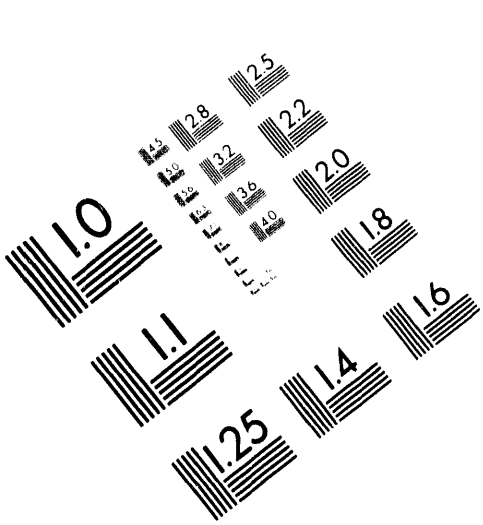





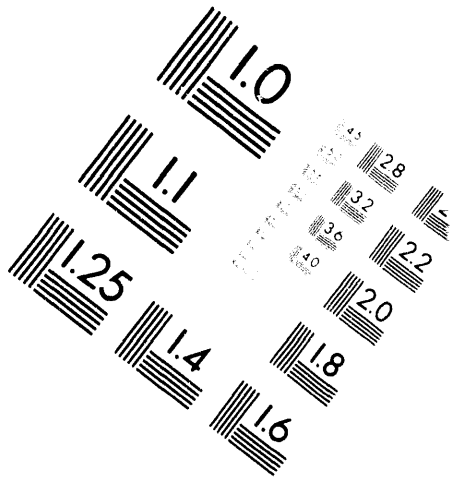

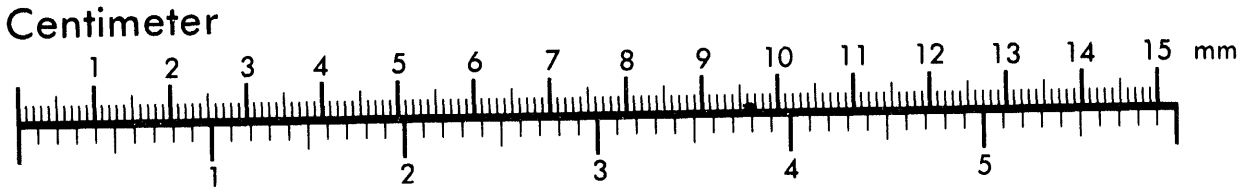


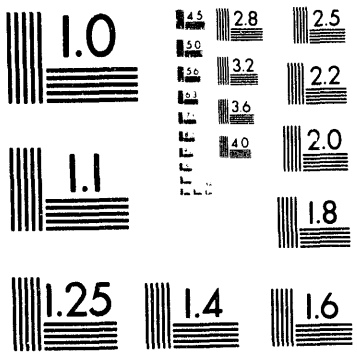

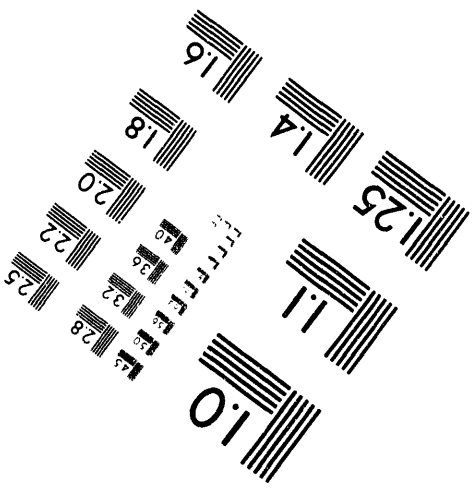



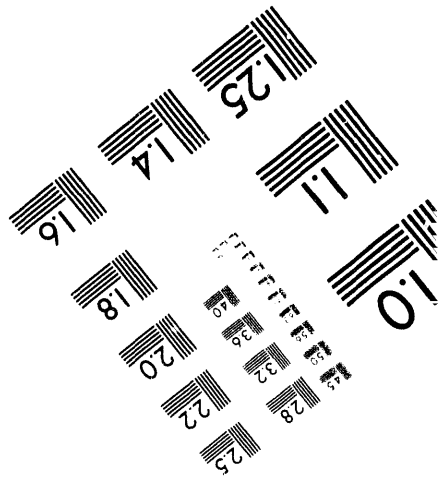

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# IN SITU REMEDIATION INTEGRATED PROGRAM: SUCCESS THROUGH TEAMWORK

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# In Situ Remediation Integrated Program: Success Through Teamwork

