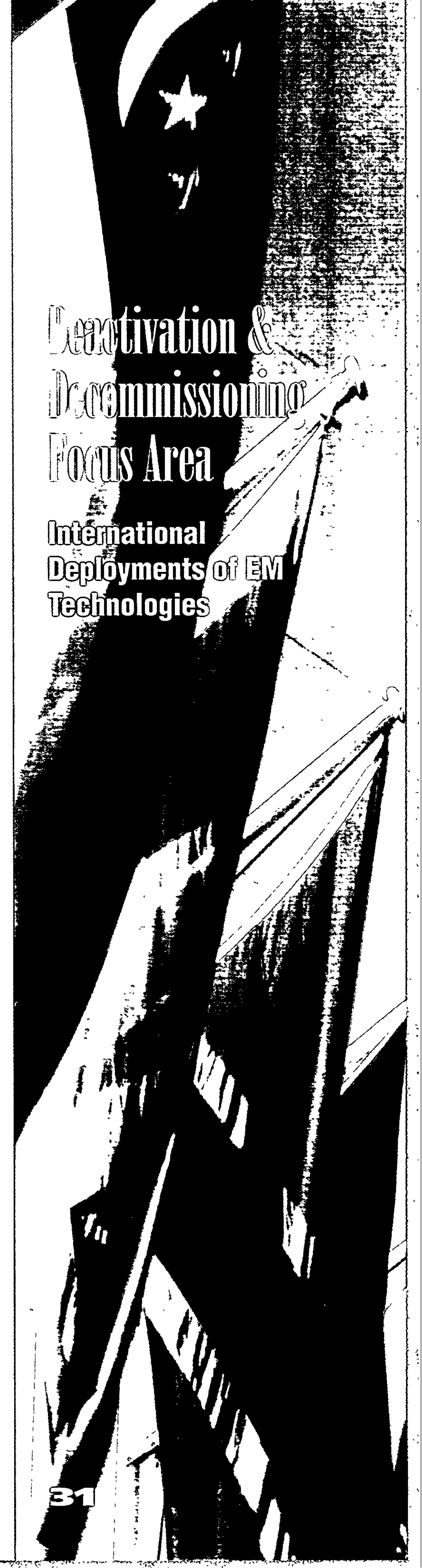
The baseline technology for locating and measuring radiation sources currently is manual surveys by trained health physics technicians. Manual surveys are time consuming, tedious, and directly expose the personnel to radiation. This leads to high labor costs, unreliable data, and potentially unnecessary worker exposures.

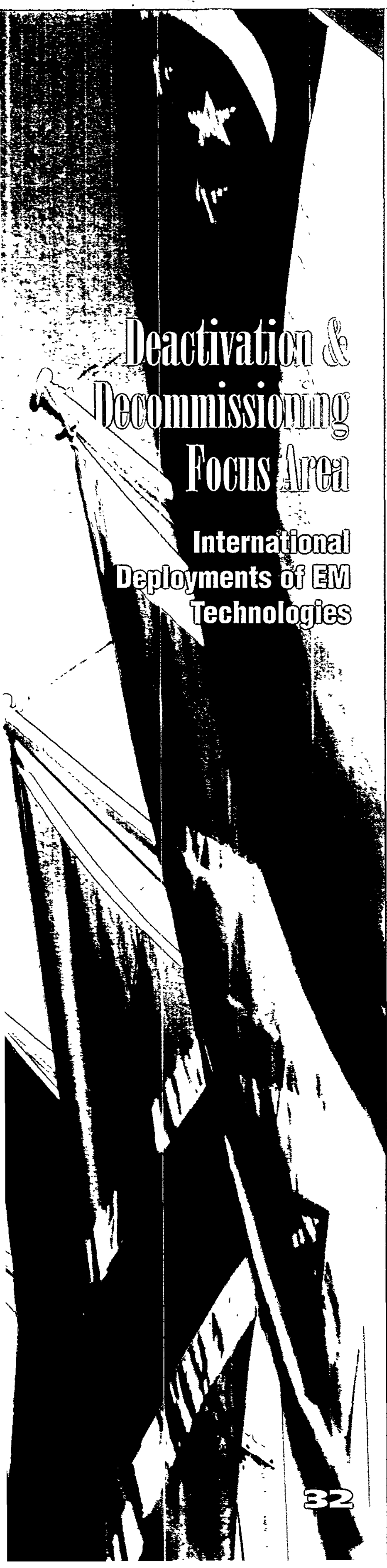
## Technology Description

The GammaCam™ System displays the relative strength and location of gamma radiation as a two-dimensional image superimposed on a corresponding visual image. This information can be used to locate hot spots and position shielding to minimize worker exposure. GammaCam™ consists of a portable sensor head that contains a gamma-ray imaging system and a TV camera. The superimposed radiation and visual images are displayed on a standard portable PC computer screen located several hundred feet from the radiation area. The PC controls the data acquisition time, the field of view, and the image display.

## Collaboration/Technology Transfer

This deployment was planned and executed in accordance with the charter established in the Memorandum of Understanding between the DOE and the Government of Estonia signed in 1994. The GammaCam™ technology was developed as a Technology Reinvestment Project, funded by the Advanced Research Projects Agency, and managed by the DOE. DOE-Idaho executed and managed the award.







## Technology Benefits

*Some benefits of the GammaCam™ include:*

- The use of the GammaCam™ system in determining shielding requirements and in positioning shielding will result in a significant reduction in the radiation dose received by operating technicians. This benefit will be more pronounced in high radiation areas.
- The GammaCam™ system can provide useful information concerning the relative strengths of the various sources and their locations from outside the radiological area. This provides useful information for planning a decontamination process with minimal radiation dose to the operator. It is also possible to use triangulation to determine the distance of the sources relative to the GammaCam™ sensor.
- The GammaCam™ system can provide information on floor and wall contamination from outside the contaminated area. This eliminates the need for extensive worker protection in obtaining these measurements. It will also reduce the radiation exposure to personnel if the floors and walls were highly radioactive.
- Training in the setup and use of the GammaCam™ is easy and can be done in a few hours. Due to some of the characteristics of the imaging system, a day of training in the use of the system is required to properly interpret the resulting images.

## Technology Capabilities/Limitations

Any site that needs to locate radiation sources would benefit from the use of the GammaCam™ system. In decommissioning a room containing glove boxes or an area containing extensive piping, a gamma camera can provide useful information on the number, location, and intensity of radiation sources. This information can be used to locate hot spots and position shielding to minimize worker exposure. Since much of this information is obtained with minimal radiation exposure to personnel, this is a useful tool in implementing ALARA programs. The GammaCam™ system enables characterization of high radiation sources when manual surveys would be impossible because of personnel dose constraints.

The primary weaknesses of the system are that GammaCam™ cannot directly measure a uniform radiation field, and there is a need to watch for image artifacts under certain conditions.

## Technology Cost Savings Data

A significant portion of the cost is related to a one-time cost for instructing the site personnel who will operate the equipment and for mobilization and demobilization of the equipment (where the equipment is leased). The costs for the GammaCam™ are sensitive to the rates charged for leasing the equipment which is related to the length of time for the lease (rates used in this analysis were based on a one month lease). The number of hot spots identified will control the number of setups and surveys and affects costs substantially. Additionally, the cost for shipment can vary, depending upon distance and location of site. The time required to ship, which can vary from 3 to 10 days, will also impact the length of time required for leasing. Another factor that can result in significant cost variation is the geometry of the area being scanned. Lower survey production rates may result from columns or objects that block the view of the scanner due to additional setups or less than optimal distances from the object. Production rates for scans at a distance of 11 feet and 50 degree field of view were 137 $ft^2$/minute while scans at distances of 6 feet and 25 degree field of view were 6.2 $ft^2$/minute. Finally, depending on the strength of the source, the production rate may vary due to time required to achieve the proper resolution.

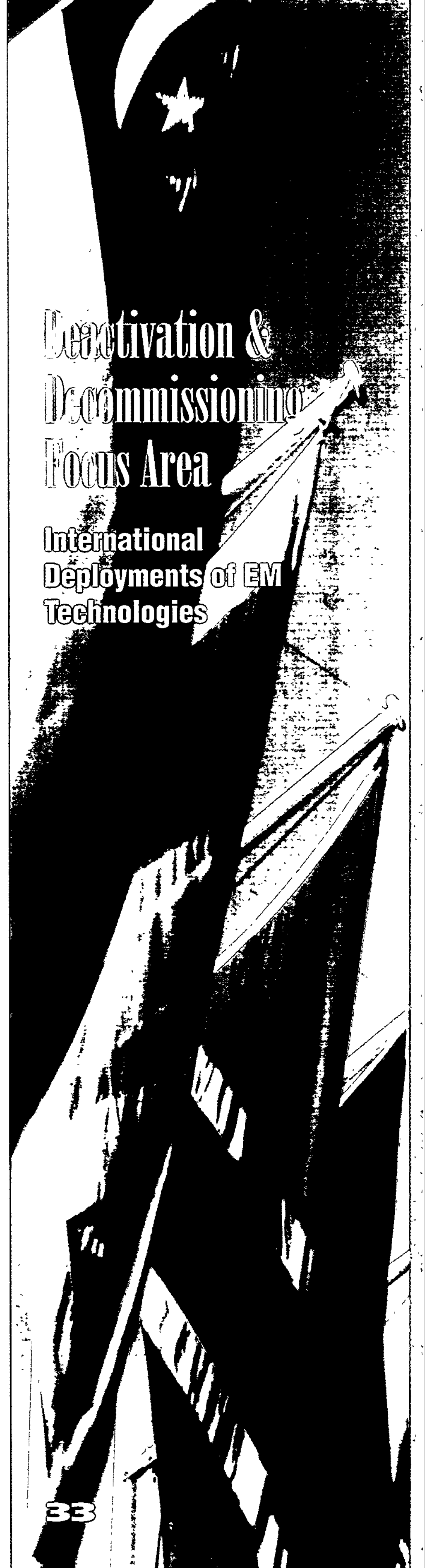
## Accomplishments and Ongoing Work

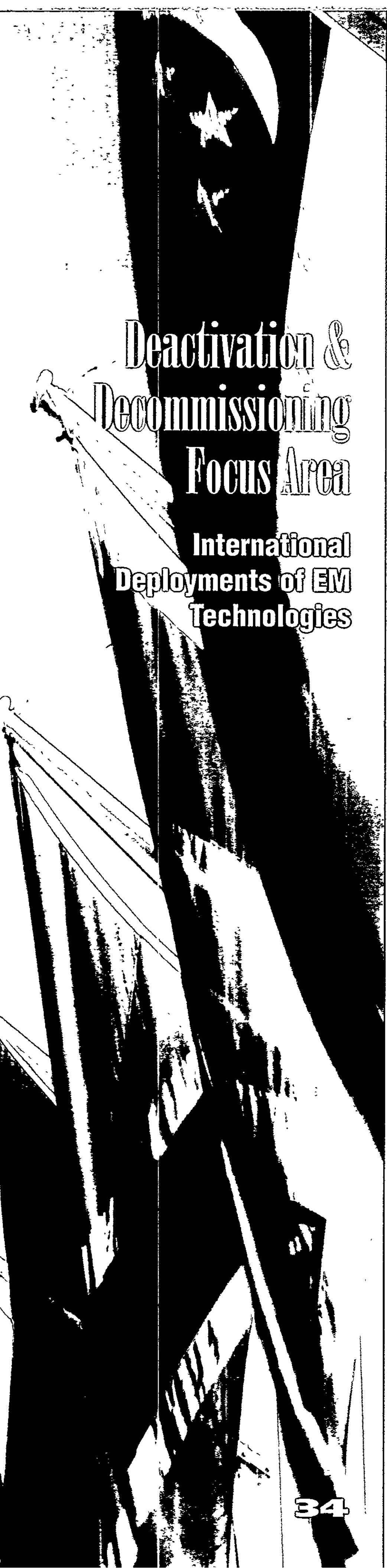
The GammaCam™ has been successfully deployed at commercial U.S. nuclear facilities for refueling and decontamination and decommissioning activities, at several DOE sites, and at emergency response centers in Japan, in addition to the site in Estonia.

Deployments at U.S. DOE sites include Hanford, INEEL, LANL, and West Valley. Refueling deployments at commercial U.S. nuclear sites include Arkansas Nuclear One, Wolf Creek, Peach Bottom, Palisades, Fermi, Edwin Hatch, South Texas Project, Comanche Peak, Brunswick, and Farley. U.S. decontamination and decommissioning deployments include Maine Yankee, Trojan, Big Rock Point, Millstone, and San Onofre.

Multiple systems were delivered in 2000 to the Japanese Defense Agency for nuclear emergency response applications.

The further development of the GammaCam™ lead to a 3-D gamma ray imaging technology demonstration at the U-221 facility in Hanford. This 3-D gamma ray imaging system, called GammaModeler, was demonstrated as a beneficial technology for the Canyon Disposition Initiative. This system creates 3-D representations merging gamma sources and visual images of contaminated equipment (i.e. vessels and cells). This 3-D representation provided better information on source position and intensity. An Innovative Technology Summary Report on the GammaModeler is planned to be issued in 2000.






Gamma ray imaging has also expanded into hot cell clean up at INEEL and HLW tank characterization at West Valley. A modified and shielded sensor head was developed and built for deployment at West Valley to characterize underground HLW storage tanks. It is anticipated that this deployment will lead to additional tank farm and hot cell applications.

## Regulatory Acceptance Information

Since GammaCam™ is designed for use when decontaminating structures, there is no regulatory requirement to apply CERCLA's nine evaluation criteria. However, some evaluation criteria required by CERCLA, such as protection of human health. The safety issues with the GammaCam™ system are limited to those routinely encountered in an industrial environment.

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# High-Level Waste Tanks Remediation Focus Area

The Mobile Waste Retrieval [illegible]

Fluidic" technology. The [illegible]

transfer to the processing facility. [illegible]

three phase mixing process [illegible]

## Collaboration/Technology Transfer

The Mobile Retrieval System [illegible]

Reservation, and is manufactured by AEA Technology Engineering [illegible]

during this deployment was performed [illegible]

## Technology Benefits

The use of Power Fluidics™ eliminates the use of [illegible]

tact with the radioactive liquid or sludge and therefore [illegible]

taminated equipment. Significant savings are [illegible]

technology including:

- Eliminating replacement costs of [illegible]
- Eliminating frequent routine maintenance and [illegible]
- Reducing secondary waste due to [illegible]
- Reducing health physics and safety [illegible]
- Can be applied to other sites across the DOE complex.


# AEA Mobile Retrieval System

**OST Technology Management System Number:** 2947
**Domestic Deployment Site:** Oak Ridge National Laboratory, Oak Ridge, Tennessee
**Country Developed:** United Kingdom
**Deployment Date:** FY00

## Technology Need

Within DOE there exists a need for a mobile retrieval system that can easily be moved from tank site to tank site. Systems exist for waste retrieval, however they only have capabilities of handling waste from one or two tanks. AEA Technology's system was designed with capabilities of handling waste from a large number of tanks utilizing proven and reliable technology.

## Technology Description

The Mobile Waste Retrieval System is based upon AEA Technology's patented Power Fluidic™ technology. The pulsed jet agitation system mixes sludge with supernate to enable transfer to the processing facility. The pulse jet pump mixes the sludge and supernate in a three phase mixing process including: a suction phase, a drive phase, and a vent phase.

## Collaboration/Technology Transfer

The Mobile Retrieval System is an ASTD funded activity at DOE's Oak Ridge Reservation, and is manufactured by AEA Technology Engineering Services, Inc. Work during this deployment was performed in conjunction with Bechtel Jacobs and ATG.

