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**U.S. Department of Energy
Office of Environmental Restoration
and Waste Management**

Office of Technology Development
A National Program

**FY 1993 Program Summary
Office of Research and Development
Office of Demonstration, Testing and Evaluation**

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EXECUTIVE SUMMARY

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This report summarizes significant FY93 programmatic information and accomplishments relevant to the individual activities within the Office of Technology Development Program for Research, Development, Demonstration, Testing, and Evaluation (RDDT&E).

Introduction

A brief discussion of the mission of the Office of Environmental Restoration and Waste Management (EM) and the Office of Technology Development (EM-50) is presented.

The Problems

This section provides an overview of the major problem areas confronting DOE. These problem areas include: groundwater and soils cleanup, waste retrieval and processing, and pollution prevention.

EM Program Overview

This section highlights the organizational elements within EM and in particular the Office of Technology Development. Also provided is an EM-50 Funding Summary for FY92 and FY93.

RDDT&E

This section discusses the RDDT&E programs and summarizes their key problem areas, then explains three salient program-formulating concepts: Integrated Demonstrations (ID), Integrated Programs (IP), and the "technology window of opportunity".

Program Summary

Detailed information for each of the programs within RDDT&E is presented and includes a Fact Sheet, a list of Technical Task Plans (TTP) and an Accomplishments and Objectives section.

Appendix

The general topic of technology partnerships and private sector involvement is addressed. Argonne 1990 Solicitation, Small Business Innovation Research (SBIR), Program Research and Development Announcements (PRDA), Cooperative Research and Development Announcements (CRADA), Research Opportunity Announcements (ROA), Interagency Agreements (IAG), and Grants are discussed. A listing of DOE facilities and sites is also provided.

TABLE OF CONTENTS

Executive Summary	3
1.0 Introduction	7
2.0 The Problems	9
3.0 EM Program Overview	13
4.0 Research, Development, Demonstration, Testing, and Evaluation (RDDT&E)	17
5.0 RDDT&E FY93 Program Summaries	19
5.1 Groundwater and Soils Cleanup	19
5.1.1 Cleanup of VOCs in Non-arid Soils The Savannah River Integrated Demonstration	21
5.1.2 Volatile Organics in Arid Soils Integrated Demonstration	33
5.1.3 Mixed Waste Landfill Integrated Demonstration	39
5.1.4 Fernald Uranium Soils Integrated Demonstration	47
5.1.5 Dynamic Underground Stripping Integrated Demonstration	57
5.1.6 Characterization, Monitoring, and Sensor Technology (CMST) Integrated Program	61
5.1.7 In Situ Remediation Integrated Program	67
5.1.8 Minimum Additive Waste Stabilization	75
5.1.9 Resource Recovery	83
5.2 Waste Retrieval and Processing	87
5.2.1 Buried Waste Integrated Demonstration	89
5.2.2 Underground Storage Tank Integrated Demonstration	101
5.2.3 Deactivation, Decommissioning and Recycle	111
5.2.4 Efficient Waste Separation Processes	115
5.2.5 Mixed Waste Integrated Program	121
5.2.6 Rocky Flats Compliance Program	129
5.2.7 Supercritical Water Oxidation (SCWO) Program	135
5.3 Pollution Prevention	139
5.3.1 U.S. DOE/U.S. Air Force MOU/MOA	141
5.3.2 Environmentally Conscious Manufacturing	147
5.3.3 Waste Component Recycling, Treatment, and Disposal Integrated Demonstration (WeDID)	155
5.4 RDDT&E Innovation	159
5.4.1 RDDT&E New Initiatives and Innovative Technologies	161
6.0 Supporting Technologies, Infrastructure, and Transportation Program Summaries	171
6.1 Robotics	173
Appendix A - Technology Development Partnerships	181
A1. Small Business Innovation Research	185
A2. Summary of Argonne National Laboratory 1990 Solicitation	187
A3. Summary of Program Research and Development Announcements	191
A4. Summary of Cooperative Research and Development Agreements	205
A5. Research Opportunity Announcements (ROA)	211
A6. Summary of RDDT&E Interagency Agreements (IAGs)	213
A7. Grants	217
Appendix B - Site/Facilities Where Environmental Restoration and Waste Management Activities are Being Conducted	219

INTRODUCTION

For over forty years, the Department of Energy (DOE) designed, manufactured, and tested nuclear weapons for national defense purposes. The complex generated large quantities of hazardous and radioactive waste. As was the case with most manufacturers that operated before an understanding of environmental stewardship was developed, DOE weapons production resulted in the contamination of soils and groundwater. DOE has set a goal to clean up its complex and to bring all sites into compliance with applicable environmental regulations. This initiative is slated for completion by the year 2019.

Four years ago there was no coordinated plan for identifying or cleaning these contaminated sites. Since 1989, DOE's Office of Environmental Restoration and Waste Management has invested time, money, and manpower to establish a wide range of programs to meet this immense challenge. DOE is responsible for waste management and clean up of more than 100 contaminated installations in 36 states and territories (Figure 1). This includes 3,700 sites: over 26,000 acres, with hazardous or radioactive contaminated surface or groundwater, soil, or structures; over 26,000 acres requiring remediation, with the number growing as new sites are defined; 500 surplus facilities awaiting decontamination and decommissioning and

approximately 5,000 peripheral properties (residences, businesses) that have soil contaminated with uranium tailings.

Within EM, the Office of Technology Development (EM-50) is responsible for managing an aggressive national program of applied research, development, demonstration, testing, and evaluation (RDDT&E) for environmental cleanup, waste management and related technologies. The technology development program is designed to resolve major technical issues, to rapidly advance beyond current technologies for environmental restoration and waste management operations, and to expedite compliance with applicable environmental laws and regulations. The underlying strategy is to identify and develop high-payoff environmental restoration and waste management technologies that can: (1) clean up the 1989 inventory of DOE nuclear component manufacturing sites; and, (2) manage DOE-generated waste faster, better, safer and cheaper than is possible with current environmental cleanup technologies. In many cases, the development of new technology presents the best hope for ensuring a substantive reduction in risk to the environment and improved worker/public safety within realistic financial constraints.

Figure 1. Examples of DOE Contaminated Sites.

THE PROBLEMS

This section provides an overview of the magnitude and extent of the environmental problems across the DOE complex. Many of these problems are not unique to DOE but are associated with other Federal agencies as well as private industry. Therefore, technical solutions developed within the EM RDDT&E programs will not only benefit DOE, but should have direct applications to outside markets. The problem areas described below are grouped into three general areas: groundwater and soils cleanup, waste retrieval and processing, and pollution prevention.

Groundwater and Soils Cleanup

Some of the most pressing environmental restoration needs for the DOE involve cleanup or containment of radioactive and hazardous contaminants in soils and groundwater. The DOE soils and groundwater programs were designed to identify, develop, and demonstrate innovative technology systems capable of removing or reducing potential health and environmental risks. These risks are the result of previous storage and disposal practices that left behind a legacy of radioactive and hazardous materials (including heavy metals and toxic organic compounds) in the surrounding soil and groundwater. Sources of this contamination at the DOE sites include: previous disposal of contaminated wastes in ponds, seepage pits, trenches, and shallow land burial sites; spills and leakage from waste transport, temporary storage facilities, and underground storage tanks; and unregulated discharges to the air and surface waters.

The DOE is responsible for waste management and clean up of more than 100 contaminated installations in 36 states and territories. This includes 3,700 sites within the DOE complex; over 26,000 acres with hazardous and radioactive contaminated surface water, groundwater, and soil that are in need of some measure of remediation. Additionally, there are approximately 5,000 peripheral properties (e.g., residences and businesses) that have soil contaminated with uranium tailings. One of the biggest challenges facing the DOE is effective characterization of contamination in soil and groundwater. Characterization must take place before a contaminant site can be properly prioritized. To accomplish this, methods are being developed that are capable of mapping vast areas at depths up to 250 ft below ground level. Results are three dimensional images that are valuable tools for proper selection and placement of remediation technologies. Complicating remediation efforts further is the fact that techniques for accessing and removing contaminants differ in arid and non-arid environments. As a result, technologies must be demonstrated and evaluated at multiple sites.