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## ABSTRACT

The In Situ Remediation Integrated Program (ISR IP), managed under the U.S. Department of Energy's (DOE) Office of Technology Development, focuses research and development efforts on the in-place treatment of contaminated environmental media, such as soil and groundwater, and the containment of contaminants to prevent the contaminants from spreading through the environment. As described here, specific ISR IP projects are advancing the application of in situ technologies to the demonstration point, providing developed technologies to customers within DOE. The ISR IP has also taken a lead role in assessing and supporting innovative technologies that may have application to DOE.

## INTRODUCTION

The ISR IP was established in 1991 by DOE's Office of Technology Development (EM-50). In an effort to focus resources and address priority needs, EM-50 introduced the concept of integrated programs (IPs) and integrated demonstrations (IDs). An IP is a set of applied research and development activities dedicated to providing technology solutions for a single problem category, such as in situ remediation and characterization technologies. An ID provides a cradle-to-grave system for solving a specific environmental or waste management problem. An ID assembles a group of related and synergistic technologies to evaluate their performance individually or as a complete system. The ISR IP supports the development of both in situ treatment and containment technologies that have the following benefits:

- minimizing adverse health effects on workers and the public by reducing the potential for exposure through contact with the waste
- preventing the further migration of contaminants
- reducing cleanup costs by eliminating the need for waste excavation, transport, and disposal
- remediating relatively inaccessible areas, such as the deep subsurface and areas beneath structures.

The program is supporting remediation technologies for contaminated groundwater, contaminated soils, unlined landfills, and containment systems for underground storage tanks. The technologies will be applicable to organics, inorganics, metals, and radionuclides.

## MEETING CUSTOMER-DRIVEN OBJECTIVES

The ISR IP is managed within the Office of Research and Development (EM-53) at DOE-Headquarters, with program coordination provided by staff at the Pacific Northwest Laboratory in Richland, Washington. The program provides developed technologies to three primary customers: DOE's Integrated Demonstrations within EM-50, the Office of Environmental Restoration (EM-40), and the Office of Waste Management (EM-30). Over 30 projects within the areas of containment, bioremediation, physical/chemical treatment, and subsurface manipulation have been funded this fiscal year. Several of the technologies being developed within the projects are ready, or nearly ready, for field demonstration.

Three specific objectives shape the goals of the ISR IP: 1) develop in situ remediation technologies using the expertise from industry, academia, DOE's national laboratories, and contractors; 2) maximize and expand the applicability of in situ tec ... many end users; and 3) deliver the technologies so that DOE and industry can select and evaluate the technologies for remedial actions. The ISR IP addresses these objectives by serving as a link between the individual projects, the end users, and industry, providing the interfaces and coordination needed to advance in situ remediation technologies to the demonstration point.

## STATUS OF SELECTED PROJECTS

The following paragraphs describe some of the ISR IP projects that are ready, or nearly ready, for field demonstration. Table 1 lists all the ISR IP projects and their projected year for demonstration. The projects are described in more detail in the FY 1993 and FY 1994 annual reports[1,2]. Figure 1 shows the ISR IP participants from industry, academia, national laboratories, and DOE contractors. Containment technologies are described in the paper entitled "Development of Containment Technology," published elsewhere in these proceedings, and therefore are not presented here[3].

Electrokinetics is a promising technology for the removal of metals and radionuclides from soils at DOE sites. Three projects are currently underway. A project at Sandia National Laboratory, "Electrokinetic Remediation of Heavy Metal Contaminated Unsaturated Soil," is evaluating the technology for the removal of chromium from arid soils. Initial results indicate that chromium can be moved through soils with as little as 3.5 wt% moisture. A field demonstration will be conducted in FY 1994 in conjunction with the Mixed Waste Landfill Integrated Demonstration. Industrial participants in this project include Sat-Unsat, Inc., and K-Tech, Inc. A second project at Westinghouse Savannah River, "Field Demo of Electrokinetic Migration Technology at the Old TNX Basin," is demonstrating the ability of the Isotron Corporation's proprietary Electrosorb TM Technology to remove mercury contamination from soils at the Old TNX seepage basin. In particular, the polymer matrices designed into the electrode assemblies will be evaluated to determine their effectiveness in trapping mercury and controlling the pH at the electrodes. This field test is underway and will be completed in FY 1994. A third project, "Electrokinetics in Uranium Contaminated Soils," also uses Isotron Corporation for developing the electrokinetics technology specifically for the removal of uranium. Treatability studies are underway.