## Technology Benefits

The use of Power Fluidics™ eliminates the use of any mechanical or moving parts in contact with the radioactive liquid or sludge and therefore requires no maintenance of contaminated equipment. Significant savings are achieved through the use of power fluidic technology including:

- Eliminating replacement costs of worn out components.
- Eliminating frequent routine maintenance and associated radiation exposure.
- Reducing secondary waste due to worn out components and maintenance work.
- Reducing health physics and safety paperwork associated with the maintenance.
- Can be applied to other sites across the DOE complex.

## Technology Capabilities/Limitations

A limitation of the technology was identified at the end of the tank emptying operations after the system was left idle overnight with waste inside the delivery tube. Solid debris, which was not previously identified during waste analysis, settled out of the homogeneous mixture and blocked the nozzle. This situation can be readily avoided in future work by incorporating operational procedures for emptying the system before leaving overnight. The situation was exacerbated by the fact that the nozzle was originally designed for an alternative tank containing a different type of waste and therefore was not purpose-built for this project.

## Technology Cost Savings Data

The Mobile Waste Retrieval System can be used to empty numerous waste tanks at a particular site and then be taken to other sites across the DOE complex that possess a similar need without accruing additional production, design, or manufacturing costs. It is more cost effective in terms of plant lifetime costs to have one reliable, maintenance free system, which has the ability to remove waste from all of the tanks.

## Accomplishments and Ongoing Work

Power Fluidic pump samplers and mixers have been used in UK nuclear installations for over 15 years in which time over 400 fluidic systems have been installed with no failures. Numerous additional deployments are currently being developed across the DOE complex to expand upon the 12 approximate deployments already conducted in the past 4 years.

## Regulatory Acceptance Information

Data not available.

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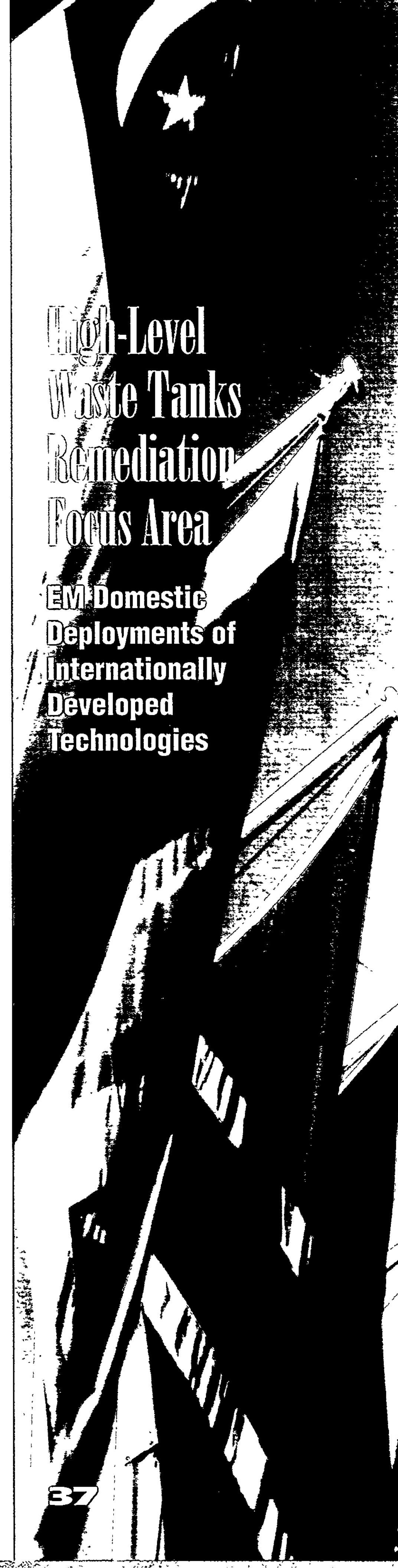



# AEA Power Fluidic Sampler

**OST Technology Management System Number:** 2007
**Domestic Deployment Site:** Savannah River Site, Aiken, South Carolina
**Country Developed:** United Kingdom
**Deployment Date:** FY00

## Technology Need

Millions of gallons of radioactive and hazardous wastes are stored in underground tanks across the DOE complex. To manage this waste, tank operators need safe, cost-effective methods for mixing tank material to keep the contents homogenous, transferring tank waste between tanks, and collecting samples. In some cases, samples must be collected at different depths within storage tanks containing various kinds of waste including salt, sludge, and supernatant (liquid resulting from neutralization of HLW using caustic soda). For well-mixed tanks and processing tanks, a single sampling depth may be adequate.

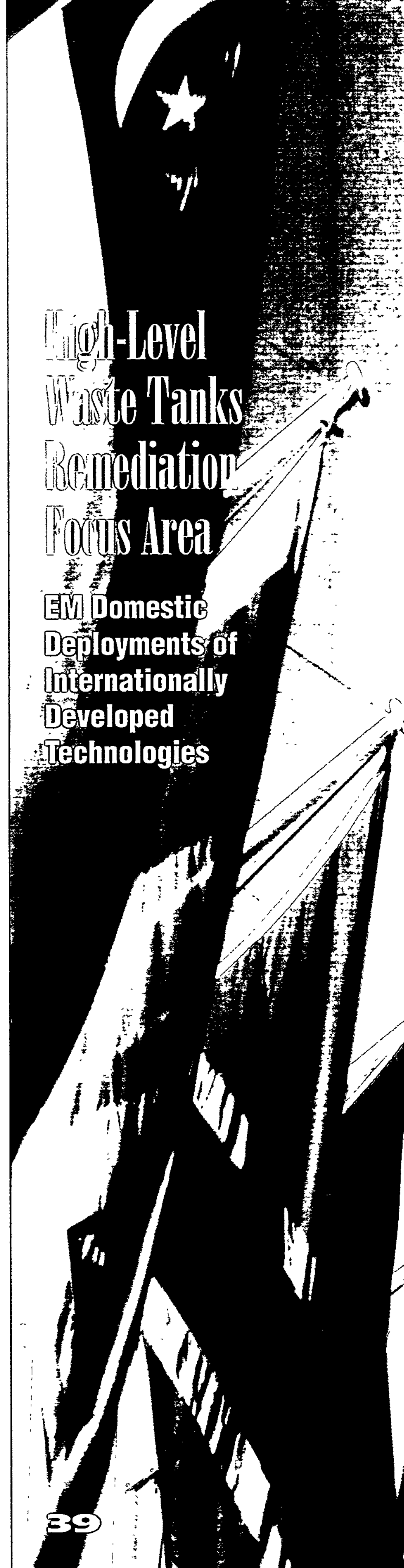
With baseline methods, a grab sampler or a core sampler is manually inserted or lowered into the tank, waste is maneuvered into the sampler chamber, and the sample is withdrawn from the tank, inserted into a shielded sample cask and then transported to a laboratory for analysis. The mixing pumps in the tank must be shut down before and during sampling to prevent airborne releases. These methods require substantial hands-on labor, cause worker exposure to radiation, cannot be performed during inclement weather, and often produce non-representative and unreproducible samples.

## Technology Description

The Fluidic Sampler manufactured by AEA Technology Engineering Services, Inc., enables tank sampling to be done remotely with the mixing pumps in operation. The Fluidic Sampler includes a reverse flow diverter pump with a specially designed sampling tee installed in the discharge piping that delivers a sample of the liquid through a sample needle to a sample bottle. Sampling while the tank contents are being agitated yields consistently homogenous representative samples and facilitates more efficient feed preparation and evaluation of the tank contents located in a shielded housing above the tank top.

## Collaboration/Technology Transfer

This project is a collaborative effort involving AEA Technology; SRS; Pacific Northwest National Laboratory (PNNL); DOE EM; Tanks Focus Area; the Characterization, Monitoring and Sensor Technology (CMST) and Robotics Technology Development Crosscutting Programs; and IP.




## Technology Benefits

*The Fluidic Sampler shows these benefits over the baseline technology:*

□ Improved safety (reduced radiation exposure to personnel and the environment):

1. Keeps the sample in a shielded and sealed container at all times.
2. Eliminates the need to open a tank riser to obtain a sample.
3. Eliminates worker manipulation of potentially contaminated equipment associated with baseline grab sampling options.

□ Reduced cost:

1. Improved sample representativeness and reproducibility means fewer samples need to be taken and analyzed to accurately characterize tank contents.
2. Increases plant productivity by reducing maintenance and allowing plant processes to continue during sampling (i.e., no lost processing time while tank agitators are stopped and restarted).

□ Increased reliability/maintainability:

1. Allows samples to be taken from a homogeneous mixture.
2. Eliminates maintenance because there are no moving parts.

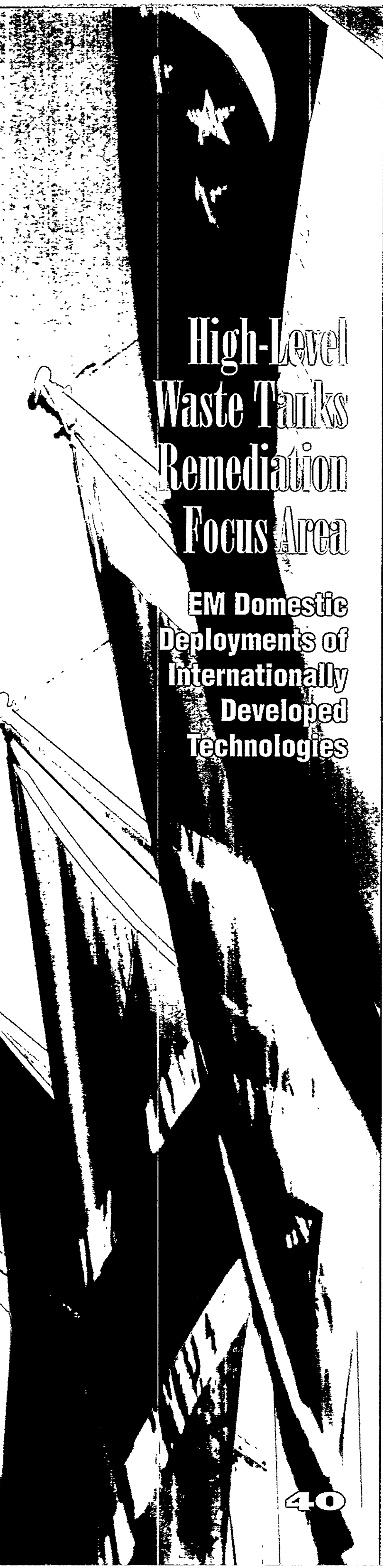
## Technology Capabilities/Limitations

The Fluidic Sampler can be designed to facilitate a wide variety of uses. Sampling can be conducted from a number of discrete depths (depending on riser size and the pumping application) and for large range of viscosities. This technology causes no routine release of contaminants, and no potential impacts from transportation of equipment, samples, waste, or other materials are associated with this technology.

A possible limitation of the Fluidic Sampler is that it must be used with a sludge type in the design range of the Fluidic Sampler. The solution is to establish during the design stage ranges for viscosity, density, and other pertinent properties that might be encountered for the application.

Installation of the Fluidic Sampler can be challenging, since it involves lifting the equipment over the top of the tank. A plug must be opened to deploy the sampler into the tank. The plug area must have a special tent built around it with a special air system to ensure that airborne releases are controlled. Lifting the sampler over the tank involves using a crane. Working with the crane is logistically demanding and requires advance planning.

Finally, sampling waste that contains volatile organics requires an alternative approach to filling the sample bottle. Modifications are needed to ensure that the filled bottle contains representative quantities of volatile organic constituents.




## Technology Cost Savings Data

A cost analysis was performed comparing the baseline technology to the AEA Fluidic Sampler at a demonstration that was performed at SRS in 1998. The results of the analysis showed that the Fluidic Sampler will not produce a net cost saving over the baseline technology until the fourth year of use. However, a $1.5 million dollar savings will be realized during years five through nine.

## Accomplishments and Ongoing Work

The first fluidic sampler was deployed in Tank 48 (formerly an in-tank precipitation process tank) at SRS. This sampler has been used to successfully obtain a sample of contents of that tank while tank mixer pumps were in operation. A second sampler is in the process of being installed on Tank 40 (a sludge washing tank) which is also equipped with mixer pumps.

AEA Technology Engineering Services, Inc. designed the Fluidic Sampler and holds all patent and licensing rights.

## Regulatory Acceptance Information

There are no additional state or regional regulatory permits or requirements for deployment of this technology. DOE site plans will be in effect; key safety and baseline operational change documents will be produced as necessary. Aspects of Fluidic Sampler design that deal with entry or installation into a radiological controlled area (RCA) are coordinated with Health Physics Technology and the Radiological Controls and Health Physics Department to minimize the time spent in the RCA.

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# AEA Fluidic Pulse Jet Mixer

**OST Technology Management System Number:** 1511
**Domestic Deployment Sites:** Oak Ridge National Laboratory, Oak Ridge, Tennessee; Savannah River Site, Aiken, South Carolina
**Country Developed:** United Kingdom
**Deployment Date:** FY98, FY99 (ORNL); FY99 (SRS)

## Technology Need

Hundreds of DOE underground storage tanks contain radioactive waste requiring remediation. After many years of storage, the wastes have separated into layers of liquid and sludge. Remediation of these tanks involves waste removal, transfer and processing to stabilize the radioactive and hazardous waste components for long-term disposal. The heavy layer of sludge must be mobilized to remove it from a tank and then maintained in suspension during transfer to a processing facility. A preferred method involves mixing the sludge with existing tank liquids rather than adding more liquids and increasing the waste volume. This approach produces slurry that can easily be removed from a tank. Other alternative technologies include jet pump mixers, agitator-based systems, pulsed-air systems, sluicing, air-lift circulators, arm- or crawler-based retrieval methods, and chemical retrieval.

## Technology Description

AEA's Fluidic Pulse Jet Mixer was developed to mix and maintain the suspension of solids and to blend process liquids. The mixer can be used to combine a tank's available supernate with the sludge into a slurry that is suitable for pumping. The system uses jet nozzles in the tank coupled to a charge vessel. A jet pump creates a partial vacuum in the charge vessel, allowing it to be filled with waste. Next, air pressure is applied to the charge vessel, forcing sludge back into the tank and mixing it with the liquid waste. When the liquid waste contains 10% solids, a batch is pumped out of the tank.

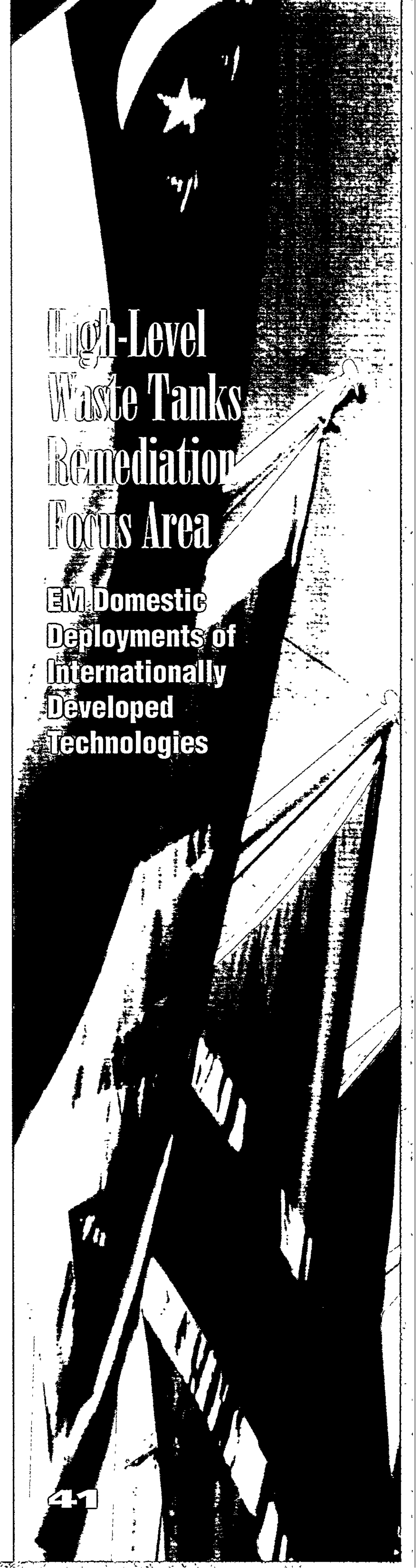
## Collaboration/Technology Transfer

Major developers of this technology include AEA Technology Engineering Services, Inc., ORNL's Robotics & Process Systems Division, and the PNNL's Energy Technology Division.