Volatile Organic Compound (VOC) contamination of soils and groundwater is one of the most common environmental problems in the United States and DOE complex. When VOCs are released into the soil, they rapidly migrate throughout the environment forming large contaminant plumes, eventually

resulting in contaminated groundwater. Two of the more prominent examples of this phenomena can be found at the Savannah River site (a non-arid environment) where there is a plume larger than three square miles; and at the Hanford site (an arid site), where a 7 square mile plume resulted from the disposal of an estimated 363-580 cubic meters of carbon tetrachloride. Over 220 sites with similar contamination have been identified in arid environments within the DOE complex. Add radioactive contamination to the before mentioned hazardous constituents and the result is a DOE problem for which few adequate solutions currently exists.

Also prevalent throughout the DOE complex is the contamination of surface soils with heavy metals that where a result of weapons assembly and testing processes during weapons construction. At the Nevada test site alone, over 5 square miles of soil is contaminated with plutonium. Cleanup of this area will require the treatment of approximately 25 million cubic feet of soil. Five other DOE sites also have contamination similar to that at the Nevada test site. Eight other DOE sites have identified similar contamination problems with uranium. At Fernald, uranium has been transported by rain and snow to varying depths below the surface, making remediation difficult. Estimates indicate there are 1.5 million cubic meters of uranium contaminated soil at Fernald. Heavy metal contamination is also a problem in surface and groundwater. The Berkeley Pit at Butte Montana, contains 17 billion gallons of contaminated water, with an inflow of 5-7 million gallons per day.

The contaminants discussed above exhibit high concentration levels, high mobility, and high toxicity, as well as long-term persistence in the environment, and for these reasons they represent some of the high priority problems for which innovative technologies are sought. However, technologies are also under development for treatment of non-volatile organics, dense non-aqueous phase liquids, radionuclides, nitrates and explosive materials. In most cases, non-intrusive or in-situ methods (methods that characterize or treat the contaminants in place) for environmental restoration are preferable from technical and regulatory standpoints. From a regulatory standpoint, these technologies are preferable because they minimize (1) harm to the environment, (2) public exposure, and (3) volume of waste. Technically, these methods avoid the

risks and costs associated with handling contaminated soils and groundwater. Nevertheless, cases exist for which non-intrusive and in-situ methods may not be applicable. Given this circumstance, other innovative technologies must be explored, including extraction, containment, recovery, and processing alternatives that reduce or eliminate environmental and health risks.

Development of innovative technologies for clean up of groundwater and soils is not a need unique to the DOE. Other Federal agencies as well as private industry are in need of improved methods for these types of clean up. The Environmental Protection Agency has identified 1,235 sites with sufficient contamination to place them on their National Priorities List (NPL). In the past two years, the number of sites entering remedial action has grown steadily.¹ Out of 712 NPL sites with Records of Decision (ROD), an estimated 80% require remediation of groundwater, 74% need soil remediation, and 15% require action to clean up sediments. It is estimated that NPL sites without RODs contain similar types of contamination. In an effort to promote the development of new technologies to expedite clean up of the NPL sites, the Environmental Protection Agency established the Superfund Innovative Technology Evaluation (SITE) program. The Department of Defense (DOD) is responsible for clean up of their facilities contaminated as a result of training, industrial, or research activities. As of September 1991, the DOD had identified 7,000 sites that will require remediation. The largest of these DOD remediation sites will result in the treatment of nearly 2.2 million cubic yards of soil. The DOE currently works with the EPA SITE, and DOD programs in a joint effort to expedite remediation of groundwater and soils contamination.

Waste Retrieval and Processing

Waste retrieval and waste processing constitutes one of the largest problems for the DOE. To address this need, the DOE Office of Environmental Restoration and Waste Management designed a set of programs focused on identifying, developing and demonstrating innovative technologies for the purpose of treating this waste while reducing the risk to human health and the environment. Within the DOE complex, large quantities of high-level waste, low-level waste, and transuranic waste have been buried or stored and now are in need of retrieval and treatment. Before 1970, most low-level and transuranic wastes were buried in common shallow land burial grounds. A majority of the high level waste was stored in underground storage tanks.

Effective May 8, 1992, all DOE mixed waste streams fell under EPA's land disposal restrictions and, as such, can no longer be disposed of without prior treatment to destroy, separate, or immobilize the hazardous component. For all mixed low-level and high-level waste must be treated before final disposal. In the case of mixed transuranic wastes destined for deep geologic disposal, the hazardous components must not exceed established waste acceptance criteria. Most of the hazardous components of the mixed wastes have not been characterized; however, from past knowledge, they represent the entire gamut of

organic and inorganic hazardous wastes. Available technology is inadequate to solve many of the problems at hand. The result is a mixed waste dilemma that poses serious legal and technical problems that need to be resolved.

Presently, DOE has identified more than 1 million 55-gallon drums and boxes of waste in storage, and 3 million cubic meters of buried waste. Over the years, many of the older disposal containers have been breached resulting in contamination of the adjacent soil. Considering transuranic solid waste, approximately 190,000 cubic meters have been buried, and 60,600 cubic meters have been retrieved and stored. Mixed transuranic waste composes 58,000 cubic meters of this inventory. High-level waste stored at four DOE sites represent another 381,000 cubic meters of volume. Currently, 77 million gallons of high-level waste is contained in 332 underground storage tanks as sludge/liquids. There are also small amounts, approximately 4,000 cubic meters of high level waste, stored as granular calcined solids. Most of the high-level wastes are mixed with hazardous contaminants and are thus considered mixed wastes. The remainder of the waste in storage is low-level waste. This remainder is made up of 3,000,000 cubic meters, including 247,000 cubic meters of mixed low-level waste. Currently no effective treatment is known to exist for 107,000 cubic meters of this mixed low-level waste.

Another form of waste, representing potentially large volumes, is associated with decontamination and decommissioning of contaminated buildings and equipment. More than 500 separate facilities have been identified, and it is possible that as many as 7,000 facilities at 39 different sites could be scheduled for decontamination and decommissioning. Although materials will be recycled when possible, this activity will result in new waste generation that is immeasurable at this time. Additionally, as much as 20,000 cubic meters of mixed waste, in 100 separate waste streams, is still being generated on an annual basis from ongoing transition activities.

Developing cost-effective innovative hazardous and mixed waste characterization and treatment technologies is not only a requirement for DOE, but for other Federal Agencies and commercial businesses as well. Current EPA estimates project a total national present value program cost of about 18.7 billion, and annual cost of about 1.8 billion using available technologies. Furthermore, the EPA assumes there exists approximately 773,000 sites with underground storage tanks that are subject to regulation and remediation.² Most of these tanks contain petroleum products and require remediation of the tank as well as the surrounding soil as a result of leakage problems. Although occurrences of radioactive contaminated waste is less frequent in the public sector, that does not erase the fact that there are currently no widely accepted technologies available to treat this waste. Development of efficient, low risk mixed waste treatment systems and facilities is one of the most pressing issues facing public and private environmental restoration and waste management efforts. The DOE is currently working with other Federal agencies and private sector firms to bring innovative hazardous and mixed waste treatment technologies on line as swiftly as possible.

Pollution Prevention

Manufacturing processes are the source of much of the generated hazardous waste within DOE, other Federal agencies, and U.S. industry. The Environmental Protection Agency estimates that the national cost of pollution control, treatment and disposal in 1990 was almost \$115 billion, with industry's share at about \$73 billion.³ The Office of Technology Assessment estimates that 99% of these costs are for end-of-pipe pollution control.⁴ Recognizing that pollution prevention is the preferred alternative to end-of-pipe pollution control, the DOE has established a national research program for pollution prevention and waste minimization at its production plants. During FY 1989/1990 the Office of Environmental Restoration and Waste Management (EM) through the Office of Technology Development established a comprehensive pollution prevention technical support program to demonstrate new, environmentally-conscious technologies for production processes.