The project "In Situ Treatment Using Magnetic Separation," managed by Argonne National Laboratory, involves Bradtec-U.S., Inc.; Barrier Membrane Containment, Inc. (BMC); Rust Environment and Infrastructure; and B&W Nuclear Technologies. The project is developing and demonstrating the MAG*SEP™ technology, a process for remediating groundwater in situ by injecting and subsequently removing magnetic particles designed to adsorb contaminants. In addition, the containment technology by BMC will be demonstrated for directing groundwater flow. The technology could potentially recover low levels of radioactive and/or inorganic hazardous contamination while leaving nonradioactive, nonhazardous species mostly unaffected. Process chemistry is underway for two sites--the Savannah River Site and the Berkeley Pit in Butte, Montana. A field demonstration at the Savannah River Site is scheduled for FY 1995.

The project "In Situ Redox Manipulation," managed by Pacific Northwest Laboratory, is testing and evaluating the use of permeable subsurface treatment barriers for immobilizing inorganic (metals, inorganic ions, and radionuclides) and destroying organic (primarily chlorinated hydrocarbons) contaminants by altering the chemistry of the aquifer system. The treatment barrier is a zone of favorable redox potential created by adding chemical and/or microbiological reducing agents. Laboratory tests have shown sodium dithionite to be effective in reducing the ferric iron in Hanford soils. Metal-reducing bacteria are capable of reducing ferric iron in Hanford soils, an alteration that can reduce $Cr^{+6}$ to $Cr^{+3}$, dechlorinate $CCl_4$, and reduce uranium. A field test is scheduled for FY 1995. Sonic drilling is planned for installation of the wells.

The project "In Situ Chemical Treatment: Evaluation of the In Situ Chemical Treatment Approach for Remediation of Soils and Groundwater," managed by Westinghouse Hanford Company, is developing an in situ chemical treatment approach for remediating metal- and radionuclide-contaminated soils and groundwater by injecting reactive gases that would bind the contaminants to sediments, immobilizing them. The project is contracting with Enserch Environmental for the field design. Bench-scale tests were completed using soil from three DOE facilities and contaminating the soils with chromium, uranium, and nitrate. Greater than 90% of the chromium was immobilized, 50% of the uranium immobilized, and nitrate was unreactive using as low as 100-ppm $H_2S$ in $N_2$. A field test in conjunction with the Mixed Waste Landfill Integrated Demonstration is scheduled for FY 1995.

TABLE 1. Fiscal Year in Which Technology Ready for Demonstration

| TECHNOLOGY | 1994 | 1995 | 1996 |
|---|---|---|---|
| ***TREATMENT (BIOREMEDIATION)*** | | | |
| Adsorption/Desorption Relative to Applying Bioremediation to Organics | | | X |
| Bioremediation of PCB Contamination | X | | |
| Demonstration of Cometabolic Techniques | X | | |
| Modeling Strategies for Optimizing In Situ Bioremediation | X | | |
| Biomass Remediation System | | X | |
| Biosorption of Uranium | | X | |
| In Situ Microbial Filters | | X | |
| Mixed Chlorinated Solvent In Situ Bioremediation in the Vadose Zone | | | X |
| ***TREATMENT (PHYSICAL/CHEMICAL)*** | | | |
| Electrokinetic Remediation of Heavy Metal Contaminated Unsaturated Soil | X | | |
| Optimal Remediation Design: Methodology and User-Friendly Software for Contaminated Aquifers | X | | |
| Remediation of DNAPLs in Low K Soils | | X | |
| Field Demo of Electrokinetic Migration Technology at Old TNX Basin | X | | |
| Electrokinetics in Uranium Contaminated Soils | | X | |
| In Situ Chemical Oxidation of Soils | | X | |
| In Situ Chemical Treatment: Evaluation of the In Situ Chemical Treatment Approach for Remediation of Soils and Groundwater | | | X |
| In Situ Corona for In Situ Treatment of Nonvolatile Organic Contaminants | | X | |
| In Situ Groundwater Treatment Using Magnetic Separation | | X | |
| In Situ Redox Manipulation | | X | |
| In Situ Vitrification (ISV) | | X | |
| In Situ Treatment of Mixed Contaminants in Groundwater | | | X |
| NAPL Contaminated Soil/Groundwater Remediation Using Foams | | | X |
| ***CONTAINMENT*** | | | |
| Chemical Barriers Feasibility and Field Demonstration | X | | |
| Chemically Enhanced Barriers to Minimize Contaminant Migration | X | | |
| Cryocell Technology Applications at Non-Arid Sites | X | | |
| Develop/Demonstrate Methods of Placing a Horizontal In Situ Grout Barrier | X | | |
| Evaluation of Two New Flowable Grout Techniques for In Situ Barrier Construction | X | | |
| Hydraulic and Diffusion Barriers in the Vadose Zone Surrounding Buried Waste | X | | |
| Containment of Contaminants Through Physical Barriers From Viscous Liquids Emplaced Under Controlled Viscosity Conditions | | X | |
| Development and Testing of a Water-Permeable Reactive Barrier | | X | |
| Development of Frozen Soil Barriers for Arid Sites | | X | |