## Technology Benefits

*The AEA Pulse Jet Mixer offers many benefits over alternative technologies:*

- The life cycle of a pulse jet mixer is 25 years, as opposed to three years for a mechanical pump (replacement costs for a mechanical pump is approximately $1 million dollars).




- □ The system is nearly maintenance free because it has no moving parts inside the tank.
- □ The system can often connect to a tank using the tank's existing infrastructure, which will save several million dollars per installation.
- □ The system can be used for multiple tanks by being moved from tank to tank, or the system can be used to mix sludges in multiple tanks when cross-connections to nozzles exist.
- □ Rapid installation is possible due to a modular design, thereby minimizing worker exposure.
- □ Generation of secondary waste is minimized.

## Technology Capabilities/Limitations

One limitation found was that the sludge removal at Oak Ridge was limited by the physical characteristics of the sludge and the tank configuration.

## Technology Cost Savings Data

During the deployment of the Fluidic Pulse Jet Mixer at the Oak Ridge Reservation, a cost analysis was performed and showed the innovative technology reduced costs by 75% as compared to an alternative technology.

## Accomplishments and Ongoing Work

In December 1997, the Fluidic Pulse Jet Mixer was deployed at the Oak Ridge Bethel Valley Evaporator Service Tank (BVEST) W-21. The deployment safely transferred sludge and supernatant to secure storage and demonstrated the pulse jet mixing technique's applicability to DOE's underground storage tank remediation. The waste will be processed as part of the Melton Valley Storage Tanks-Transuranic (MVST-TRU) Waste Treatment and Disposal Project. The Pulse Jet Mixer retrieved between 80-90% of 6,000-10,000 gallons of sludge and supernatant from Tank W-21.

In February 1999, the Fluidic Pulse Jet Mixer safely transferred sludge and supernatant from ORNL's BVEST Tank C-2 and the Oak Ridge Reservation's tanks to secure storage. The innovative technology again demonstrated the pulse jet mixing technique's applicability to DOE's underground storage tank remediation. The waste will be processed as part of the MVST-TRU Waste Treatment and Disposal Project. The Fluidic Pulse Jet Mixer retrieved 98.9% of 8,180 gallons of sludge and supernatant from Tank C-2.

In June 1999, AEA's Fluidic Pulse Jet Mixer was installed at SRS F Tank Pump 1 to maintain sludge solids in suspension with supernate during waste transfer operations.

## Regulatory Acceptance Information

The wastes generated from the AEA Fluidic Pulse Jet Mixer deployment at Oak Ridge consist of PPE, contaminated equipment and hardware, plastic sheeting and containers, hydraulic fluids, and structural steel support and platforms. These materials must be decontaminated or disposed of as radioactive waste. The disposal site must meet Resource Conservation and Recovery Act Land Disposal Requirements (RCRA).

There were no regulatory issues associated with SRS's deployment of the AEA Fluidic Pulse Jet Mixer in F-Tank Farm Pump Tank 1.

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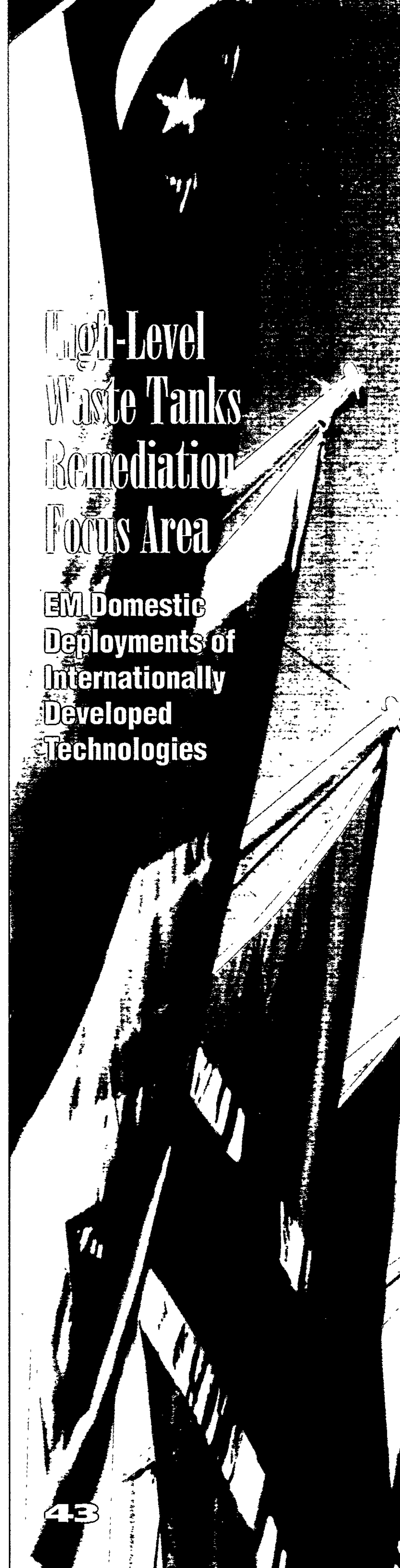



# Light Duty Utility Arm (LDUA)

**OST Technology Management System Number:** 85
**Domestic Deployment Sites:** Idaho National Engineering and Environmental Laboratory, Idaho Falls, Idaho; Hanford Site, Richland, Washington; Oak Ridge National Laboratory, Oak Ridge, Tennessee
**Country Developed:** Canada
**Deployment Dates:** INEEL 1998 to 2000; Hanford Site 1996; ORNL 1997 to 2000

## Technology Need

During the production of nuclear weapons and reprocessing reactor fuels, HLW was generated. This radioactive waste is currently stored in hundreds of DOE underground storage tanks requiring remediation. In order to effectively deactivate and decommission these tanks, the tanks require wall inspection, waste characterization, and waste retrieval. Improved methods and equipment are needed to characterize and monitor waste, waste products, processing facilities, and the environment during all aspects of waste storage, treatment, and disposal to reduce environmental, safety and health risks associated with these activities.

*Current baseline technologies for HLW tank remediation include:*

- For tank inspections, in-tank cameras.
- For waste sampling, baseline technologies can only sample directly below (no lateral sampling) the tank riser (portal giving access to tank waste).
- For waste remediation, 'past-practice sluicing' is used for bulk supernate and soft sludge only. This technology also adds a significant volume of water to the tank, increasing the volume of secondary waste.

## Technology Description

The LDUA is the core of a suite of technologies. It provides a mobile, multi-axis positioning system that accesses DOE's radioactive waste tanks through existing openings in the tank dome. This flexible and adaptive system provides a robotic platform capable of deploying in situ surveillance, inspection, waste analysis, and light-duty retrieval tools called end effectors. The system is operated remotely, reducing exposure to operators and provides significant advantages over prior methods that limited deployment of tools to positions directly below tank access risers.

A modified version of the LDUA, the MLDUA, was developed to support retrieval activities at the Oak Ridge Reservation. The MLDUA has the same capabilities as the LDUA with a slightly longer horizontal reach and greater payload capacity. The MLDUA is skid mounted as opposed to the truck-mounted LDUA.

## Collaboration/Technology Transfer

The LDUA was fabricated by Spar Aerospace of Brampton, Ontario, Canada with the assistance of numerous subcontractors. Development of the LDUA was coordinated by Westinghouse Hanford Company and contributions were made by PNNL, INEEL, LANL, ORNL, Sandia National Laboratories, and Westinghouse Savannah River Company (WSRC).

SPAR Aerospace was the major developer of the MLDUA with technical direction and oversight from ORNL, Westinghouse Hanford Company, and PNNL. The current vendor is MacDonald Dettwiler Space and Advanced Robotics.

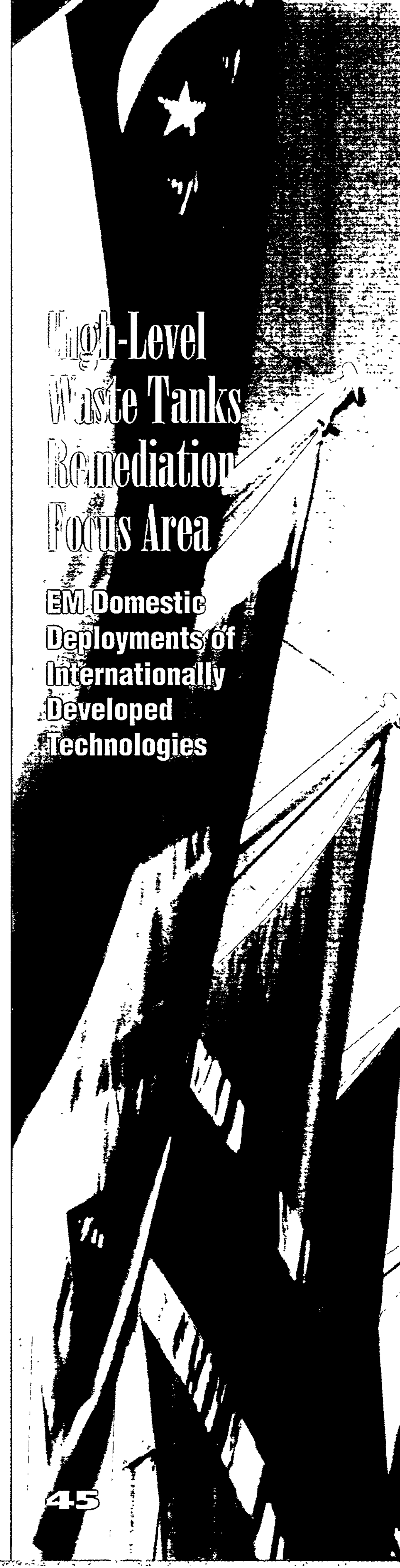
## Technology Benefits

*Benefits of the LDUA include:*

- Provides in-tank positioning capability over a large working volume for a variety of characterization and waste retrieval tools.
- Limits worker exposure through remote operations.
- Minimizes generation of secondary wastes by performing tasks in situ.
- System can be tele-operated or automated for repetitive or tedious tasks.
- Designed for use in high-radiation, chemically hostile environments.
- Easy decontamination and transport to multiple tasks.

## Technology Capabilities/Limitations

The LDUA system was developed to provide an integrated system of technologies to deploy tools and sensors, called end effectors, in underground storage tanks. Prior methods used at DOE tank sites were limited to positioning sensors and tools to locations directly below access penetrations. Although these methods of examination will still be used and are adequate for some operations, the LDUA system will greatly enhance the DOE's capability to perform in-tank operations. The LDUA system has a flexible and adaptive design that allows it to be used for many types of in-tank operations. The system has the significant benefits of limiting worker exposure through remote operations and minimizing generation of secondary wastes by performing tasks in situ. Ongoing development of end effector technologies for the system will provide new capabilities to support existing programs and to respond to new initiatives directed towards characterization, mitigation of safety issues, and remediation of waste storage tanks.




The system is functionally divided into major equipment subsystems and additional ancillary and support equipment. These subsystems include (1) arm and deployment system, (2) tank riser interface and confinement system, (3) operations control center, (4) utilities and support systems, and (5) end effectors. Three types of LDUA deployment platforms have been delivered to support specific site needs at the Hanford Site, ORNL, and the INEEL. The Hanford Site LDUA is a truck-based system providing a light-duty payload primarily focused on inspection and characterization applications. This design was modified to provide a lighter weight trailer based mobile platform for INEEL, due to concerns on tank dome loading restrictions. Other aspects of the INEEL system are identical to the Hanford Site LDUA. The LDUA was developed for the ORNL Gunite and Associated Tanks (GAAT) to enable the technology to be extended to perform waste heel retrieval operations, characterized by a 45-ft. vertical extension, 15-ft. horizontal reach, and 200-lb. payload, it has the ability to be deployed through a 12-in. riser.

*The toolbox of various end effectors deployed by the LDUA will enable tank cleanup:*

- Remote Tank Inspection End Effector—a non-destructive evaluation for analyzing tank surface integrity.
- Stereo Viewing System End Effector—enables stereoscopic close-up viewing of the tank surface and features, and tank waste contents.
- Heel Sampling End Effector—will obtain solid from the tank bottom.
- Pipe Cutting and Isolation System—will cut, clean, and cap pipes within the tank.
- Gunite Scarifying and Confined Sluicing End Effectors—utilizes water jets to scour hard tank waste and tank surfaces followed by retrieval of sluicing water with entrained waste that has been mobilized.

## Technology Cost Savings Data

Although the LDUA does not directly account for cost savings the technology does indirectly result in cost savings realized through the deployment of its various specialized end effector. For example, deployment of the Robotic Tank Inspection End Effector (RTIEE) results in cost benefits because the data obtained on tank structural conditions may enable a less expensive closure option to be selected. Furthermore, if the RTIEE reveals that tank structural integrity is acceptable, tanks with little or no waste could be reused instead of building new tanks. The cost of a new tank at the INEEL is $67 million. INEEL could have the need for additional tanks and the RTIEE could fulfill the tank reuse certification need.

## Accomplishments and Ongoing Work

Ongoing development of end effector technologies for the LDUA will provide new capabilities to support existing programs and respond to new initiatives directed towards characterization, mitigation of safety issues, and remediation of waste storage tanks.

Three types of LDUA deployment platforms have been delivered to support specific site needs at the Hanford Site, ORNL, and INEEL. The Hanford Site LDUA is a truck-based system providing a light-duty payload primarily focused on inspection and characterization applications. The Hanford Site LDUA was deployed in September 1996 in Tank 241-T-106 and is being prepared for additional deployments.

The LDUA design was modified to provide a lighter weight trailer based mobile platform for INEEL, due to concerns of tank dome loading restrictions. Other aspects of the INEEL system are identical to the Hanford Site LDUA. The INEEL LDUA was deployed in 1998 through 2000 to sample liquid waste and inspect the tank structure.

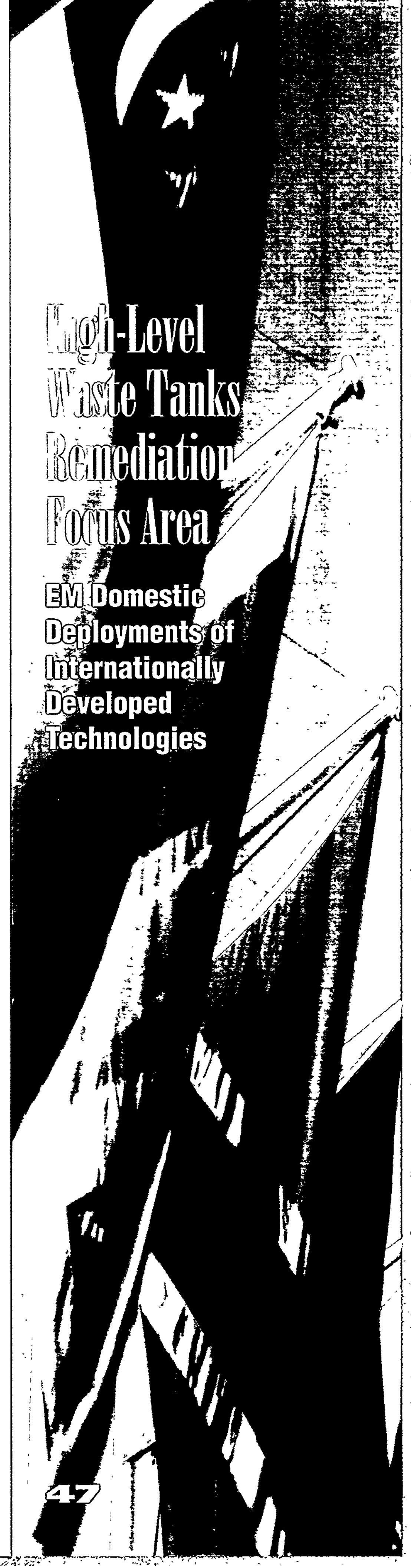
The LDUA was deployed in 1997 through 2000 at the ORNL and has successfully been used to retrieve waste from several of the GAATs and is being used in ongoing operations.