The DOE/EM is responsible for the dismantlement of approximately 2,000 weapons per year requiring the treatment of approximately 230 cubic meters of components yearly. The Department estimates that a 10-fold reduction in waste volume is possible through advanced processes and technologies resulting in a annual storage cost savings of about 95 percent, from \$2.8 million to \$112,000. In addition, EM estimates indicate that innovative resource recovery processes could provide approximately \$10 million per year through the resale of precious metals such as silver, gold, and platinum.

EM together with other agencies and industry, is developing technological solutions to address common waste stream problems such as chlorinated solvents, toxic metals from finishing operations, VOCs from cleaning operations, and waste acid recycle. For example, EM works closely with the electronics and electromanufacture process industry to develop processes, and their associated technologies, which reduce or eliminate the use of chlorinated fluorocarbons and chlorinated hydrocarbons. DOE estimates that it uses in excess of 180,000 liters of chlorinated hydrocarbons in the cleaning of electronic components annually. EPA estimates indicate that contaminated soil, sediment, and sludges at sites listed on the National Priorities List (those without RODs) from electronic/electrical equipment alone approaches 1.5 million cubic yards.⁵

The Pollution Prevention program supports an integrated approach to pollution prevention and waste minimization through the development and demonstration of technologies which focus on process modifications, material substitutions, recycling and reuse, and energy efficiency in support of applicable Federal, State and local environmental regulations. Advances in this area have the potential to provide significant cost savings through efficient use of raw materials and lower costs associated with waste storage, treatment, and disposal. In addition, they have the potential to stimulate U.S. competitiveness and economic growth through the growth of a "clean" technology industry.

¹ U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response Technology Innovation Office, Cleaning Up the Nation's Waste Sites: Markets and Technology Trends

² U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response Technology Innovation Office, Cleaning Up the Nation's Waste Sites: Markets and Technology Trends

³ U.S. Environmental Protection Agency, Office of Policy Planning and Evaluation, Environmental Investment: The Cost of a Clean Environment, EPA-230-11-90-083, November 1990.

⁴ U.S. Congress, Office of Technology Assessment, Serious Reduction of Hazardous Waste: For Pollution Prevention and Industrial Efficiency, OTA-ITE-317, September 1986.

⁵ U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response Technology Innovation, Cleaning Up the Nation's Waste Sites: Markets and Technology Trends.

EM PROGRAM OVERVIEW

Organizational Structure

The EM organization *(Figure 2) was established to provide visibility, focus, and accountability for DOE's waste management and cleanup efforts.

The EM Office of Policy and Program Information (EM-4) serves as a central coordinate for DOE EM public participation and program information activities. EM-4 establishes public participation policy and guidance, conducts public participation activities, and coordinates public participation activities inside and outside the agency. The goal of public participation is to identify public concerns, needs, and objectives through two-way communications between DOE and the public before decisions are made. This interactive process improves DOE understanding of public concerns, and improves the public's understanding of DOE decisions and subsequent technology development activities.

The EM Office of Planning and Resource Management (EM-10) supports program office financial management, procurement, and administrative activities, and EM-10 coordinates the annual update of the EM Strategic Plan and Five-Year Plan.

The EM Office of Oversight and Self-Assessment (EM-20) performs independent internal oversight within EM to ensure compliance with environmental and safety laws/regulations and, with DOE Quality Assurance (QA) policies. EM-20 is also charged with enhancing the technical validity and cost-effectiveness of programs and projects. In addition, it is responsible for independent cost estimating functions for EM.

The EM Office of Waste Management (EM-30) has program responsibilities for waste management at all DOE sites, including the treatment, storage, and disposal of several types of waste: transuranic, low-level radioactive, mixed, and solid sanitary. EM-30 is also responsible for the storage, treatment, and processing of defense high-level radioactive waste (HLW), waste minimization efforts, and corrective activities at waste management facilities.

The EM Office of Environmental Restoration (EM-40) has program responsibilities for remediation of inactive hazardous and radioactive waste sites at all DOE installations and some non-DOE sites, including remedial actions and decontamination/decommissioning (D&D) activities.

Figure 2. DOE Organizational Structure as of June 1993.

The EM Office of Technology Development (EM-50) has program responsibilities for the development of better, faster, cheaper, and safer technologies for meeting DOE's 30-year goal for environmental restoration and waste management, and for managing crosscutting activities.

The EM Office of Facility Transition and Management (EM-60) plans, implements, and manages the orderly transition of facilities from their operational base to EM-30 and EM-40 and their subsequent disposition. EM-60 establishes and implements a consistent process to safely deactivate and dispose of DOE facilities.

Office of Technology Development EM-50

The Office of Technology Development (EM-50), (Figure 3) has the overall responsibility for the development of technologies to meet DOE's 30-year goal for environmental restoration. Activities within EM-50 include: applied research and development; demonstration, testing, and evaluation of new and existing technologies; analytical support services; DOE-wide transportation of material (particularly radioactive hazardous substances and hazardous wastes); emergency management; and education, outreach, and technology integration programs.

The Office of Technology Integration and Environmental Education and Development (EM-52) supports EM-50's efforts to (1) ensure a skilled, knowledgeable workforce to

meet DOE's 30-year cleanup goals; and (2) provide both international and domestic environmental technology integration frameworks to encourage and facilitate the infusion and diffusion of innovative environmental technologies through collaborative partnerships with U.S. industry, the National Laboratories, other Federal agencies, universities, and foreign organizations.

The Office of Program Support (EM-53) provides management, financial, and internal program support to the line organizations that comprise EM-50. Its mission includes providing management systems and processes, planning, training, and presentation support. Responsibilities include budget, personnel, facilities, travel, quality assurance, and logistics support.

The Office of Research and Development (EM-54) is responsible for the development of applied research and development programs at DOE sites nationwide. Programs are designed to identify operational needs in the areas of environmental restoration, waste operations, and corrective activities to rapidly advance beyond currently available technologies, and to provide solutions to key technical issues that, if not solved in a timely manner, will adversely affect DOE's ability to meet its 30-year cleanup goal.

The Office of Demonstration, Testing and Evaluation (EM-55) is responsible for identifying environmental restoration and waste management technologies in the research and development stage that are ready for transition to the demonstration arena. Those technologies are fielded as

Figure 3. Office of Technology Development Organizational Structure as of June 1993.

complete systems to demonstrate a solution to a technological need. Programs are conducted to rapidly advance selected technologies so they can be utilized by DOE to meet its 30-year cleanup goal in a cost-effective manner.

The Office of Special Programs (EM-56) supports programs and activities that crosscut all offices within EM such as: (1) Transportation Management; (2) Emergency Management; (3) Laboratory Management; and (4) Liaison and Communications Support. Activities are conducted in conjunction with other EM program offices to ensure proper coordination and line management control.

Funding Summary

For FY93, the total funding appropriated to Environmental Restoration and Waste Management (EM) Office of Technology Development Program was \$385 million. This amount represents approximately 6 percent of the total EM appropriation for FY93. The total funding for the Office of Technology Development is shown by major program in **Figure 4** and by major function in **Figure 5**.

PROGRAM	FY92	FY93
Research, Development, Demonstration, Testing and Evaluation	\$ 169,463	\$ 200,130
Groundwater and Soils Cleanup	54,588	81,060
Waste Retrieval and Processing	54,177	73,941
Pollution Prevention	6,004	3,502
RDDT&E Innovation and Support	54,694	41,627
Supporting Technologies and Infrastructure	\$ 29,674	\$ 43,000
Liaison and Communications	0	0
Analytical Laboratory Management	9,979	14,500
Robotics	17,480	24,800
Decision Support	2,215	1,500
Emergency Management	0	2,200
Transportation Management	\$ 18,870	\$ 19,800
Technology Integration and Education Development	\$ 37,380	\$ 36,905
Educational Development	21,928	21,615
Technology Integration	7,740	11,990
International Technology Exchange	7,712	3,300
Program Support	\$ 34,775	\$ 41,295
Program Direction	\$ 15,050	\$ 15,570
Environmental and Molecular Sciences Laboratory	\$ 17,100	\$ 28,500
TOTAL	\$ 322,312	\$ 385,200

Figure 4. Appropriation by Program

Figure 5. Appropriation by Function

RESEARCH, DEVELOPMENT, DEMONSTRATION, TESTING AND EVALUATION (RDDT&E)

The RDDT&E programs of the EM Office of Technology Development are driven by the needs of the DOE Offices of Environmental Restoration (EM-40) and Waste Management (EM 30), which include the critical problems of high level waste tanks; characterization, treatment and storage of mixed waste; migration of contaminants; containment of existing landfills; and decommissioning and final disposition. The activity areas within RDDT&E, **Figure 6**, are discussed below.