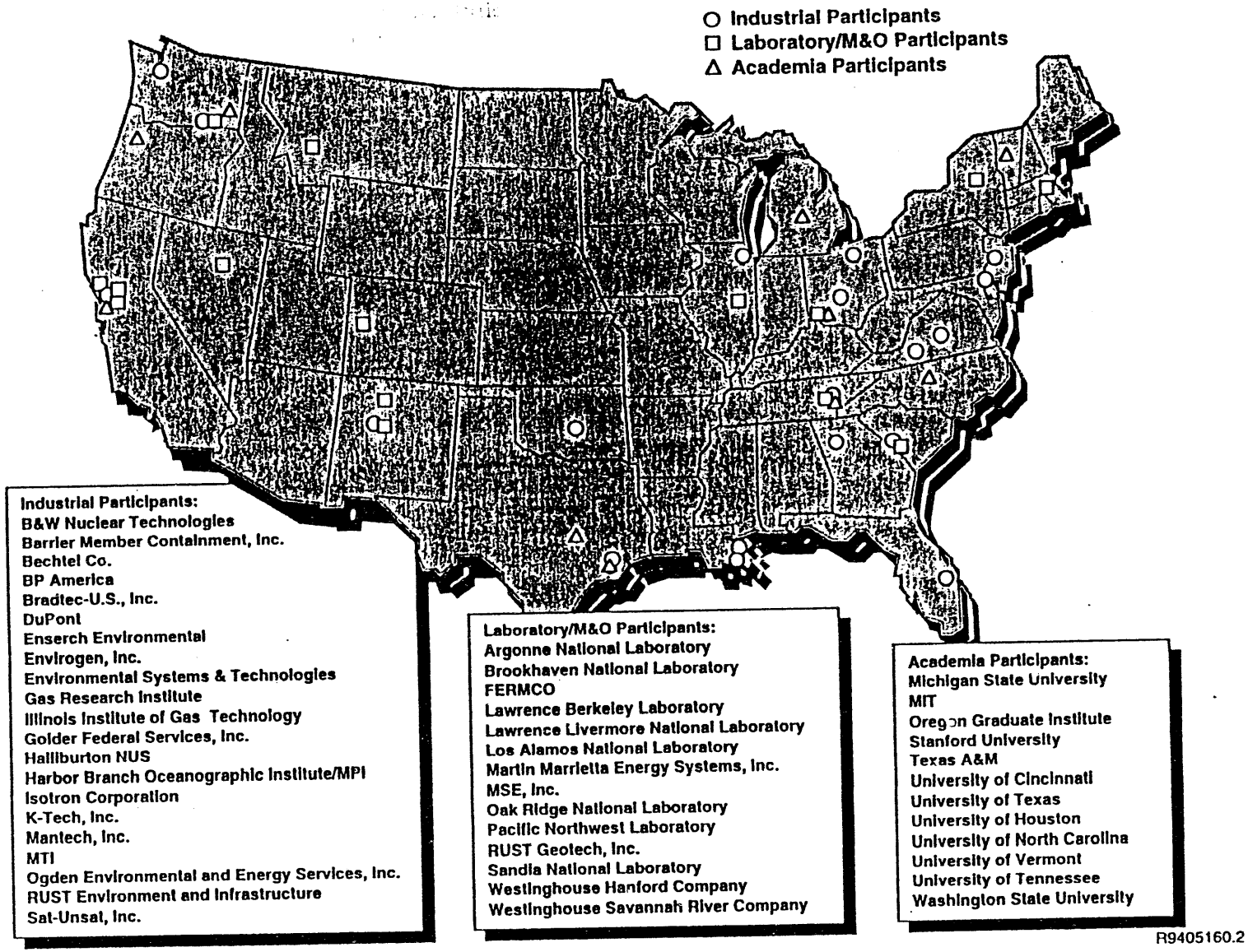


FIGURE 1. ISR IP Participants

The project "Biomass Remediation System," managed by MSE, Incorporated, is demonstrating the feasibility of using terrestrial and aquatic plants to remediate soils, sediments, and surface water contaminated by heavy metals and radionuclides. The treatment is based on the Ukrainian fractionation separation technology (FST), which establishes the distribution of specific elements or isotopes in plant biomass samples. The work is being performed in conjunction with MTI and Harbor Branch Oceanographic Institute. The FST process, using mechanical and electrochemical technologies, should concentrate and separate the contaminants of concern from the bulk biomass and/or recover uncontaminated biomass fractions that could be more easily disposed.

Proof-of-process testing has been completed for the Ukrainian FST using plants harvested around Butte, Montana. Improvements to the fractionation technology are required to achieve recovery greater than 70%. Laboratory tests are under way to determine the effectiveness of algae in removing metals from waste water. A field test to investigate the effectiveness of plants in removing uranium from Fernald soils is scheduled for the summer of 1994.

The project "NAPL-Contaminated Soil/Groundwater Remediation Using Foams," managed by Argonne National Laboratory, is developing a technology involving foams as a source of dispersive gas bubbles separated by thin liquid films containing surfactants to release and mobilize DNAPL contaminants in the subsurface. Other project participants include the Gas Research Institute and the Illinois Institute of Technology. The foam can either be produced in situ within the contaminated zone or above ground and injected into the zone, where it drives contaminants upward towards the surface. The contaminants can be collected using a vacuum extraction system, or the foam can be coupled with biodegradation capability to biodegrade the contaminants.

The project "Remediation of DNAPL-Contaminated Low Permeability Deposits," managed by Oak Ridge National Laboratory (ORNL) and the American Petroleum Institute (API), is evaluating and testing in situ technologies for both source control and mass removal of DNAPLs (e.g., TCE and PCE) in low permeability soils. The project is examining in situ treatment technologies, including separation and transfer processes (e.g., vapor extraction and subsurface mobilization) and destruction processes (e.g., chemical and biological degradation). Thermal enhancement methods, hydraulic and pneumatic fracturing, and mixing will also be assessed. The initial activities will be the preparation of transport/fate and remediation technology focus papers to assess and evaluate technologies for inclusion in the project. Field-scale tests are planned at sites in Sarnia, Canada; Cincinnati, Ohio; and Portsmouth, Ohio. The tests will evaluate effects on pneumatic and hydraulic control, and heat and mass transfer, of fracturing methods coupled with hot air and steam injection.

The project "Biosorption of Uranium," managed by ORNL, is developing a biosorption technology for removing uranium and other heavy metals from waste water. The proposed process uses biosorbents immobilized in permeable beads that are in turn contained within flow-through bioreactor systems. This project is being conducted under a CRADA with Ogden Environmental and Energy Services. This technology is slated for demonstration in Germany. Various strains of bacteria, yeast, fungi, and algae have been screened for their ability to extract uranium from contaminated water.

*Pseudomonas aeruginosa*, the lead candidate for binding uranium from acidic water, has been shown to bind over 30% of its dry weight as uranium.

## ADVANCING THE APPLICATION OF IN SITU TECHNOLOGIES

The ISR IP is striving to rapidly develop in situ technologies to meet the needs of the IDs, EM-40, and EM-30. Three technologies have been field tested, and 10 technologies will be ready for transfer to the IDs, EM-30, or EM-40 in FY 1995. Industrial participants are contributing to R&D activities and field tests at DOE sites. R&D activities for in situ technologies conducted by industry through the program research and development announcement, research opportunity announcement, and small business innovative research solicitation are being integrated into the ISR IP and linked with the end users. The ISR IP is a primary contributor, along with industry and the U.S. Environmental Protection Agency (EPA), in the Remediation Technology Development Forum, the objective of which is to advance in situ technologies. International in situ technologies are also being evaluated for their application at DOE sites.

## ACKNOWLEDGMENT

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