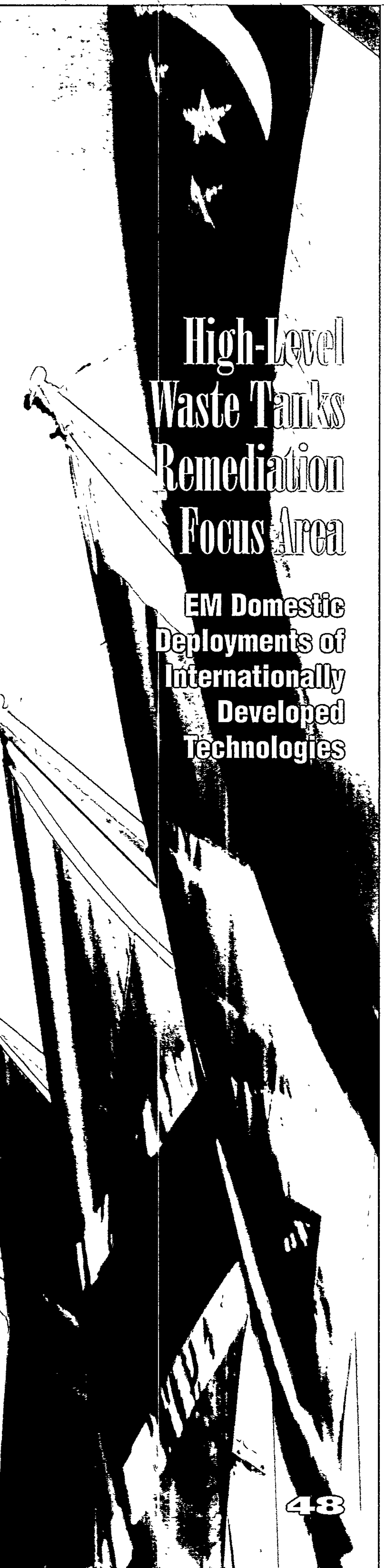
Cold test of the LDUA under the GAAT Treatability Study with characterization and waste retrieval tools as an integrated system was completed in mid FY97. Initiated in June 1997, the MLDUA was deployed at ORNL Gunite tanks for characterization and remote waste retrieval operations. ORNL demonstrated the ability to remove sufficient waste from tanks to allow the tanks to be closed and enable progress on the restoration of the Bethel Valley Watershed. By March 1999, the arm and associated technologies had removed sludge and debris from two 85,000 gallon tanks and two 170,000 gallon tanks at ORNL.

## Regulatory Acceptance Information

No regulatory issues or special permits were required with the use of the LDUA at Hanford or ORNL. The main regulatory concern was the selection of hydraulic fluid used, because small amounts leak into the tank during operation. Because the standard petroleum-based hydraulic fluid could cause regulatory problems if enough leaked into the tank, both systems use a mineral oil-based fluid that does not present regulatory difficulties. This technology addresses requirements in CERCLA and RCRA at ORNL.

Secondary wastes generated by the retrieval equipment include used parts and decontamination supplies. Except for reusable equipment, items used in the tank are considered contaminated equipment and are disposed of as hazardous waste.



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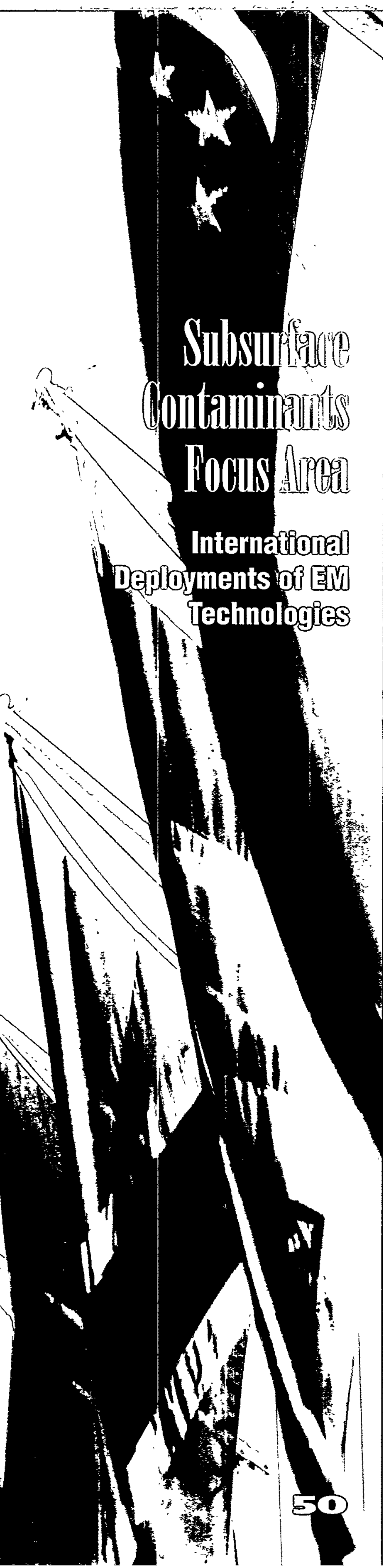
# Subsurface Contaminants Focus Area




# DNAPL Bioremediation—Remediation Technologies Development Forum: Natural Attenuation: Principles and Practices

**OST Technology Management System Number:** N/A
**International Deployment Site:** Western Europe
**Deployment Date:** FY98

## Technology Need

Chlorinated hydrocarbon contamination such as trichlorethylene (TCE) and tetrachloroethylene (PCE) have been used for many years by industry and the federal government during routine operations. These compounds were disposed of in a variety of ways that caused groundwater contamination. Based on a survey of 3% of the waste sites on DOE lands, it can be estimated that there are over 800 plumes of TCE and/or PCE contaminated groundwater across the DOE complex alone. The U.S. Department of Defense (DOD) and the private sector (as well as numerous environmental consortia in Europe) also recognize this type of contamination as a priority.

## Technology Description

Natural attenuation (also known as intrinsic remediation or natural restoration) was defined by Office of Solid Waste and Emergency Response of the Environmental Protection Agency (EPA) as follows:

The term "natural attenuation" refers to naturally-occurring processes in soil and groundwater environments that act without human intervention to reduce the mass, toxicity, mobility, volume or concentration of contaminants in those media. These in situ processes include biodegradation, dispersion, dilution, adsorption, volatilization and chemical or biological stabilization or destruction of contaminants.

Simply stated, natural attenuation would be an accepted remedy when physical, chemical, and/or biological processes act to reduce the mass, toxicity, and/or mobility of subsurface contamination in a way that reduces risk to human health and the environment to acceptable levels.

The Remediation Technologies Development Forum (RTDF) Bioremediation of Chlorinated Solvents working group performed in-depth laboratory and field studies to better understand and predict natural attenuation. As a result of these efforts, the RTDF group assisted in the development of a "Principles and Practices" manual and training course for Natural Attenuation, which together serve as a framework to evaluate natural attenuation of chlorinated volatile organic compounds (VOCs) based on scientific knowledge. This information has been provided to regulators and stakeholders across the U.S. in an effort to increase the awareness and therefore the reliability of natural attenuation.

## Collaboration/Technology Transfer

The RTDF Bioremediation of Chlorinated Solvents Working Group includes the following members: Dow, DuPont, EPA, General Electric, Geosyntech, ICI, Monsanto, Novartis, DOE, DOD, and Zeneca.

The Natural Attenuation Training Course was jointly developed and delivered by the Interstate Technology and Regulatory Cooperation in situ bioremediation work group.

A European version of the course was subsequently championed by ICI and the Network for Industrially Contaminated Land in Europe. This European version of the course is currently planned for conversion into a distance learning package with assistance from the UK Institute of Petroleum, ICI, the UK Atomic Energy Authority, the UK Environment Agency, BP Amoco, and Shell.

## Technology Benefits

Some of the commonly recognized benefits of natural attenuation include: 1) it provides for in situ destruction with no waste generation, 2) it is already occurring at many sites, 3) the most toxic and mobile organic contaminants usually degrade most quickly and reliably, 4) it is non-intrusive, 5) it is cost effective, 6) it is easily combined with other remedies, and 7) there is no "down time" due to equipment failures.

## Technology Capabilities/Limitations

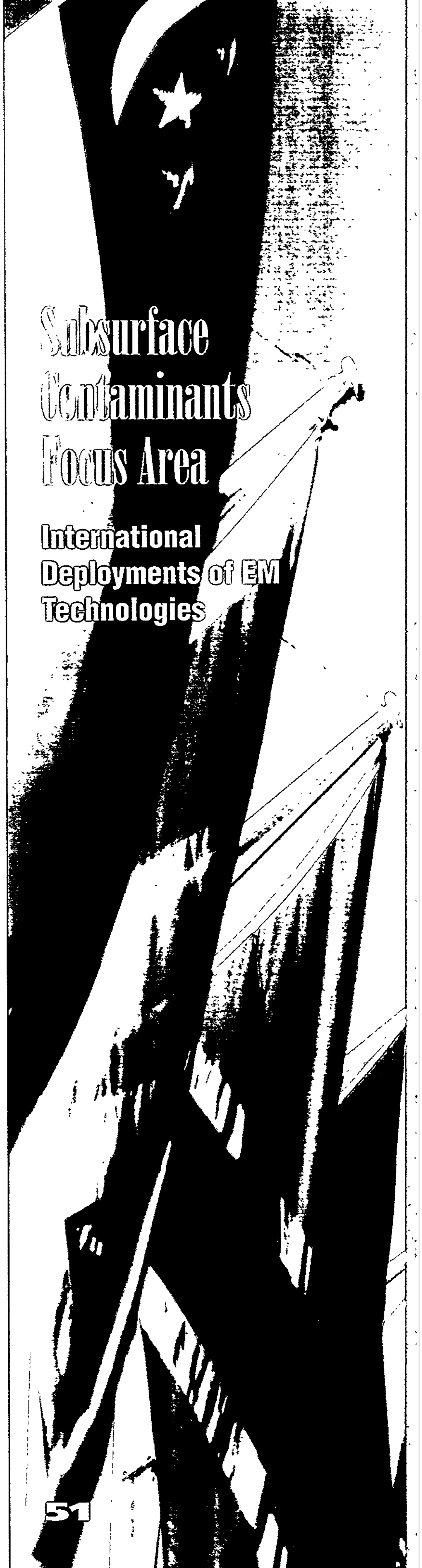
Some of the disadvantages of natural attenuation include:1) remediation time frames may be as long as those required by groundwater extraction and treatment, 2) requires continuous monitoring (therefore requiring careful cost estimating prior to implementation), 3) aquifer heterogeneities complicate site characterization (not unique to natural attenuation), and 4) intermediates of biodegradation may be more toxic than original contaminants.

## Technology Cost Savings Data

This is difficult to provide, although in general natural attenuation would not be applied at a specific site unless it is estimated to be more cost effective than other potential remedies.

## Accomplishments and Ongoing Work

The Natural Attenuation Training Course has been provided to over 1,500 regulators and stakeholders across the U.S. Current efforts in Europe continue to expand the dissemination of this information.




## Regulatory Acceptance Information

Traditionally, regulatory acceptance hurdles included the public misperception that natural attenuation was a "do nothing" approach, as well as a lack of experience and expertise on the part of regulators. One of the primary purposes of the training course was to provide the necessary information and expertise to regulators and stakeholders such that natural attenuation can be reliably applied to specific sites, thereby establishing confidence and ultimately increasing the acceptance of this technology.

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# Phytoremediation of Heavy Metal Contaminated Soils

**OST Technology Management System Number:** 2188
**International Deployment Site:** Katowice, Poland
**Deployment Date:** FY99

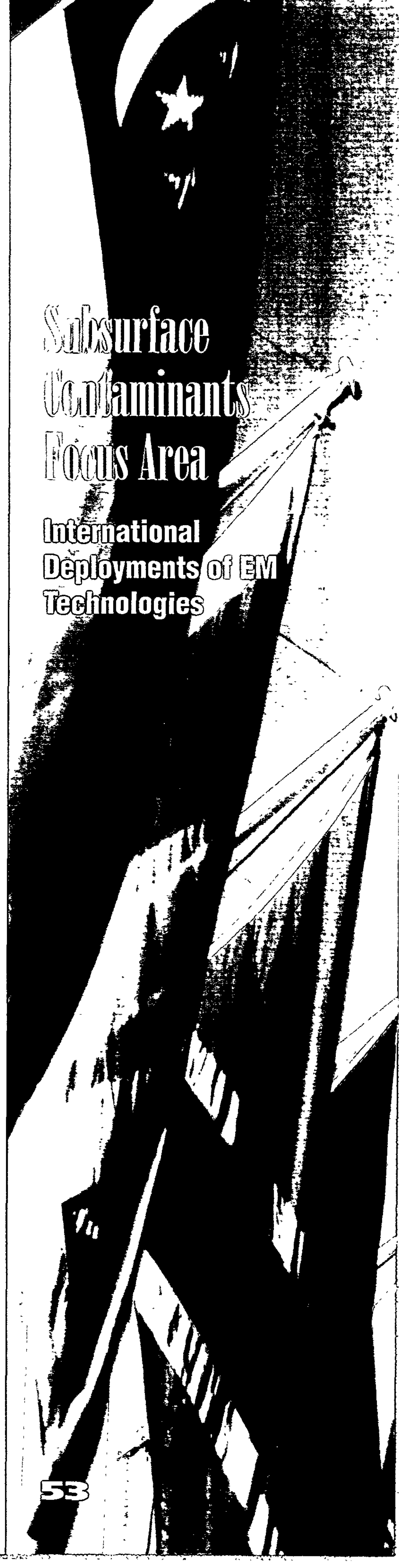
## Technology Need

The DOE complex faces a wide variety of environmental contamination problems, including heavy metal contamination of soil. DOE sites at Oak Ridge, Hanford, Argonne, Savannah River, Idaho, and Brookhaven all have extensive heavy metal contamination in soils. Technologies currently do not exist to economically remove heavy metals from large areas of contaminated surface soil. Existing technologies are best applied to small areas with high levels of contamination, and are quite expensive. There is, however, a need within the DOE complex for technologies that address low to moderate levels of soil contamination over relatively large areas.

The Upper Silesian region of Poland also has many sites contaminated with heavy metals due to decades of mining and non-ferrous metals smelting. Additionally, soil conditions in many of the prime agricultural areas of Poland do not meet national standards for contaminant concentrations, and are thus placed under restrictions. Persistent pollutants, most notably heavy metals, are the major reason for these restrictions. Remediation of these lands continues to be a major objective for the Polish government.

In 1995, DOE signed a Memorandum of Cooperation with the IETU, Katowice, Poland. The overall objective of this joint international project between the United States and Poland is to assist DOE in meeting its environmental restoration and waste management goals. These goals are to be accomplished by developing technologies that are safer, faster, more effective and less expensive than many of those currently in use, as well as by encouraging the introduction and use of U.S. environmental technologies and services outside of the United States. Developing technologies are advanced by this cooperative association by identifying, evaluating and deploying Central & Eastern European technologies, as well as by field testing appropriate U.S. developed technologies in southern Poland. In addition to the advancement of DOE environmental remediation needs, this project will provide Poland, as well as other countries in the region, with exposure to and experience in U.S. site characterization, risk assessment and remediation methods and technologies. This will enable these countries to more effectively cope with their own environmental problems that are often pervasive and widespread due to decades of environmental neglect.