Groundwater and Soils Cleanup activities focus on the development of technology systems to clean up and contain hazardous/radioactive contaminants in groundwater and soils. Sources of soil and groundwater contamination include: previous disposal of wastes in ponds, seepage pits and trenches, and shallow land burial sites; spills and leakage from waste transport and storage facilities, including underground tanks; and discharges to the air and surface waters.

Waste Retrieval and Waste Processing activities focus on technologies for retrieving and processing hazardous, radioactive, and mixed waste from current DOE weapons complex operations, treating buried and stored waste, and decontaminating and decommissioning facilities no longer in operation.

Pollution Prevention activities involve the integration of new technologies and technology systems into processes to reduce the toxicity or amount of hazardous and/or radioactive materials at the source, and to reduce the toxicity and volume of waste for disposal through recycling, reuse, and treatment.

RDDT&E Innovation activities focus on ensuring that private industry and other Federal agencies are major participants in developing and deploying technologies for Environmental Restoration and Waste Management.

Robotics Technology Development activities are aimed at DOE site complex work in hazardous environments and the handling of hazardous materials. Site needs include Underground Storage Tank remediation, buried waste retrieval, waste minimization, decontamination and decommissioning, containment analysis automation, and other processes.

These programs are executed in three phases: Innovative Technology; Research and Development (R&D); and Demonstration, Testing, and Evaluation (DT&E). The Innovative Technology phase supports the transition of technology from concept to proof of concept. The goal is to prepare a technology for the Applied R&D phase.

Figure 6. EM-50 Activity Areas.

Integrated Demonstrations And Integrated Programs

In 1989, the EM Office of Technology Development introduced the concepts of "Integrated Demonstration" and "Integrated Program" as an approach to more effectively manage RDDT&E activities. The Integrated Demonstration (ID) and Integrated Program (IP) are systems engineering concepts used by the EM Office of Technology Development to describe the interrelated stages of technology development process.

An Integrated Program is a set of RDDT&E activities dedicated to meeting needs for technology solutions for a single problem category (e.g., minimization, characterization, treatment, storage, and disposal) common to Environmental Management activities across the DOE complex. Integrated Programs focus the development of a technical base for environmental technologies and are centrally-managed, though not necessarily centrally located.

An Integrated Demonstration (ID) provides an end-to-end system for solving environmental management problems at a site. An ID addresses specific parts of environmental issues by applying multiple technologies and comparing them at various stages of development.

Technologies developed and tested in IDs and IPs, effectively applied, can result in successful cleanup of environmental wastes at tremendous savings of time, energy and money.

Technology Window Of Opportunity

A major portion of technologies for cleanup are to be selected and specified through the regulatory process and Records of Decision in the next 5-7 years, creating a **"window of opportunity"** to realize significant savings from technology innovation or advancement in the interim. In FY92, the EM Office of Technology Development initiated an on-going analysis of completed and prospective compliance agreements to ascertain the dates by which RDDT&E activities must be completed, and the estimated savings to be achieved by employing new and innovative technological solutions to environmental restoration and waste management problems. The results to date point to a narrow **"window of opportunity"** within which the introduction of new and innovative technology solutions must be accomplished. If EM is to realize significant returns on U.S. investment in technology development, RDDT&E activities must be substantially completed by the late 1990's.

As an example, for the remediation of volatile organic compounds (VOCs) in arid soil, (Figure 7) the majority of Records of Decision (RODs), which determine the selected remedial action, are scheduled to be completed by 1995. To impact these decisions, new technologies must be proven and in place ahead of time. The situation is similar across EM facilities. For new technologies to significantly lower remediation costs, modifications to the current regulatory compliance framework will be required. These changes must be pursued in cooperation with other Federal agencies, States, Indian Tribes, and the general public.

Figure 7.
Technology
Development Window
of Opportunity

RDDT&E FY93 PROGRAM SUMMARIES

CLEANUP OF VOCs IN NON-ARID SOILS THE SAVANNAH RIVER INTEGRATED DEMONSTRATION

Abstract

One of the most common environmental problems in the United States is soils and groundwater contaminated with volatile chemical solvents classified as Volatile Organic Compounds (VOCs), which were used as degreasers and cleaning agents by industry and many government facilities. Leakage of solvents (trichloroethylene and tetrachloroethylene) from an underground process sewer line has contaminated soils and underlying groundwater at the Savannah River Site. This site was chosen for DOE-OTD's integrated demonstration of innovative technologies for cleanup of non-arid soils and groundwater contaminated with VOCs. These pages briefly describe the use of the integrated demonstration approach, the technologies and systems being demonstrated and evaluated, the results of full-scale field demonstrations, cost savings examples, and the approach for technology transfer and implementation.

What is an Integrated Demonstration?

An integrated demonstration is a management concept developed to facilitate timely and effective application of new and enhanced technologies to meet the Department of Energy's environmental restoration needs. An integrated approach best utilizes government funding and talent by minimizing duplication of effort and assuring rapid evaluation of new technologies. Multiple technologies are assembled and evaluated as tools for a cradle-to-grave solution to a specific problem representing a generic environmental issue.

Entire systems of technologies are evaluated with respect to performance, safety and cost effectiveness. Through collaborative partnerships with DOE laboratories, universities, federal agencies, and private industries, the developers of each technology are brought together with experts in the many facets of the demonstration. Chemists, geohydrologists, geophysicists, biologists, drilling engineers, environmental engineers, environmental modelers, materials scientists, and others involved in the project, each approach the project from a unique perspective. Major savings in time and federal tax dollars can be realized by demonstrating multiple technologies at one test bed. Site characterization, modeling, and monitoring information can be shared, validated, and compared, thereby increasing its technical and interpretive value and improving evaluation of the technologies being demonstrated.

Technologies and systems to be demonstrated are selected by a team of experts based on a number of criteria such as readiness for demonstration, likelihood of success, cost effectiveness, benefits of the new technology as compared to conventional technology, etc. All technologies and systems demonstrated are compared to one another and to conventional technology to assure effective evaluation. Successfully demonstrated systems are then transferred for full-scale implementation at government and industrial sites. Cooperative efforts between government, universities, and industry are an integral part of the program.

Introduction

A major task for DOE is the management of environmental wastes at its various facilities where radioactive, hazardous, and mixed wastes have accumulated for as long as 45 years. Previous disposal practices, once considered state of the art, have proven inadequate or faulty, resulting in potentially serious soil and water contamination. DOE has committed to cleaning up contaminated locales to levels acceptable to state and federal regulators. However, present day technologies may not be capable of accomplishing this task within a reasonable period of time. Hence, the DOE Office of Technology Development was formed to develop innovative solutions to the environmental restoration and waste management problems.

The Savannah River Site (SRS) was selected as the first test bed where innovative technologies could be evaluated using the integrated demonstration approach. The overall approach has been to develop and demonstrate in situ remediation systems with potential for faster and cheaper cleanup of soils and groundwater. The in situ remediation systems are being proposed as enhancements to the conventional technology.

The Savannah River Site is a 300 square mile complex located along the Savannah River near Aiken, South Carolina. It supports national security through production of nuclear materials. Due to past operations in the metals fabrication facility at the site (M-area), waste disposal practices have

**The Department of Energy's
Savannah River Site**

resulted in contamination of groundwater and soils with VOCs. The Integrated Demonstration Site is located within this contaminant plume.