The development and demonstration of phytoremediation of heavy metals was seen as an ideal application for this cooperative research association.



## Technology Description

Phytoremediation is the application (planting/growing/harvesting) of selected plant species that are known to uptake (in proportions higher than other species) contaminants such as heavy metals and radionuclides from soil. Phytoremediation applies to sites which have low to moderate concentrations of these contaminants (but which are still of concern to regulators and stakeholders). Since the rate of uptake is limited by the plant's rate of growth, phytoremediation is a somewhat slower process than more aggressive (but costlier) approaches like soil excavation. The method has been shown to be effective for the lead, copper, cesium, arsenic, cadmium, zinc, nickel, and uranium.

Phytoremediation is in an unusual state of development at the current time. The academic research behind heavy metal accumulation by plants has lead to an interest in the commercialization of this technology for environmental remediation. Considerable research has been conducted and reported on the laboratory-scale application of phytoremediation. Little information is available concerning the full-scale application. The goal of this project continues to be the optimization of full-scale application of phytoremediation and the development and presentation of those results. It is intended that this information will assist DOE in evaluating this technology for application within the DOE complex. The target metal for this project is lead in soil (cadmium also is being evaluated).

## Collaboration/Technology Transfer

The primary developers of this technology are Florida State University and the IETU in Poland in collaboration with WSRC. This project initially collaborated with one of the leading commercial developers of phytoremediation—Phytotech. Phytotech has recently gone out of business, however the technology rights have been purchased and initial discussions are planned with the new technology holder.

## Technology Benefits

The phytoremediation technology is expected to significantly lower risks. Two scenarios apply: 1) if, due to the baseline cost and lack of strong regulatory pressure, a soil site with low levels of contamination is unremediated, then an exposure risk remains that could be reduced through phytoextraction; and 2) compared with the baseline (excavation, transport and disposal of contaminated soil), there will be less potential for exposure to the contaminated soil.

This innovative technology also fills a technology gap where remediation currently cannot be performed. Potential applications for this technology include any site with low levels of metals or radionuclides in surficial soils such as Argonne, SRS, Fernald, Brookhaven, and Rocky Flats.

## Technology Capabilities/Limitations

Phytorextraction is applicable to any site that will support plant growth and to any contaminant that has been shown to be taken up by plants. Plants take up contaminants gradually and perform better in multiple crops.

*Phytoremediation is limited by certain site conditions:*

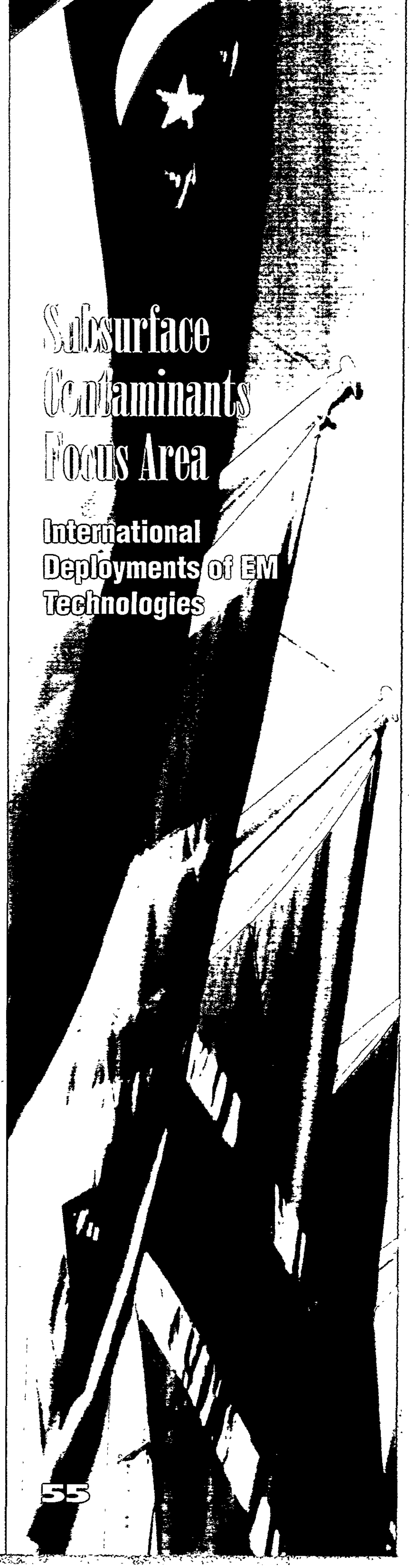
- Site soil must be capable of supporting plant growth.
- The contaminants must lie within depths penetrated by roots (approx. 50 cm).
- Only the bioavailable fraction of soil contaminants will be able to taken up by the plants. Soil amendments are used to increase the portion of contaminants that are bioavailable, however, phytoremediation will remove 100% of contamination in most circumstances.
- Multiple crops of plants will be required to remove all available contamination. This will result in a multi-year remediation effort in most cases.

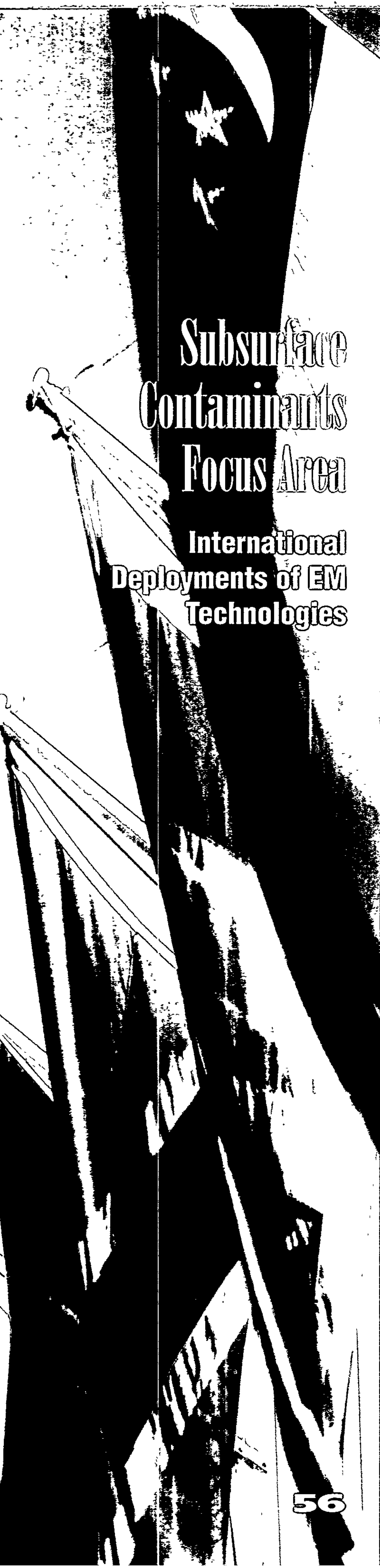
## Technology Cost Savings Data

Cost benefits are expected. For sites with relatively low levels of shallow soil contamination, phytoextractiontion should have a cost advantage over the equipment and labor-intensive baseline approach of excavation/transport/disposal. However, even in the absence of a cost savings, phytoextraction results in the removal of contamination from site soils. The baseline technology transports the contaminated soil to a site for disposal.

## Accomplishments and Ongoing Work

Phytoextraction of heavy metals from soils is being evaluated by the IETU in Katowice, Poland as the baseline technology for removing low to moderate levels of heavy metals (e.g., lead, cadmium) from large areas of surface soil. This project has evaluated phytoextraction at a large scale (1 hectare) using standard agricultural methodologies and equipment. This large scale application was used to quantify the costs of a full-scale phytoextraction deployment. Current activities focus on cost reduction and process optimization. The objective of this project is to collect information necessary to support a large scale deployment of phytoextraction at a DOE site.






*FY99 activities included:*

1. **Evaluation of Soil Amendment Ethylenediaminetetracetic Acid (EDTA)**: soil microbial toxicity tests were conducted for the phytoextraction amendment EDTA. The results show that EDTA does not adversely affect soil microbial populations.

2. **Management of Contaminated Crops**: various methods for harvesting and disposing of the contaminated plants were investigated. Harvesting considerations included timing the harvest to minimize material loss through plant tissue aging and decomposition, managing the physical harvesting to maximize the recovery of contaminated material while using standard agricultural methods, and handling the harvested materials to minimize loss and adverse impacts to human and non-human receptors.

3. **Amendment Application Technology**: developed a mechanized approach to amendment application that utilizes modified agricultural equipment and should result in a faster, more uniform and accurate application of amendments to target soils. A design protocol was developed and was tested under full field conditions.

4. **Streamlined Site Characterization and Treatability Studies**: developed an approach that integrates site characterization and identification of optimal conditions for the proposed plant species to extract the target contaminants into one step in order to facilitate rapid decisions concerning technology feasibility, and to reduce cost and effort.

5. **Soil and Plant Amendment Studies**: new specialized plant species and soil amendments were identified as candidates for the phytoextraction process, and were applied in a field scale demonstration to evaluate their effectiveness and costs. Native plant species continued to be screened for metal accumulation capabilities.

*FY00 activities include:*

1. **Computerized Application of Soil Amendments (Phytoremediation)**: development of an automated soil amendment device to quickly apply amendments based on soil metal concentration, which could reduce costs up to 30%.

2. **Evaluation of Novel Mercury Remediation Technology**: site characterization study to identify an appropriate site for field testing of a new technology for reducing the bioavailability of ionic forms of mercury in soil and groundwater.

## Regulatory Acceptance Information

Regulatory hesitancy is anticipated for phytoextraction. Work being conducted in this project, as well as a growing interest in this technology should provide the basis for discussions with regulators. Specific objectives of this project were designed to address potential regulatory concerns.

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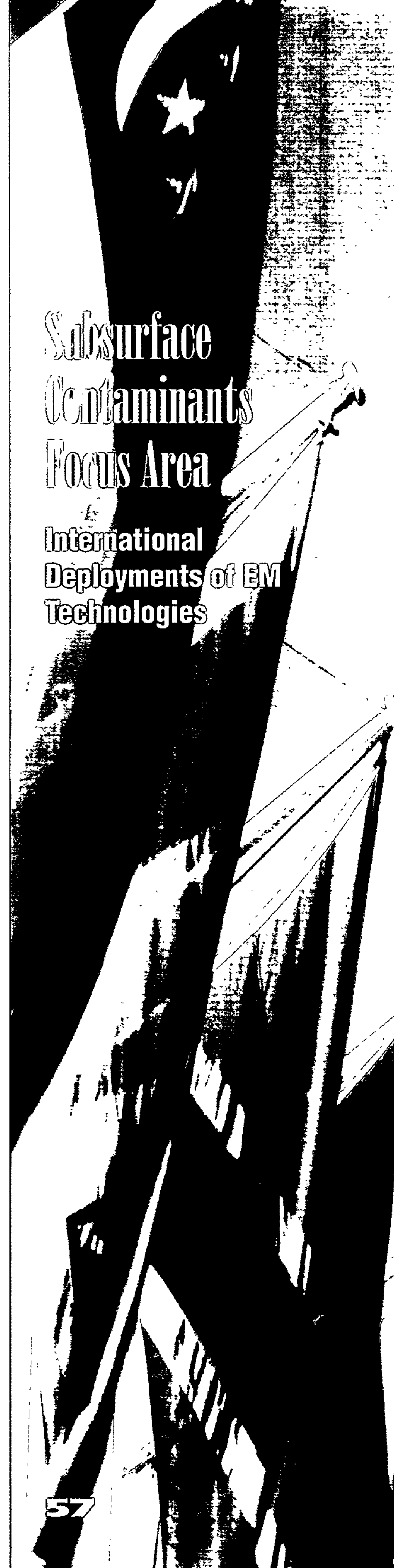



# Baroball™

**OST Technology Management System Number:** 2331
**International Deployment Site:** Czechowice Oil Refinery, Poland
**Deployment Date:** FY97

## Technology Need

In 1995, DOE signed a Memorandum of Cooperation with the IETU, Katowice, Poland. The overall objective of this joint international project between the United States and Poland is to assist DOE in meeting its environmental restoration and waste management goals. These goals are to be accomplished by developing technologies that are safer, faster, more effective and less expensive than many of those currently in use, as well as by encouraging the introduction and use of U.S. environmental technologies and services outside of the United States. Developing technologies are advanced by this cooperative association by identifying, evaluating, and deploying Central & Eastern European technologies, as well as by field testing appropriate U.S. developed technologies in southern Poland. In addition to the advancement of DOE environmental remediation needs, this project will provide Poland, as well as other countries in the region, with exposure to and experience in U.S. site characterization, risk assessment and remediation methods and technologies. This will enable these countries to more effectively cope with their own environmental problems that are often pervasive and widespread due to decades of environmental neglect.

The Czechowice Oil Refinery in southern Poland, formerly the Vacuum Oil Company (a U.S. company), has been producing petroleum products for industrial and commercial applications for over 100 years. Disposal practices, including unlined, above ground lagoons for process waste disposal, have contaminated soils with petroleum hydrocarbons, and created conditions that are unacceptable under current environmental standards in Poland. Currently available clean-up technologies are inadequate or unacceptable due to excessive costs, increased risks, long schedules or the production of secondary waste streams, the need to identify and evaluate innovative remediation technologies is critical. A DOE-supported bioremediation technology demonstration project was conducted at the refinery. The biopile constructed at the refinery required subsurface oxygenation - the Baroball™ technology provided a low-cost passive approach for pumping air through the subsurface.

Bioremediation, as practiced in this project and implemented in the biopile, relies on the presence of indigenous microbial communities with the capability of degrading the target contaminants. The approach for this technology is to identify those physical or chemical parameters that limit the activity of the target microbes and to then increase the availability of the limiting factors. Oxygen is frequently a limiting factor in bioremediation. This was true of the Czechowice Oil Refinery biopile. Oxygen is provided to the biopile by pumping air through the subsurface. The baseline technology for such pumping uses commercial electric blowers that provide a predetermined flow of air through a subsurface aeration system. The Baroball™ technology provides a passive pumping capability that is driven by changes in barometric pressure, and was used in this project to provide oxygen to enhance the activity of microbial communities associated with a petroleum-contaminated soil biopile.

## Technology Description

Barometric pumping was originally developed to remove VOCs from the soil by taking advantage of changes in barometric pressure above and below ground. Wells screened in the unsaturated zone have been observed to inhale ambient air and exhale soil and gas. These natural airflows in wells are determined by barometric pressure fluctuations, permeability of the subsurface, and depth of the well screen. The difference between surface and subsurface pressures is the driving force for these flows. When the subsurface pressure is higher, contaminants naturally move upward where they can be treated/released. Its design consists of a simple plastic sphere that seals the well from incoming surface air. In the case of the biopile, the passive movement of air through the target subsurface area was the objective of the Baroball™ deployment.

## Collaboration/Technology Transfer

The major developer of this technology is DOE/OST. Following development, the technology was commercialized. The devices used in this project were acquired commercially from a U.S. vendor.

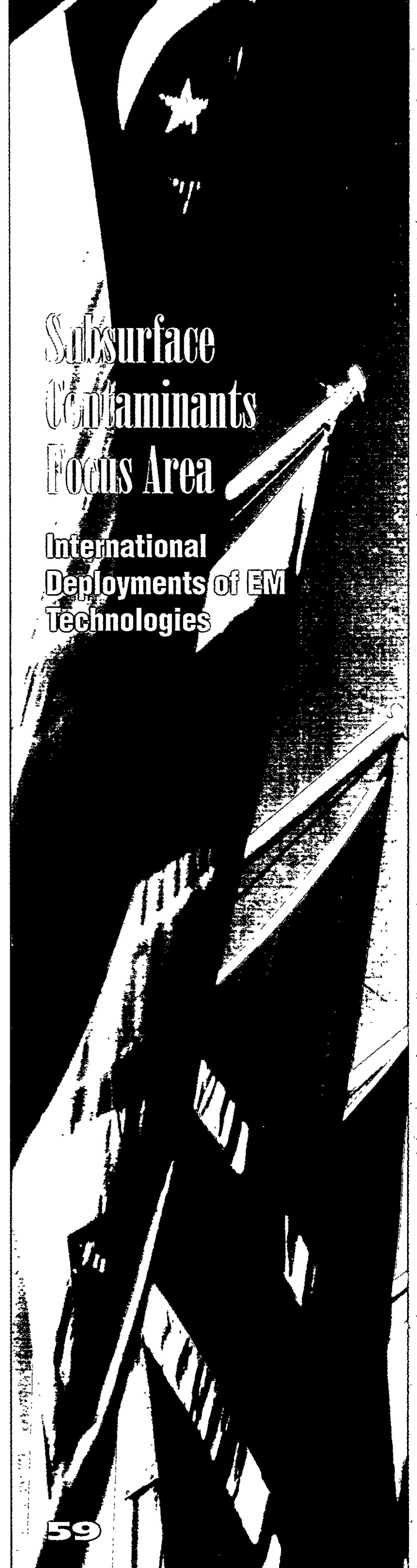
## Technology Benefits

*Benefits of the Baroball™ technology include:*

- Ease of installation and low maintenance operation.
- Reduced costs for removing contaminants from the subsurface.
- Significantly increases the effectiveness of barometric pumping by preventing the inflow of air into a venting well when atmospheric pressures reverse, a condition that can reduce contaminant removal by diluting and disbursing the pollutant.

## Technology Capabilities/Limitations

The Baroball™ technology is capable of providing air to subsurface microbial communities. The effectiveness of this approach was documented in the Czechowice Oil Refinery biopile project. The limiting factor in this application was the rate at which this air deliver took place. The existing microbial community adjusted to the increased oxygen presence by increasing the degradation of petroleum hydrocarbon contaminants. This adjust-




ment was less than in the actively (blower) aerated section of the biopile, however the process was effective in both cases. The Baroball™ technology as deployed in the biopile balances the additional time to reach a target remediation standard with a reduction in construction and operating costs.

## Technology Cost Savings Data

The cost of the Baroball™ devices themselves is negligible. The operating cost of the Baroball™ technology is essentially zero (there is a need for minimal inspection and maintenance to maintain the performance of the seal). This is in comparison with the significant costs of acquiring, installing, and maintaining an electric blower.

## Accomplishments and Ongoing Work

This project demonstrated the effectiveness of the Baroball™ technology for passive pumping of air as an oxygenation process for bioremediation.

## Regulatory Acceptance Information

The Baroball™ technology is a proven device that uses barometric fluctuations to move air through the subsurface. The volume of this movement can be predicted from atmospheric data, resulting in an accurate estimate of the performance of this "pump". In those situations where the potential pumping rate is acceptable for site remediation needs, the Baroball™ is an acceptable alternative to active pumping.

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# Biopile

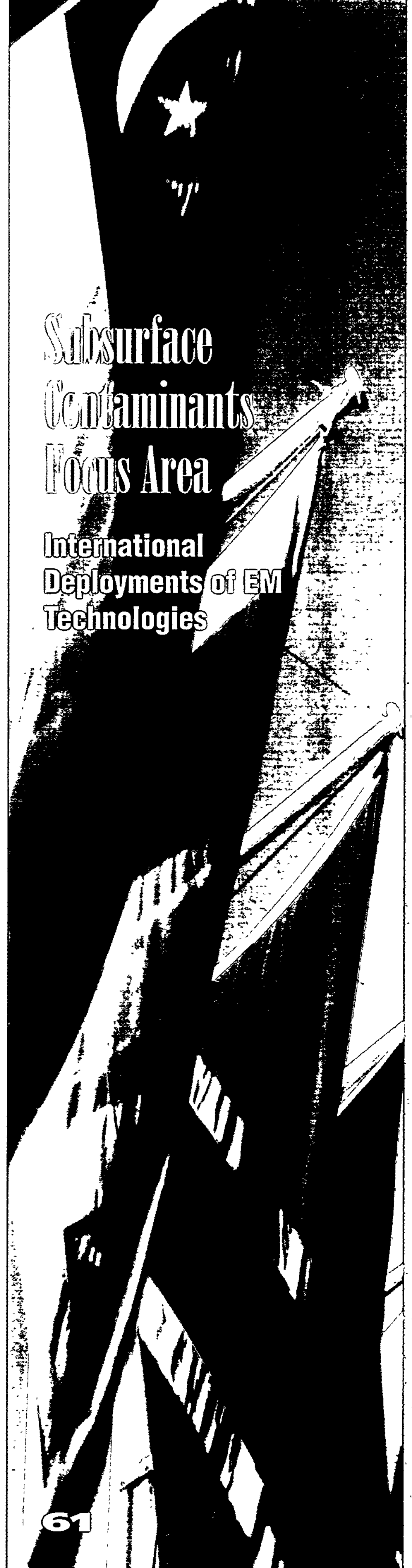
**OST Technology Management System Number:** N/A
**International Deployment Site:** Czechowice Oil Refinery, Poland
**Deployment Date:** FY97

## Technology Need

Petroleum contaminated soils represent a widespread problem internationally. The U.S. DOE complex contains a large number of contaminated sites, many of which have identified petroleum products among the contaminants. DOE sites with petroleum contamination include petroleum storage facilities, historic disposal areas and landfills, which are estimated to contain over 3 million cubic meters of buried waste. This waste exists in a variety of forms, including petroleum hydrocarbons, and has the potential to contaminate the environment. It is estimated that over 200 million cubic meters of soil are contaminated with petroleum and other hazardous wastes.

The Czechowice Oil Refinery in southern Poland, formerly the Vacuum Oil Company (a U.S. company), has been producing petroleum products for industrial and commercial applications for over 100 years. Disposal practices, including unlined, above ground lagoons for process waste disposal, have contaminated soils with petroleum hydrocarbons, and created conditions that are unacceptable under current environmental standards in Poland. Currently available clean-up technologies are inadequate or unacceptable due to excessive costs, increased risks, long schedules, or the production of secondary waste streams, the need to identify and evaluate innovative remediation technologies is critical.

In 1995, DOE signed a Memorandum of Cooperation with the IETU, Katowice, Poland. The overall objective of this joint international project between the United States and Poland is to assist DOE in meeting its environmental restoration and waste management goals. These goals are to be accomplished by developing technologies that are safer, faster, more effective, and less expensive than many of those currently in use, as well as by encouraging the introduction and use of U.S. environmental technologies and services outside of the United States. Developing technologies are advanced by this cooperative association by identifying, evaluating and deploying Central & Eastern European technologies, as well as by field testing appropriate U.S. developed technologies in southern Poland. In addition to the advancement of DOE environmental remediation needs, this project will provide Poland, as well as other countries in the region, with exposure to and experience in U.S. site characterization, risk assessment and remediation methods and technologies. This will enable these countries to more effectively cope with their own environmental problems that are often pervasive and widespread due to decades of environmental neglect.




## Technology Description

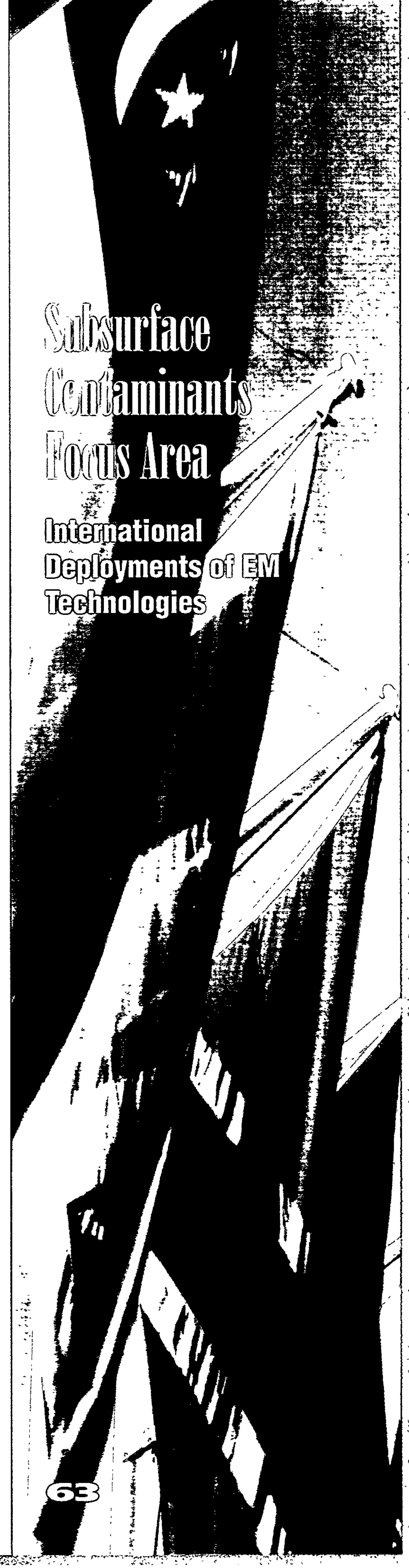
This project focused on the use of a form of bioremediation known as biostimulation. This is a process in which conditions for the growth of indigenous microbes are optimized by supplying adequate amounts of electron acceptor(s), water and nutrients (e.g., nitrogen, phosphorus and trace elements), to the contaminated material. Because biodegradation rates for petroleum hydrocarbons are fastest under aerobic conditions, maintaining adequate oxygen levels and moisture control are two of the key scientific considerations associated with this project.

The biopile process is very similar to active bioventing, where air, as an oxygen source, and other amendments are forced through the vadose zone sediments either by vacuum extraction or by injection to stimulate the microbial oxidation of the hydrocarbons. As the name implies, biopiling is an ex situ process. The contaminated material is excavated and recombined or amended with other materials before being placed in an engineered structure to support and stimulate the biological reactions necessary to oxidize the hydrocarbons.

## Collaboration/Technology Transfer

Participants in this project include: DOE-EM, IETU, Czechowice Oil Refinery, Florida State University, Ames Laboratory, and WSRC. DOE is the project sponsor and provides overall project direction. The IETU is the Polish partner in this activity and provides most of the hands-on research activity. The Czechowice Oil Refinery provides the location for this technology development activity. The Refinery provides on-site logistical and infrastructural support to the project. Florida State University, through a Cooperative Agreement with DOE, provides overall project management and is the source of funding for IETU and refinery activities. Ames Laboratory provided the expertise to plan, implement, and evaluate a site characterization effort using the Expedited Site Characterization (ESC) methodology. WSRC, Biotechnology Group provided oversight for the design and deployment of an innovative bioremediation technology.

U.S.-derived technologies and U.S. vendors, or their subsidiaries are used whenever applicable. The project utilized a number of U.S. (and DOE-) developed technologies, including: ESC, direct push subsurface sampling (Geoprobe, Cone penetrometer), and BaroBalls™. Technology advances resulting from this project are returned to DOE through WSRC. Some of the knowledge gained in this project has already been applied to landfill remediation activities at SRS.





## Technology Benefits

Petroleum contaminated soil is a widespread concern for DOE, other federal agencies, and a variety of commercial interests in the U.S. and worldwide. The advances in bioremediation of petroleum hydrocarbons that result from this project can reduce the cost and increase the efficiency of deploying bioremediation. Specifically, the design advances will reduce the initial costs of biopile construction, while the data on operational parameters (e.g., aeration) will reduce the costs of operation.

## Technology Capabilities/Limitations

Bioremediation has been shown to be a viable approach to remediation of petroleum hydrocarbon contamination of soils. The advances made by this project promise to increase the efficiency of this technology while decreasing the costs. Bioremediation, as practiced in this project, relies on the presence of indigenous microbial communities with the capability of degrading the target contaminants. The approach for this technology is to identify those physical or chemical parameters that limit the activity of the target microbes and to then increase the availability of the limiting factors. In this context, there are few limitations to the application of bioremediation to the remediation of organic contamination. The technology is capable of degrading organic contaminants in a wide variety of environmental settings at relatively low cost.

## Technology Cost Savings Data

Collection of cost data was not a primary objective of this research-oriented project. However, estimates of the costs of this approach to bioremediation are comparable to other potentially-applicable technologies. The advantage of the biopile approach used in this project is the immediate reduction in potential exposure (and therefore risk) and the ability to deal with contamination on-site without the need for sophisticated technology.

## Accomplishments and Ongoing Work

The innovative biopile design used a combination of passive and active aeration in conjunction with injection of nutrients and surfactants to increase biodegradation of the very acidic soil containing high concentrations of polynuclear aromatic hydrocarbons. Simultaneous lab studies using soil columns were used to optimize treatment techniques and verify field observations under more controlled conditions. This full-scale demonstration showed that, with minimal cost, the total mass of petroleum hydrocarbons could be

reduced by more than 81% (120 metric tons) over the 20 month project. During this time the most toxic compounds were reduced to levels acceptable for multi-use resource activities. Though a variety of biodegradation monitoring methods were used, measures of microbial number and activity (i.e., direct fluorochrome counts and dehydrogenase activity) were found to be best correlated with rates of biodegradation in the biopile. In addition, our data indicate that passive aeration could reach the same end point as active aeration, it would just take longer. Rates of biodegradation were comparable to other prepared bed studies of petroleum contaminated soil, i.e., 121 mg/kg soil/day (82 mg/kg soil/day in the passive side). However, given that this material was highly weathered and very acidic these rates are much higher than expected. Much of this increase can probably be attributed to the vegetative material added as a bulking agent, surfactant addition, and to the aeration process.

The finding that microbial counts and dehydrogenase measurements accurately reflect biodegradation rates suggests that these direct measurements can be used to provide real time control of biopile operation to maximize biodegradation rates under a variety of conditions. The cost savings from passive aeration may provide an advantage over active aeration when clean-up time is not a primary consideration. This demonstration also emphasized that biodegradation is initially quite rapid, but in less than 12 months requires additional stimulation via nutrient or surfactant addition. The remediation strategies that have been applied at the Czechowice Oil Refinery waste lagoon were designed, managed, and implemented under the direction of the Savannah River Technology Center/IETU team in cooperation with the Czechowice Oil Refinery and Florida State University, for DOE. This collaboration between DOE, IETU, and its partners, provides the basis for international technology transfer of new and innovative remediation technologies that can be applied to DOE sites, in Poland, and at other locations worldwide.

During the operation of the biopile, several unique indigenous microbes have been discovered. Due to the long operating history of the refinery and the use of an acid cracking process to refine the crude oil, indigenous microbial communities have adapted to the low pH environment and low temperature climate. These conditions are of interest to DOE, since many of DOE's sites have acidic wastes and are located in colder climates.

The project currently identified 36 microbial isolates, which may exhibit properties and capabilities currently unreported in scientific literature. Microbial analysis and isolation will provide the opportunity to determine if any of these microorganisms are unique and, thus, patentable for use at contaminated DOE sites with conditions similar to those found in Poland. By identifying and patenting unique microorganisms/bioprocesses, DOE would be ensuring that these organisms are available for use throughout the DOE complex and the world.

*Ongoing projects include:*

- ☐ The testing of the effectiveness of surfactants in the biopile.
- ☐ Long-term monitoring of degradation activity following active bioremediation.
- ☐ A microbial patentability study.
- ☐ Application of the biopile technology to a mobile "bioreactor" that could be deployed to remediate small-scale spills and Investigatively-Derived Waste (IDW) resulting from site characterization activities.
- ☐ Completion of a report on bioremediation to assist DOE in identifying new areas of research through which the specific techniques learned during this deployment can be applied to environmental remediation of the DOE complex.