The principal objective of the Integrated Demonstration (ID) at the Savannah River Site is to establish, validate and implement systems as ready for full-scale use in the remediation of soils and groundwater contaminated with VOCs. Several remediation technologies involving the use of directionally drilled wells for extraction and delivery are being demonstrated. These include in situ air stripping (sparging), in situ bioremediation, and thermally enhanced vapor extraction (radio-frequency and ohmic heating). Innovative monitoring and characterization technologies are being developed to support analysis and evaluation of the performance of the remediation systems.

Because many of the remediation systems incorporate vapor extraction, offgas treatment technologies have been and will be demonstrated. Technologies that emphasize destruction of contaminants will be demonstrated side by side so that cost and performance data can be easily compared and the new technologies can be compared to baseline technologies.

Project Background

The Savannah River Site was especially well suited as the test bed for this integrated demonstration project due to the presence of a pre-existing line source that contributed contamination to both soil and groundwater, on-going environmental remediation efforts at the site, and full cooperation from the concerned environmental regulatory agencies.

The soil and sediments at the SRS project site consist of interbedded sands, silts, and clays, with sands predominating. The water table is present at a depth of approximately 135 feet.

Conventional means for removal of volatile contaminants from soils and groundwater include pumping the groundwater to the surface followed by air stripping with above-ground equipment, vacuum extraction of volatile subsurface contamination, or site excavation for physical removal of the contaminated materials.

Pump-and-treat groundwater technology has been demonstrated at the SRS as an effective method for hydraulic plume control and for removal of significant contaminant mass. 270,000 pounds of VOCs have been removed from the subsurface since 1984.

However, cleanup of groundwater to drinking water standards is problematical using the conventional technology. The Environmental Protection Agency presently recommends installation of pump and treat systems as a first step in remediation of groundwater, but also recognizes the need to develop innovative solutions that can be used to enhance the conventional systems. In situ remediation technologies can destroy contaminants in place or contaminants can be extracted as a vapor, reducing the excessive energy requirements for pumping groundwater to the surface for treatment. The remediation system enhancements should be directed at source treatments such as vapor extraction of the vadose zone.

A promising technology for enhancement of remediation system performance is horizontal drilling, developed by the petroleum and utility installation industries, and demonstrated at the SRS. Horizontal wells can significantly improve access to the subsurface. The entire lateral section of a horizontal well is screened to allow for a broader distribution of gas or liquid for injection or extraction. Just as horizontal wells have improved the performance of oil recovery systems in old petroleum fields, they have been shown to improve environmental remediation system recovery at SRS. Although more costly per linear foot to install than vertical wells, a horizontal well system can save significantly on operating expenses, thus reducing overall remediation costs during the lifetime of the project.

The positioning of horizontal wells can be planned to conform to the distribution of subsurface contamination, optimizing the remediation system design by providing more surface area for contacting the contaminant plume. Because many water bearing formations are deposited as relatively thin but extensive zones, horizontal well systems provide more efficient fluid delivery to those locations and hence improve contaminant recovery. Horizontal wells can also be used to access contaminant sources below existing facilities, thus speeding up the remediation process by treating the most contaminated areas

The Savannah River Integrated Demonstration

The objectives of this Integrated Demonstration are:

- Demonstration and evaluation of new technologies to remediate groundwater and soil in place.
- Demonstration of new technologies for characterization, monitoring, and modeling of environmental restoration activities.
- Technology transfer and implementation to both government and industrial facilities.

first. In conjunction with other supporting technologies, horizontal well systems represent a promising new approach for environmental remediation.

Four different directional drilling technologies have been modified from the petroleum, river crossing, and utility industries for demonstration for environmental applications at the SRS. The four directional drilling systems are being compared and evaluated in terms of technical performance and cost effectiveness. In the meantime, the wells installed as part of these demonstrations have been and will be used for the remediation system demonstrations.

Remediation System Demonstrations

The technology emphasis for this integrated demonstration is in situ remediation because it has tremendous advantages over above-ground treatment. In situ remediation technology has the potential to be more effective in less time at a reduced cost and also has the benefit of minimizing worker exposure. Three in situ remediation systems have been or will soon be demonstrated: (1) in situ air stripping or air sparging, (2) in situ bioremediation, and (3) in situ heating. Innovative characterization and monitoring technologies directly support the system performance analysis and thus are discussed in conjunction with the remediation systems.

In Situ Air Stripping

The first remediation technology demonstrated as part of this integrated demonstration was the DOE-patented in situ air stripping horizontal well system, designed to remove solvents from soils and groundwater. This remediation system combines vapor extraction of the vadose zone with air injection into the groundwater. The air injection is based upon the same principle utilized by the above-ground pump-and-treat conventional technology. Two horizontal wells were installed along an abandoned process sewer line that was known to have leaked trichloroethylene and tetrachloroethylene to the subsurface. One well, installed below the water table and within the contaminated zone, was used for injection of air. The second well, installed above the water table, was used as a vapor extraction well. Both wells were designed to be operated concurrently to remove the volatile organics stripped from both the groundwater and soils. An underground injection well permit was obtained from the state regulatory agency before initiation of the demonstration of this innovative technology.

Initial operation of the system involved simple vapor extraction. Comparison of this horizontal well vapor extraction system with a vertical well system previously demonstrated at the site showed a five-fold increase in contaminant removal rate simply due to the horizontal well geometry. This five-fold improvement in efficiency due to the horizontal well geometry is similar to that recorded for the petroleum recovery industry.

Horizontal well in situ air stripping was demonstrated for a period of twenty weeks. A total of 16,000 pounds of chlorinated solvents were removed from the test site during that period. This solvent removal rate was equivalent to that of 11 groundwater pump and treat wells pumping 500 gpm. Typical air extraction flow rates were 600 standard cubic feet per minute (scfm) from the extraction well, operated at a sub atmospheric pressure of approximately 10.3 inches of mercury. Air injection rates were varied to determine their effect on extraction levels, but typically were 10% to 50% of the extraction rate. The difference between injection and extraction assured that there was net positive gas flow toward the extraction well so that the injected air did not move the contaminant beyond the boundaries of pre-existing plumes. The addition of air injection below the water table to the overall remediation system produced a 15 percent increase in the removal rate of VOCs from the subsurface. The maximum removal rate for total VOCs was 130 pounds per day when the horizontal wells were operating at 600 scfm extraction and 270 scfm injection.

Analysis of groundwater samples from monitoring wells, measurements of injection and extraction well gas pressure and contaminant chemistry, and helium tracer tests were conducted to document the performance of the system. Groundwater monitoring has shown that trichloroethylene and tetrachloroethylene concentrations in groundwater dropped significantly in many of the monitoring wells. Helium tracer testing was used to determine if the injected and purged gases

Modified from the utility industry, this rig drills horizontal wells without generating drilling fluid wastes.

Schematic diagram of horizontal well in-situ air stripping concept

were quantitatively recovered. Helium was selected as the tracer gas because it is not found naturally in high concentrations in the air and because it could be easily monitored. Helium was added to the injected air and the distribution of helium moving through the groundwater and soil in the unsaturated zone was measured and profiled. The data obtained confirmed the fact that the subsurface at the SRS test site contained high permeability and low permeability heterogeneities (typical of a natural system). The results of this tracer testing enhance the understanding of flow paths, residence times, and distribution of the gases between the air injection and extraction wells.

Depth discrete sampling of the sediments provide three-dimensional characterization data both before and after the demonstration. This information is used to support evaluation of the performance of the remediation system. Biological monitoring of groundwater and sediment samples has shown that contaminant degrading organisms have flourished at the site during air injection.

Crosshole geophysical tomography (both seismic and resistivity) successfully mapped moisture changes (fluid saturation distribution) in the subsurface as air stripping test conditions were modified. These technologies successfully demonstrated a method to detect the area of influence of the air injection by generating and recording the progress of various waves as they move through the ground. In addition, single-

point in situ fluid flow sensors, based on thermal perturbation principles, monitored groundwater flow paths (direction and rate) in three dimensions during air injection. These sensors provided real-time data and replace hydraulic gradient measuring methods, which require the installation of wells and a longer lag time in producing data. This information is critical to evaluating the effectiveness of the remediation system and design of full-scale systems.