## Regulatory Acceptance Information

Bioremediation is a well-accepted technology for many types of organic contamination. The advances made in this project should not result in regulatory concern. In the event that such concerns are raised, the documentation provided by this project's results will assist users in addressing regulatory concerns.

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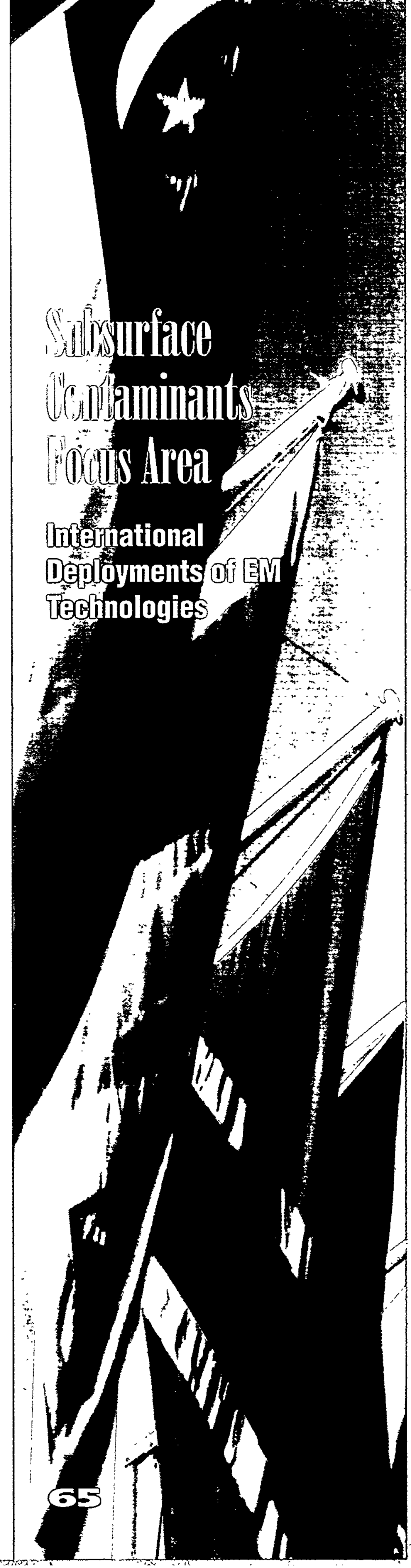



# Process for Contaminant Removal and Waste Volume Reduction to Remediate Groundwater Containing Certain Radionuclides, Toxic Metals and Organics

**OST Technology Management System Number:** 1522
**International Deployment Site:** Chalk River, Ontario, Canada
**Deployment Date:** FY96

## Technology Need

The migration of radionuclides, toxic metals, inorganic ions and organic compounds from a source can lead to contamination of an aquifer, and subsequently can have health consequences on the local public. The water containing dissolved or dispersed contaminant species requires processing to remove the contaminants. Selectively removing hazardous constituents from the contaminated water can be a major advantage because it reduces the secondary waste volumes and perhaps the reagent costs. An ideal solution is to remove only the contaminants in the concentrating step, while allowing the reagents to be recycled. In actual situation, however, selective removal of contaminants is difficult because of interferences from non-hazardous species present in the waste.

The technology objective was to develop and demonstrate an improved ex-situ treatment process for removing a variety of contaminants including low levels of radionuclides, heavy metals and specific organics from groundwaters. The goal was to generate clean effluent while minimizing secondary waste generated as a result of the treatment.

## Technology Description

This process consists of sequential chemical conditioning, microfiltration and dewatering by low-temperature evaporation and/or filter pressing to achieve high contaminant removal efficiencies. The conditioning of the contaminated water by a sequential addition of chemicals and adsorption/ion exchange materials produces a poly-disperse system of size enlarged complexes of the contaminants in three distinct configurations: water-soluble metal complexes, insoluble metal precipitation complexes and contaminant-bearing particles of ion exchange and adsorbent materials. Waste volume is reduced by dewatering of the polydisperse system by cross-flow microfiltration, followed by gravity settling, filterpressing or evaporation. The bulk of the filtrate is discharged if it meets the specified target water quality, or is recycled.

## Collaboration/Technology Transfer

The process to remove mixed contaminants from aqueous wastes has emerged through a logical evolution of ideas and experience gained in particular from a co-operative project between Atomic Energy of Canada Limited (AECL) and DOE, managed by DOE's Argonne National Laboratory (ANL). Versions of this process are available under AECL's trademark, CHEMIC™, and are marketed in the U.S. by NATI Environmental Technologies.

## Technology Benefits

A three-step chemical treatment-microfiltration sequence combined with a final dewatering step should be sufficient to remove most inorganic and organic contaminants from water; a polishing step involving sorption columns may be included if stringent quality control and lower limits for contaminant levels in the treated water, and expanded use of the treatment to cover wider-range of contaminants are desired. The process can be readily combined with other specialized steps that would be required for organic contaminants removal to form an integrated treatment train. The process is flexible to adapt to simpler situations and ideal for chemistry changes under field conditions without changing equipment.

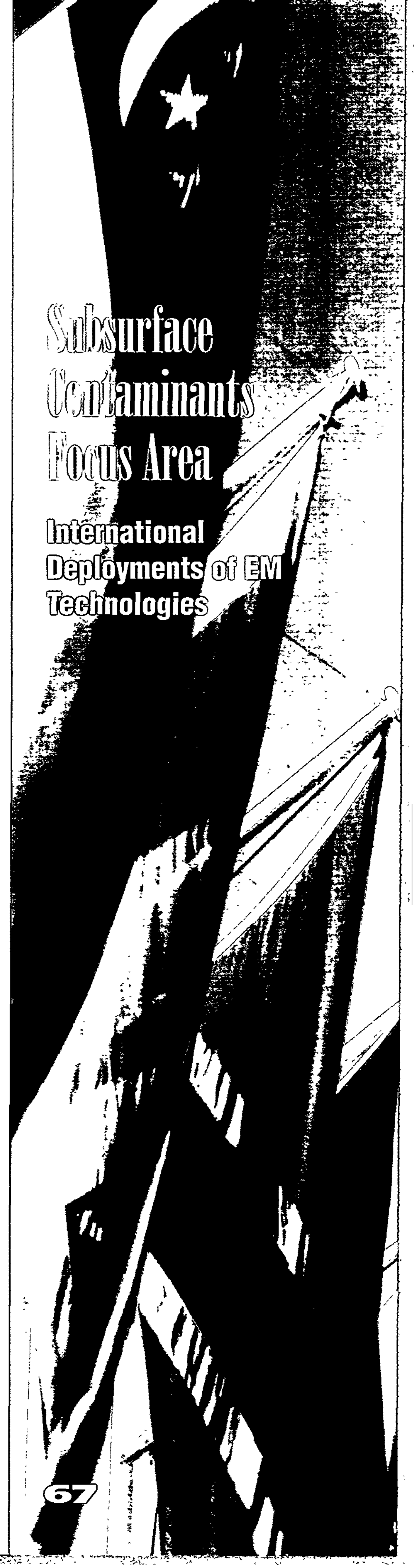
The process is suitable for continuous operation and demands less space than conventional systems. Steady-state is achieved quickly and its modular construction provides the convenience of trailer-mounted portability. The process can be readily adapted to a broad range of volume throughputs and is simple to operate and control. It can process aqueous solutions to produce water suitable for discharge or reuse. The process permits treatment of waste solutions containing a variety of radioactive and hazardous species, and uses common, low-cost chemicals and other waste by-products for cost-effectiveness.

## Technology Capabilities/Limitations

The CHEMIC™ technology offers the customer the capability to process aqueous solutions to produce water suitable for discharge or reuse, and a small volume of secondary waste (typically 1/1000th the volume of the original process feed). The technology can be built to be portable for use at different contaminated sites, resulting in efficient use of capital. Common, low-cost chemicals and other waste by-products are used for cost-effectiveness. The process is applicable to a wide-range of waste solutions containing heavy metals radionuclides and trace organics in various combinations in contaminated groundwater or pond water. Contaminants that can be treated include strontium-90, cesium-137, cobalt-60 and other trace radionuclides, acidic soil leachate containing radionuclides such as uranium, radium or cesium-137, groundwaters and landfill leachates containing low concentrations of uranium and arsenic, and fuel bay waters containing fission and activation products.

## Technology Cost Savings Data

In many instances, the CHEMIC™ process can outperform processes fixed-bed ion-exchange/sorption and reverse osmosis processes. The technology is most suited for influents containing low concentrations (e.g., tens of parts-per million or below) of contaminants; however, it can be adapted easily to higher concentrations. In conjunction with fixed-bed sorption columns as the final polishing step, the CHEMIC™ technology can produce treated water containing contaminants in parts-per-trillion levels.





## Accomplishments and Ongoing Work

The application of this technology at the Chalk River waste management site has resulted in the elimination of strontium-90 activity into a surface water system transferred from an unlined trench through the groundwater to a surface spring. On a yearly basis about 0.2 Curies [7.2 x $10^9$ Becquerels] are removed from the groundwater discharge utilizing a 24 hour/day, 7 day/week operation.

Several feasibility studies have been performed using versions of the CHEMIC™ process to remove metal contaminants (arsenic, uranium, radium, copper, zinc) from land-fill leachates, acidic mine drainage and uranium mill tailings. Techniques based on ultrasonic and/06 mechanical cavitation have been incorporated in the process to improve contaminant removal efficiencies at very low contact times through another cooperative project between AECL and DOE/EPA under the Emerging Technology Program ERP E06 during 1993-94.

A version of the CHEMIC™ process is being tested for the removal of low concentrations of mercury from waste waters to two-to-three orders of magnitude less than the current drinking water limit.

## Regulatory Acceptance Information

Data not available.

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# Characterization, Monitoring, and Sensor Technology Crosscutting Program


# StrataSampler™

**OST Technology Management System Number:** N/A
**International Deployment Site:** Mishelyak River Valley, Ozyorsk, Russia
**Deployment Date:** FY97

## Technology Need

DOE is responsible for the remediation and disposition of more than 3,700 contaminated sites, 1.5 million barrels of stored waste, 385,000 $m^3$ of HLW in tanks, and nearly 7,000 facilities. The development of new characterization and monitoring technologies that are better, faster, cheaper, and safer than existing technologies will significantly reduce the overall cost in the environmental clean-up process.

On a much larger scale, the Ministry of Atomic Energy for the Russian Federation is faced with the characterization of the world's largest amounts of surface and subsurface radioactive contaminants, located primarily in the West Siberian Basin. Within this area is Lake Karachai which was used by the Mayak Production Association as an unlined surface repository of liquid radioactive wastes from former nuclear production and separation activities. It has a groundwater contamination problem that resides within a fractured rock hydrogeological setting similar to those found at the INEEL and ORNL sites.

## Technology Description

The StrataSampler™ is a device used to collect soil vapor and water samples. The StrataSampler™ is comprised of a slotted sample chamber with an inner pass-through that allows tubing to connect to a deeper StrataSampler™ in the same well casing. The samplers are installed similar to normal well screens, but allow collection of water from several discrete intervals in each hole. Up to five samplers can be installed in a typical well.

## Collaboration/Technology Transfer

The StrataSampler™ was developed under the CMST Program. The U.S. Patent and Trademark Office has issued a patent on this invention (5,775,424). The StrataSampler™ is exclusively licensed to TIMCO Manufacturing, Inc.

## Technology Benefits

*Benefits of the StrataSampler™ include:*

- The design of the device allows the collection of discrete samples from several depths within a single borehole, minimizing the drilling costs.
- Use of the StrataSampler™ reduces the amount of construction materials since each well screen shares casing with the overlying StrataSampler™.

- □ Installation of several StrataSamplers™ reduces the amount of IDW that must be generated and ultimately disposed.
- □ Drilling and waste collection/disposal costs are typically reduced by a factor of three to five over the conventional technology.
- □ This method reduces the potential for exposure to dangerous chemicals and improves safety as a result of reduced drilling.

## Technology Capabilities/Limitations

Data not available.

## Technology Cost Savings Data

Data not available.

## Accomplishments and Ongoing Work

This technology is currently being used at the Barnwell County Landfill, the University of Miami-Ohio Experimental Well Field, the M Area DNAPL Characterization project, and Lake Karachai (Russia).

## Regulatory Acceptance Information

Data not available.

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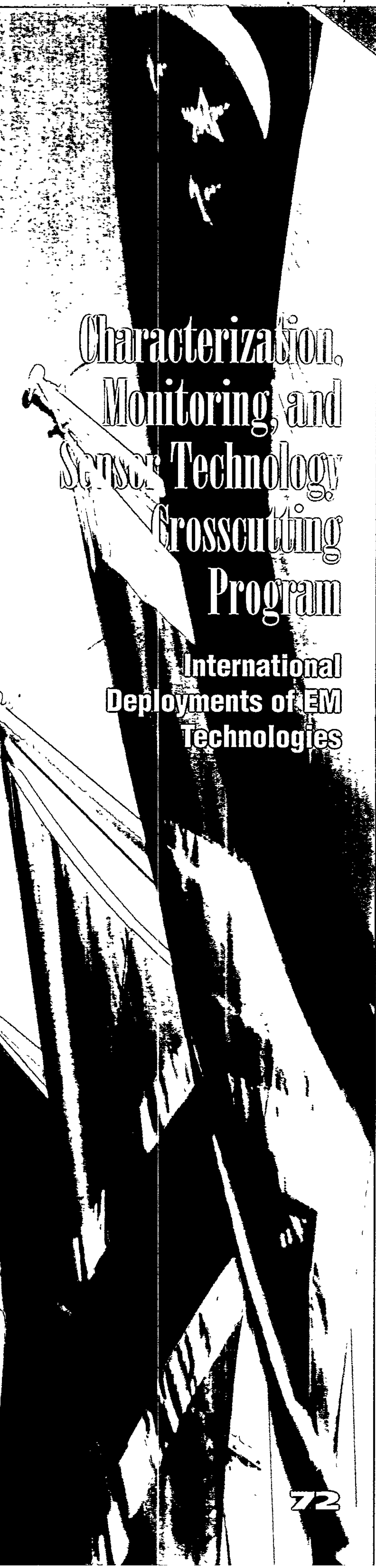



# Expedited Site Characterization (ESC)

**OST Technology Management System Number:** 77
**International Deployment Site:** Czechowice Oil Refinery, Poland
**Deployment Date:** FY96

## Technology Need

According to the *Office of Environmental Management Research and Development Program Plan* (Nov. 1998), approximately 3 million cubic meters of solid radioactive and hazardous wastes are buried in the subsurface throughout the DOE complex. An estimated 50 million cubic meters of soil and 600 billion gallons of groundwater are contaminated and will require characterization and remediation. The baseline or traditional method of site characterization uses a phased approach consisting of multiple sampling events with most samples analyzed in the laboratory. Traditional site characterization procedures conducted in a conservative regulatory environment are usually effective but can be quite costly and time consuming.

The Czechowice Oil Refinery in southern Poland, formerly the Vacuum Oil Company (a U.S. company), has been producing petroleum products for industrial and commercial applications for over 100 years. Disposal practices, including unlined, above ground lagoons for process waste disposal, have contaminated soils with petroleum hydrocarbons, and created conditions that are unacceptable under current environmental standards in Poland. Currently available clean-up technologies are inadequate or unacceptable due to excessive costs, increased risks, long schedules, or the production of secondary waste streams, the need to identify and evaluate innovative remediation technologies is critical.