Comparison of the costs of an in situ air stripping system with horizontal wells versus a standard pump-and-treat system predicts a saving of approximately 40% using the innovative technology. We propose that the innovative technology should be used as an enhancement to the standard baseline technology. The baseline technology serves to control migration of the entire contaminant plume, while the innovative technology is used at the hot spots within the plume.

In Situ Bioremediation

Enhancement of the in situ air stripping/horizontal well system to encourage in situ bioremediation is presently being demonstrated at the same site where the in situ air stripping was demonstrated. Injection of 1 to 4% methane in the air provides a food source to stimulate the indigenous microorganisms known to be capable of degrading TCE. In situ bioremediation

is an attractive technology because the contaminants are destroyed rather than moved from one medium to another. In situ biologically assisted destruction reduces costs and time of remediation, while increasing remediation efficiency and public and regulatory acceptability. System modification included a reduction in the volume of air extracted, thus encouraging the in situ process, and addition of a catalytic oxidation unit to treat the offgasses from the vapor extraction unit.

To initiate the in situ bioremediation demonstration, the underground injection well permit was modified and approved by the state regulatory agency. The demonstration has involved five stages of operation during the first nine months: (1) vacuum extraction only, 240 scfm, 3 weeks, (2) air injection, 200 scfm, 5 weeks, (3) air plus 1% methane, 240 scfm, 15 weeks, (4) air plus 4% methane, 240 scfm, 11 weeks, and (5) pulsing of air plus 4% methane versus air alone, 240 scfm, ongoing. Addition of nitrogen and phosphorous as nutrients is planned for the final stage of operation.

To support evaluation of the performance of the bioremediation system, groundwater and sediment samples have been chemically and microbially assayed, while vapor samples have been collected from the extraction well and from vadose zone piezometers to be analyzed for chlorinated compounds, carbon dioxide, and methane. These samples were collected before, during, and will be collected after the demonstration to evaluate system performance. Evidence of biostimulation includes: (1) complete consumption of all injected methane at the 1% level (stage 3), (2) increasing densities of methanotrophic microorganisms by as much as five orders of magnitude in groundwater from monitoring wells sampled during the methane injection, (3) decreases in groundwater VOC concentrations in the same monitoring wells where the methanotrophic populations increased significantly, (4) increased biomass, mineralization and enzyme activities in groundwater from monitoring wells, (5) increases in carbon dioxide concentrations in the extraction well and in vadose zone piezometers, and (6) decreases in TCE and PCE concentrations in sediments collected after the initial methane injection campaign.

Biomolecular probes, used for characterization of the subsurface microbial population at the Integrated Demonstration Site, are new, rapid, laboratory analysis techniques that can save tremendous amounts of time and money. Characterization of the indigenous microbial population in the subsurface is a critical element of the remediation demonstrations.

The in-situ bioremediation system presently being demonstrated at the Savannah River Integrated Demonstration Site

Biomolecular probes provide data in hours, replacing other methods such as viable cell counts that required weeks to obtain results. Development of additional innovative methods to more rapidly characterize the microbial population continues.

In Situ Heating

Characterization of the contaminant plume has demonstrated that a significant proportion of the contamination is present within the more clay-rich layers of the vadose zone at the Integrated Demonstration Site. Removal of this material by simple vacuum extraction is problematical because of mass transfer limitations in low permeability sediments. Treatment of these zones with heat to enhance the volatility of the contaminants will facilitate removal by vapor extraction. Two innovative thermal treatment systems, radio-frequency and ohmic heating enhanced vapor extraction, will be compared to one another and to conventional vapor extraction using a horizontal well installed within a shallow clay layer. The radio-frequency heating will utilize a dipole wand placed down the horizontal wellbore to heat a 25 foot long zone within the screened area of the well. The ohmic heating demonstration will be conducted at a later time, heating an adjacent zone within the same horizontal well. The ohmic heating is a six-phase system that will utilize a ring of six electrodes that surround the horizontal extraction well. Technical performance of these systems will be evaluated using two different types of temperature sensing devices, chemical monitoring of the vapor stream extracted from the horizontal well, chemical monitoring of vadose zone piezometers, and pre- and post-test chemical characterization of the sediments. Evaluation of the effects of heating on the indigenous microbial population and their ability to degrade contaminants will also be conducted.

Offgas Treatment System Demonstrations

Characterization of the Integrated Demonstration Site has demonstrated that at least 50% of the contaminants in the upper 200 feet are present within the vadose zone. Vacuum (vapor) extraction, a well accepted and previously demonstrated technology for treatment of the vadose zone, generates a waste stream containing VOCs. In fact, all in situ remediation systems being demonstrated include a vapor extraction component. The Clean Air Act will require treatment of all vapor streams by 1995. Baseline technology for such treatment is carbon adsorption, which generates a secondary waste that must be treated or stored, and incineration, which does not have public acceptance. Thus, innovative offgas treatment technologies that destroy the VOCs, producing carbon dioxide and water, will be demonstrated side by side to be compared for technical performance and cost efficiency. Classes of technologies to be demonstrated include but are not limited to catalytic oxidation, free radical generation, biotreatment, and carbon regeneration.

Other Characterization and Monitoring Technologies

Innovative sensors, samplers and real-time analytical measurements have been developed, demonstrated, and evaluated to monitor the effectiveness of the in situ remediation activities at the demonstration site. These technologies have broad applications for innumerable environmental restoration problems. Technologies in this category include both vadose-zone and groundwater multilevel samplers (SEAMIST, arrayed sampler, membrane sampler, etc.), fiber optic sensors, groundwater flow sensors (thermal and microphotographic), real-time field analytical equipment (ITMS, PAWS), and seismic and resistivity crosshole tomography.

The mobile cone penetrometer, capable of rapidly penetrating ground for collection of real-time geological, geophysical, and geochemical data, has been demonstrated as a cost-effective subsurface characterization tool. Traditional methods to access

the subsurface require drilling and boring operations, whereas this technology literally pushes the probe through the soil and subsurface sediments using high-pressure hydraulic rams. This method is quicker and does not cause contaminated soil displacement up to the surface. Removal of the probe can be accompanied by automatic grouting of the hole to seal it, eliminating a route for contaminant movement. The cone penetrometer can deploy many different state-of-the-art line sampling and instrument devices, such as a basic screening detector for soil resistivity and a fiber-optic fluorometric sensor that detects petroleum hydrocarbons. New sensors, such as TCE and DNAPL sensors, have been or will be incorporated into the cone penetrometer for demonstration. This characterization technique can improve design for monitoring well networks, while cutting costs by reducing the number of monitoring wells required.

Technology Implementation/Transfer

Implementation of innovative remediation systems that have been demonstrated as part of this ID will potentially save DOE and other Federal Agencies several hundred million dollars. Following successful demonstration of a new technology or system, the performance and cost effectiveness of the technology or system is evaluated against that of existing baseline technologies. Application to industrial sector problems will add significantly to overall cost savings. For example, the cost analysis report that evaluates the cost and performance of the in situ air stripping system relative to conventional cleanup technologies such as soil vapor extraction and pump and treat for the removal of VOCs, has estimated that cleanup costs at applicable sites could be reduced by 50-60%. This represents a potential cost savings of over \$140 million (assuming that this technology is suitable at 10% of the DOE sites). A cost analysis report has also been prepared for the Site Characterization and Analysis Penetrometer System (SCAPS), with projected federal agency cost savings of \$100 million.

To achieve these projected savings, a critical step in the integrated demonstration program is implementation of the successfully demonstrated technologies and systems by DOE's Environmental Restoration organizations and transfer of technologies to other government agencies and the public sector. The cost and performance evaluations are made available to perspective users of the technology/system through professional meetings, licensing meetings, and site tours. Technical symposia are held to present the innovative technologies to industry and government. Another key to

Layout of thermally enhanced vapor extraction system

technology transfer includes cooperative demonstrations at other government and industrial sites where DOE expertise and experience can be utilized to maximize the success of the demonstrations.