In 1995, DOE signed a Memorandum of Cooperation with the IETU, Katowice, Poland. The overall objective of this joint international project between the United States and Poland is to assist DOE in meeting its environmental restoration and waste management goals. These goals are to be accomplished by developing technologies that are safer, faster, more effective, and less expensive than many of those currently in use, as well as by encouraging the introduction and use of U.S. environmental technologies and services outside of the United States. Developing technologies are advanced by this cooperative association by identifying, evaluating, and deploying Central & Eastern European technologies, as well as by field testing appropriate U.S. developed technologies in southern Poland. In addition to the advancement of DOE environmental remediation needs, this project will provide Poland, as well as other countries in the region, with exposure to and experience in U.S. site characterization, risk assessment and remediation methods and technologies. This will enable these countries to more effectively cope with their own environmental problems that are often pervasive and widespread due to decades of environmental neglect.

## Technology Description

Expedited Site Characterization (ESC) is a methodology to rapidly and cost effectively conduct site characterization. ESC adopts the systems approach that integrates understanding of site geology and hydrology with contaminant analysis results from multiple techniques. Key characteristics include: a multidisciplinary team employing innovative technologies, where possible, for on-site decision making, a dynamic workplan evolving with incorporation of newly acquired data, and an emphasis on use of non-invasive and minimally-invasive technologies to reduce investigation derived wastes.

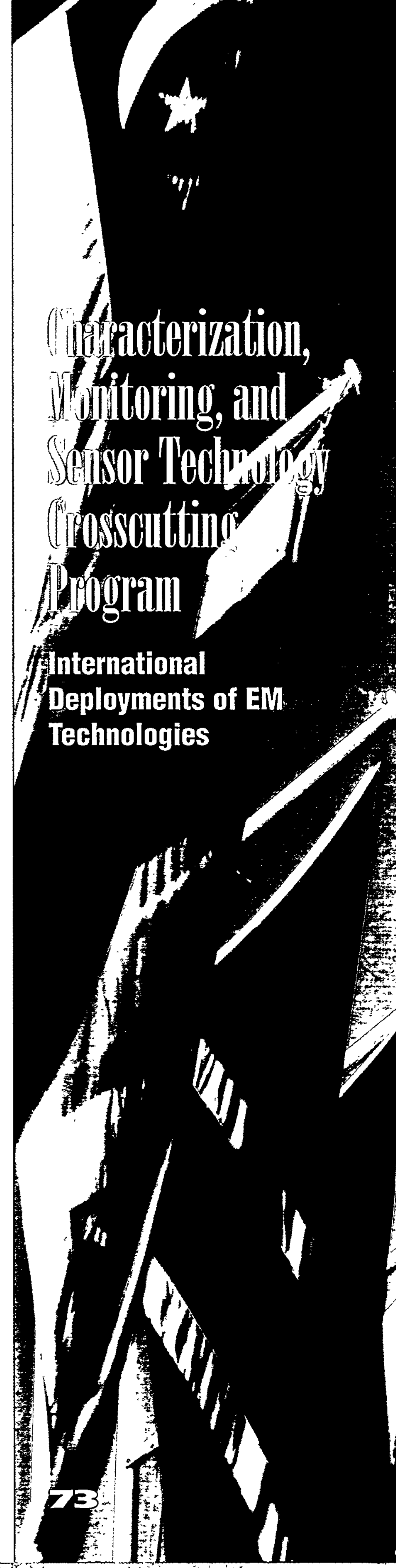
## Collaboration/Technology Transfer

ESC was originally developed by ANL, primarily for the U.S. Department of Agriculture Commodity Credit Association for the characterization of former grain storage facilities. DOE through the CMST Program funded development of an American Standards Testing Methods guide titled, "Guide for Expedite Site Characterization of Hazardous Waste Site". The guide documents the implementation of ESC at DOE sites, and is an excellent introduction to common sense, cost-effective characterization at DOE sites. ANL and DOE have trademark (QuickSite) on the application of ANL's ESC.

## Technology Benefits

*ESC demonstrates many benefits over baseline technologies. These benefits include:*

- Wider variety of measurement methods used:
  1. Employs a diverse set of measurement techniques, with less reliance on traditional monitoring well data.
  2. More than one measurement to prove or validate each essential feature of the conceptual model.
  3. Employs innovative technologies where cost savings or data quality are improved.
- An improved rate of data integration. Data are continually analyzed and integrated into the conceptual model, and the model evolves both during and between phases.
- A flexible, dynamic work plan allows newly acquired data to improve the conceptual model, while impacting and optimizing subsequent characterization activities immediately (hours to days).




□ Potential cost savings:
1. Reduction in the number of data samples collected.
2. Reduction in the number of monitoring wells installed.
3. Reduction in the time required to complete assessment.
4. Improved assessment accuracy.
5. Results that are more credible with regulators.

## Technology Capabilities/Limitations

*ESC is most appropriately used in the following types of sites:*

□ Large-scale projects, including CERCLA remedial investigations, and RCRA facility investigations.

□ Other contaminated sites where the ESC process can be reasonably expected to reduce time and cost of site characterization when compared with traditional approaches.

*The ESC approach may not be valid at the following types of sites:*

□ Small petroleum release sites.

□ Phase I real estate property transactions.

□ Contamination is limited to the near surface and there is little likelihood for migration of contaminants into the groundwater.

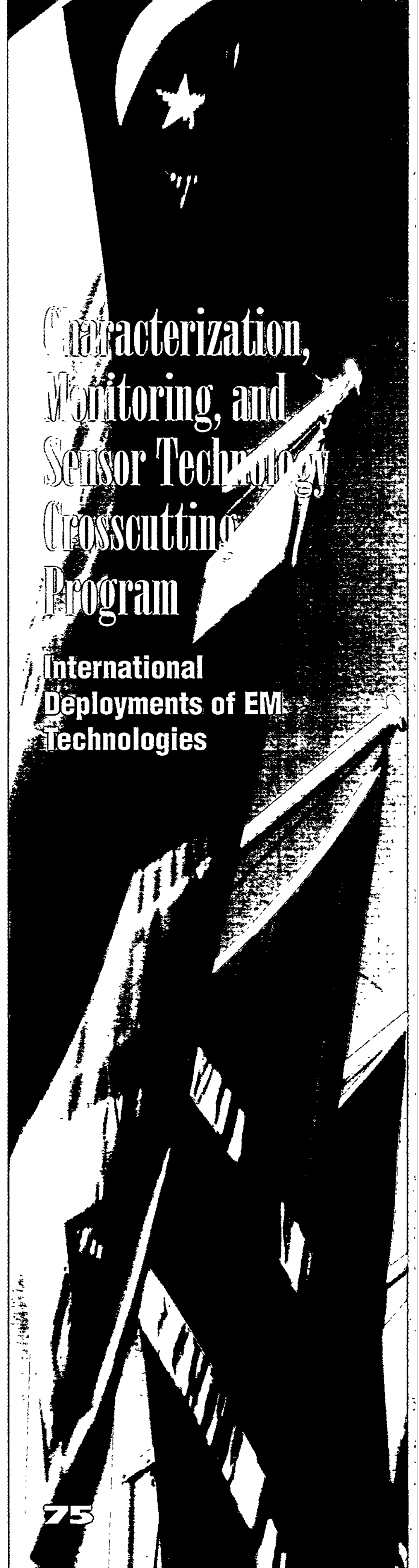
□ Cost of remedial action is less than cost of characterization.

□ Regulators may require long-term statistical monitoring of the site or a traditional approach involving grid-spaced monitoring wells may be more suitable.

□ Existing statutes or regulations prohibit use of essential features of ESC.

## Technology Cost Savings Data

The target for DOE characterization cost savings in the 2006 Plan budget is $1.34 billion. A demonstration of this technology was performed at the Pantex plant, and if this demonstration is representative, then its 50% cost savings translates into possible DOE complex-wide savings of $600 - $700 million through 2006. The availability of appropriate technologies and the ESC methodology allowed this project to characterize the refinery site in less than one month of total time. The time required to construct and prepare standard wells for this project would have taken nearly as long. This resulted in an overall cost savings to this project as well as improving the overall quality of the resulting data.



## Accomplishments and Ongoing Work

During the spring of 1996, Ames Laboratory deployed the ESC methodology at the Czechowice Oil Refinery in southern Poland. The purpose of this deployment was two-fold: 1) to provide site characterization information in support of a planned bioremediation technology evaluation, and 2) to provide a European venue for the demonstration of this DOE-developed technology.

The site characterization data was collected in two phases. An initial, screening level sampling plan was conducted in the early spring of 1996. This sampling campaign utilized qualitative sampling and analysis techniques. The results of this screening activity were used to create the initial work plan for a full-scale ESC. In May of 1996, the ESC was conducted using several DOE-developed technologies (e.g., Geoprobe) and U.S. vendors or their subsidiaries where possible.

On May 27-28, 1996, the DOE/EM JCCES sponsored a Visitor's Day at the IETU and Czechowice Oil Refinery to highlight cooperative activities and to demonstrate, for the first time in Europe, the DOE ESC methodology for streamlining the characterization of contaminated sites.

The Visitor's Day demonstration drew approximately 300 visitors including members of DOD (U.S. Air Force) and a number of DOE contractors. Also in attendance were representatives from: U.S. Foreign Commercial Service, the Polish Consul of Bratislava, U.S. Embassy in Poland, Poland National Fund of Environmental Protection and Water Management, Polish Academy of Sciences, Polish State Scientific Committee for Scientific Research, Polish Ministry of Environmental Protection, Polish Natural Resources and Forestry, Polish Ministry of Defense, Environmental Protection Bank, and Polish Ministry of Trade and Industry.

This demonstration allowed specialists to participate in the evaluation of ESC, an integral part of the Czechowice Oil Refinery Project. The demonstration provided numerous benefits to both regulators and others including: a tour of the field site, a hands-on demonstration of advanced characterization technologies by end-users and providers, access to ESC methodology, and interaction with environmental professionals. Visitor's Day also included an open session that provided the attendees with a project overview and explanation of the joint international projects between DOE and Poland.


## Regulatory Acceptance Information

Because ESC explicitly includes regulatory interaction at the initiation of the project, concerns and issues important to the regulator will be addressed early in the process thus facilitating regulatory approval. Time must be taken to insure that regulators fully understand both the process and techniques to be employed in the ESC as regulatory agents are not legally bound by the recommendations of the ESC (or any other characterization) approach. Finally, normal drilling and sampling activities require that IDW, such as drilling fluids, cuttings, and equipment decontamination fluids, be handled according to RCRA. Emphasis on the use of non-intrusive methods and reduction of the number of subsurface penetrations should minimize the amounts of IDW that are produced.

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# Laser-Induced Fluorescence (LIF)

**OST Technology Management System Number:** 1999
**International Deployment Site:** Bytom, Poland
**Deployment Date:** FY96

## Technology Need

According to the *Office of Environmental Management Research and Development Program Plan* (Nov. 1998), approximately 3 million cubic meters of solid radioactive and hazardous wastes are buried in the subsurface throughout the DOE complex. An estimated 50 million cubic meters of soil and over 600 billion gallons of groundwater are contaminated and will require characterization and remediation. DOE requires innovative technologies that remotely monitor contaminated sites, identify contaminant "hot spots", assist in clean up activities, and monitor remedial progress.

In cooperation with the Polish government, DOE has an ongoing program for the study and remediation of selected sites in the highly polluted "black triangle" area of Poland. The lead organization in Poland is the IETU, located in Katowice, Poland.

## Technology Description

This technology consists of a portable survey tool based on laser-induced fluorescence (LIF) techniques for the detection of uranium, heavy metals, organic compounds, and vegetation stress due to uptake of contaminants. The system was originally built for detecting uranium. In operation, laser light is shined on the surfaces to be examined. Energy released from the surface in the form of fluorescence is analyzed for the presence of uranium oxide molecules that may be present as a surface contaminant. Results are displayed in real-time on a monitor attached to a laser. The laser can be operated in a panning motion to survey large areas quickly, or used to survey discreet two foot by two foot areas at a time. Unlike physical swipes, which must be collected from the actual surface being surveyed, the LIF instrument can be operated up to 10 meters away from the surface being studied. Detection of surface contamination occurs virtually instantaneously. For the experiments in Poland, a modified version of this system designed to look at fluorescence from plants was used. The purpose was to follow the progress of field plots of phytoremediator plants treated sequentially with two amendments designed to maximize the uptake of certain soil contaminants. The portable system actually consisted of two subsystems: laser induced fluorescence imaging (LIFI), which produced fluorescence images of the target plants in a number of spectral bands, and laser induced fluorescence spectroscopy (LIFS), which produced reasonably high resolution spectral analysis of the emitted fluorescence. The ground-based system used a standoff from the plants of about 5 feet.

## Collaboration/Technology Transfer

The developer of this technology was DOE's Special Technologies Laboratory in Santa Barbara, California. Groups involved in the Polish deployment included IETU, Florida State University, Phytotech, Inc., and the Technical University of Budapest.

## Technology Benefits

*Benefits of LIF include:*

- Can detect optical signatures that are not observable by traditional remote sensing methods.
- Surveys of large areas can be performed in a cost-effective manner.

## Technology Capabilities/Limitations

- Demonstrated capability of detecting surface (soil, walls, etc.) contamination by various materials, including specific detection of uranium.
- Day- or night-time operation.
- Portable system has been miniaturized to handheld (backpack) LIFI system, and also has been demonstrated on low airborne flights (but only "portable" ground-based system used in Poland).
- Primary limitations associated with using the laser, i.e. added complexity, eye safety issues for large systems, and limitation on standoff distance (no high altitude flights).

## Technology Cost Savings Data

Data not available.

## Accomplishments and Ongoing Work

The LIF system (including LIFI and LIFS) was deployed to the site in Bytom, Poland, and was used to evaluate the condition of plots of phytoremediator plants as the plants were treated with several amendments designed to maximize uptake of certain heavy metals.

The LIF techniques are currently being used on several related projects for DOE and for other agencies, including further plant-stress studies, crime scene applications (forensics), mine detection applications (combined with GFP technologies), and military training area impact studies.

## Regulatory Acceptance Information

Currently, there are no regulatory concerns related to this survey tool.

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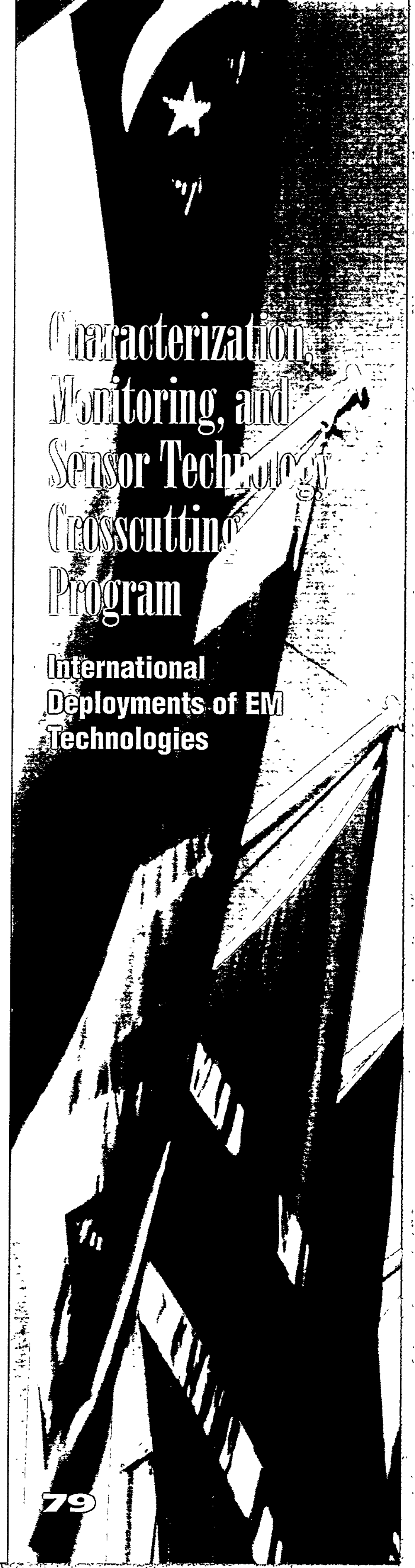

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