DOE patented technologies are licensed to the private sector. Technical support provided to prospective users of the technology assures more rapid implementation of the innovative solutions. A close working relationship with state and federal regulators assures acceptance of the innovative solution as an alternative or as an enhancement to a conventional system. A number of innovative characterization technologies have been successfully transferred to SRS Environmental Restoration and have been utilized at other SRS waste sites. Licensing of the in situ air stripping horizontal well patent to commercial vendors is another example of technology transfer. At least thirteen licenses for this technology have been granted or filed. Licenses for Sandia National Laboratory's fluid flow and Lawrence Livermore National Laboratory's TCE sensor have also been granted. The cone penetrometer fluorescence sensor has also recently been patented. The use of horizontal wells for environmental applications has flourished over the last year. DOE's involvement in promoting this innovative technology has been instrumental in its implementation.

Transfer of technologies to and from the industrial sector, DOE, and DOD is ongoing. Industrial involvement in the integrated demonstration has been substantial and has recently been influenced by establishment of Cooperative Research and Development Agreements (CRADAs) and issuance of Program Research and Development Announcements (PRDAs).

For further information on DOE's VOCs in Non-Arid Soils ID, contact:

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Selected Past Accomplishments

Demonstrated the horizontal well technology for groundwater cleanup operations. Seven non-exclusive licenses for use of the horizontal well technology have been issued or approved for companies of diverse sizes.

Underground imaging systems were field tested in the groundwater soils cleanup integrate demonstration at DOE Savannah River Site and at the Sandia National Laboratories. Underground imaging allows certain kinds of subsurface targets and hydrologic processes to be detected and monitored for control purposes; this will help facilitate the development and demonstration of in situ remediation methods.

Developed portable ion-trap mass spectrometer with detection limits below standards with less than half sample processing time.

Completed in situ air stripping test during first phase of non arid site volatile organic compound integrated demonstration.

Designed bioreactor for removing oil residues from contaminated soils which provides suitable technology for on site cleanup of soils contaminated with oil residues.

Completed in situ stripping test during first phase of non-arid site volatile organic compound integration demonstration. In situ air stripping of trichloroethylene was five times more effective than conventional pump and treat technologies. Removed 16,000 pounds of volatile organic compounds (VOCs) using air injection and horizontal well extraction.

Conducted an in situ heating pilot test that exceeded expectations; field in situ heating tests employing a radio frequency heat source are underway. Field demonstrations employ an array of technologies to ensure effective control and process optimization. This technology frees volatile organics compounds which cannot be effectively removed from clay composition soils by vapor extraction alone.

Developed and demonstrated an unsaturated flow apparatus to reliably predict contaminant movement in soil. The baseline approach uses column testing to collect the needed data which could take between one to three months per sample. The unsaturated flow apparatus is capable of performing the same analysis within 24 hours at a cost savings of 80 percent. This accelerated monitoring and control of in-ground contaminant behavior enhances the efficiency and effectiveness of clean up operations.

Completed the in situ air stripping demonstration.

Drilled a second set of horizontal wells utilizing an innovative, cost-reducing, directional drill technology.

Demonstrated site characterization and analysis cone penetrometer system in conjunction with the Army Corps of Engineers.

Demonstrated and transferred characterization (depth discrete sampling, ion-trap mass spectrometer, shear wave seismic reflection, He tracer testing), and remediation technologies and systems (based on horizontal wells and in situ air stripping) to DOE Savannah River Site (SRS) users, Hanford VOCs in Arid Soils Integrated Demonstration, and U.S. Air Force users.

Initiated full-scale field demonstration of in situ bioremediation (methane injection).

Initiated field demonstration of off-gas treatment technologies (photocatalytic, thermal catalytic, ozone oxidation) to destroy or capture and recycle trichloroethylene (TCE).

Demonstrated innovative monitoring technologies (fluid-flow sensors, electromagnetic tomography, electrical resistance tomography, chemical sensors) to provide real-time, in situ, or field screening data.

Demonstrated minimally invasive characterization technology to provide real time data (fiber optic/cone penetrometer).

1993 Accomplishments/Objectives

Successfully demonstrated full-scale in situ bioremediation of volatile organic compounds.

Completed field demonstration of in situ bioremediation demonstration.

Demonstrate performance and cost effectiveness of off-gas treatment technologies.

Complete demonstration of radio frequency heating to enhance removal of VOCs from clays in cooperation with the Air Force.

Package supporting technologies (characterization and monitoring) into systems for transfer to customers.

Initiated close-out of Savannah River Integrated Demonstration.

Conducted a number of licensing meetings to enhance industrial involvement and technology transfer (Air Stripping with Horizontal Wells - 13 license applications filed, In-Situ Bioremediation, 2 license applications filed).

Initiated transfer of successfully demonstrated in situ bioremediation system to Savannah River Site Environmental Restoration.

1994 Objectives

Complete evaluation of sensor systems and transfer to commercial sector.

Complete off-gas treatment evaluation and provide information for Environmental Restoration for use in meeting the requirements of the Clean Air Act.

Complete demonstrations and reports that document technical performance and cost analysis evaluations of the in situ thermal technologies (six-phase Ohmic) to remove VOCs.

Complete technology performance and cost analysis of in situ bioremediation with methane injection.

Complete modeling reports for VOC bioremediation with methane injection.

Complete the document package to facilitate commercialization and transfer of technologies/systems.

Complete close-out of Savannah River integrated demonstration.

Close out the first of our Integrated Demonstrations for cleanup of volatile organic compounds in non-arid soils, capturing lessons learned and successful technology transfer.

VOLATILE ORGANIC COMPOUNDS (VOCs) IN NON-ARID SOILS INTEGRATED DEMONSTRATION

Target Schedule	90	91	92	93	94
Drilling/Retrieval	■	■	■	■	■
Treatment	■	■	■	■	■
Bioremediation		■	■	■	■
Heating (RF and OHMIC)			■	■	■
In Situ Air Stripping	■	■			
Characterization	■	■	■	■	■
Off-Gas Treatment	■	■	■	■	■

VOLATILE ORGANIC COMPOUNDS IN NON-ARID SOILS TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
AL121101	INTEGRATED DEMONSTRATION GROUNDWATER AND COST ANALYSIS MODELING AT SAVANNAH RIVER SITE (SRS) INTEGRATED DEMONSTRATION	LOS ALAMOS NATIONAL LABORATORY	850	300	0
AL121102	MODELING OF BIOREMEDIATION EXPERIMENTS AT SAVANNAH RIVER SITE (SRS) INTEGRATED DEMONSTRATION	LOS ALAMOS NATIONAL LABORATORY	0	160	0
AL121109	COLD PLASMA DESTRUCTION OF SAVANNAH RIVER OFF-GAS VOLATILE ORGANIC COMPOUNDS	LOS ALAMOS NATIONAL LABORATORY	178	120	0
AL201101	GROUNDWATER FLOW SENSOR/SEISMIC IMAGING	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	300	475	670
AL221101	DESTRUCTION OF HALOGENATED SOLVENTS BY STEAM REFORMING	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	0	50	0
AL221103	UTILITY INDUSTRY DIRECTIONAL DRILLING	SYNTHETICA SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	300	300	0
AL221125	OFF-GAS TREATMENT USING PULSED COMBUSTION	CHARLES MACHINE WORKS SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	0	50	0
CH221101	DENSE NON-AQUEOUS PHASE LIQUID (DNAPL) INVESTIGATION AT SAVANNAH RIVER SITE INTEGRATED DEMONSTRATION	ARGONNE NATIONAL LABORATORY APPLIED RESEARCH ASSOCIATES (ARA) SCIENCE & ENGINEERING ASSOCIATES (SEA)	405	325	0
CH221107	INTEGRATED PULSED ULTRAVIOLET IRRADIATION/DRY SCRUBBING	ARGONNE NATIONAL LABORATORY	66	150	0
CH311101	PASSIVE MULTILAYER GROUNDWATER SAMPLER FOR INTEGRATED DEMONSTRATION EVALUATE TWO SAMPLERS BY COLLECTING PHYSICAL, CHEMICAL, AND BIOLOGICAL DATA SIMULTANEOUSLY AT SEVERAL DEPTHS WITHIN A SINGLE WELL	BROOKHAVEN NATIONAL LABORATORY AMS	0	265	155
HQ021113	CATALYTIC OXIDATION OFF-GAS/ENVIRONMENTAL PROTECTION AGENCY (EPA) - NEW JERSEY INSTITUTE OF TECHNOLOGY (NJIT) (EW50664)		0	250	0
HQ021114	CONE PENETROMETER ARMY CORE OF ENGINEERS (COE) (EW50602.000A)		750	1000	0
HQ021130	BOREHOLE TASK UNITED STATES GEOLOGICAL SURVEY (USGS) INTERAGENCY AGREEMENT (IAG) (EW50612.00)		0	10	0
HQ021132	TYNDALL AIR FORCE BASE INTERAGENCY AGREEMENT (IAG) (EW50614.000)		0	750	0
HQ021139	SOIL PHYSICAL DECONTAMINATION		45	49	0
ID111103	TECHNOLOGY DEVELOPMENT FILES: A DATA BASE SYSTEM TO ALLOW ORGANIZATION AND ACCESS OF THE DATA GENERATED BY THE NON-ARID SOILS INTEGRATED DEMONSTRATION TO ALL OF THE DOE COMPLEX	IDAHO NATIONAL ENGINEERING LABORATORY	175	200	0
ID121101	DIRECTIONAL DRILLING APPLICATIONS AT IDAHO	IDAHO NATIONAL ENGINEERING LABORATORY	0	25	0

VOLATILE ORGANIC COMPOUNDS IN NON-ARID SOILS TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
ID121102	SOIL BIOREACTOR STUDIES	IDAHO NATIONAL ENGINEERING LABORATORY	150	100	0
ID121114	VOLATILE ORGANIC COMPOUNDS RECOVERY/RECYCLE	IDAHO NATIONAL ENGINEERING LABORATORY	35	225	0
OR101103	REALTIME MONITOR FOR ORGANICS	OAK RIDGE NATIONAL LABORATORY	0	205	210
OR101104	BIOREMEDIATION OF GROUNDWATER	OAK RIDGE NATIONAL LABORATORY	0	250	0
OR101106	MULTISORBENT SAMPLE	OAK RIDGE NATIONAL LABORATORY	40	190	375
OR111101	INTEGRATED DEMONSTATION OF TRICHLOROETHYLENE DEGRADATION	OAK RIDGE NATIONAL LABORATORY	596	925	0
		UNIVERSITY OF TENNESSEE			
		UNIVERSITY OF MINNESOTA			
OR121102	TRICHLOROETHYLENE (TCE) PERCHLOROETHYLENE (PCE) VEGETATION DEMONSTRATION	OAK RIDGE NATIONAL LABORATORY	0	400	0
		UNIVERSITY OF TENNESSEE			
		UNIVERSITY OF MINNESOTA			
OR121103	DIRECT SAMPLING ION-TRAP MASS SPECTROMETRY (DSITMS) REAL TIME MONITOR DEPLOYMENT TEST	OAK RIDGE NATIONAL LABORATORY	0	465	0
OR121104	THE COLLOIDAL BORESCOPE	OAK RIDGE NATIONAL LABORATORY	190	45	0
RL311102	FIBER OPTIC PROBE FOR TRICHLOROETHYLENE (TCE) IN SOIL AND GROUNDWATER AT VOLATILE ORGANIC COMPOUNDS-NONARID INTEGRATED DEMONSTRATION	PACIFIC NORTHWEST LABORATORY	0	152	563
		FIBERCHEM			
RL321101	HIGH-ENERGY CORONA FOR DESTRUCTION OF VOLATILE ORGANIC COMPOUNDS IN PROCESS OFF GASES	PACIFIC NORTHWEST LABORATORY	220	80	0
RL321102	BIOMOLECULAR PROBE ANALYSIS: BIOREMEDIATION ORGANISMS	PACIFIC NORTHWEST LABORATORY	150	120	0
		UNIVERSITY OF WASHINGTON			
RL331003	SIX-PHASE SOIL HEATING FOR ENHANCED REMOVAL OF CONTAMINANTS	PACIFIC NORTHWEST LABORATORY	780	0	0
SF121105	DRILLING AND STABILIZING HORIZONTAL BOREHOLES IN NEAR SURFACE LOOSE AND UNCONSOLIDATED SEDIMENTS	LAWRENCE BERKELEY LABORATORY	107	60	0
SF211101	VOLATILE ORGANIC COMPOUNDS IN NON-ARID SOILS INTEGRATED DEMONSTRATION, ANALYSIS AND EVALUATION TASK	LAWRENCE LIVERMORE NATIONAL LABORATORY	0	250	1432
SF221101	FIBER OPTIC SENSOR AND ANALYSIS FOR THE INTEGRATED DEMONSTRATION FOR CLEANUP OF SOILS AND GROUNDWATER IN NON-ARID SOILS	LAWRENCE LIVERMORE NATIONAL LABORATORY	130	310	0
SF221102	SAVANNAH RIVER INTEGRATED DEMONSTRATION TEST, MONITORING TASK: UNDERGROUND IMAGING	LAWRENCE LIVERMORE NATIONAL LABORATORY	335	295	0
SF221105	VAPOR PHASED PHOTOLYTIC DESTRUCTION OF VOLATILE ORGANIC COMPOUNDS WITH ULTRA VIOLET FLASHLAMPS	LAWRENCE LIVERMORE NATIONAL LABORATORY	0	30	0

VOLATILE ORGANIC COMPOUNDS IN NON-ARID SOILS TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
SR101101	TRICHLOROETHYLENE (TCE) BIODEGRADATION DEMONSTRATION	WESTINGHOUSE ELECTRIC CORP UNIVERSITY OF SOUTH CAROLINA	0	1150	250
SR121101	SAVANNAH RIVER SITE INTEGRATED DEMONSTRATION DIRECTIONAL DRILLING	WESTINGHOUSE ELECTRIC CORP EASTMAN CHRISTENSEN	793	975	0
SR121102	INTEGRATED DEMONSTRATION FOR CLEANUP OF ORGANICS IN GROUNDWATER AND SOILS AT NON-ARID SITES CHARACTERIZATION	WESTINGHOUSE ELECTRIC CORP	1400	735	0
SR121103	INTEGRATED DEMONSTRATION FOR CLEANUP OF ORGANICS IN GROUNDWATER AND SOILS AT NON-ARID SITES OPERATIONS AND MANAGEMENT	WESTINGHOUSE ELECTRIC CORP	900	1228	0
SR121104	INTEGRATED DEMONSTRATION FOR CLEANUP OF ORGANICS IN GROUNDWATER AND SOILS AT NON-ARID SITES: INTEGRATED DEMONSTRATION COORDINATOR DIRECTED RESEARCH AND DEVELOPMENT	WESTINGHOUSE ELECTRIC CORP	0	275	0
SR121106	SAVANNAH RIVER SITE INTEGRATED DEMONSTRATION: REMEDIATION TASKS	WESTINGHOUSE ELECTRIC CORP UNIVERSITY OF SOUTH CAROLINA UNIVERSITY OF NORTH CAROLINA STANFORD UNIVERSITY	2090	2010	0
SR121107	INTEGRATED DEMONSTRATION FOR CLEANUP OF ORGANICS IN GROUNDWATER AND SOILS AT NON-ARID SITES; OFF GAS TREATMENT OPERATIONS OFFICE	WESTINGHOUSE ELECTRIC CORP NEW JERSEY INSTITUTE OF TECHNOLOGY UNIVERSITY OF WISCONSIN ECOVA JOHNSON MATHEY PURUS NUTECH ELECTRIC POWER RESEARCH INSTITUTE (EPRI) ALLIED SIGNAL	431	200	0
SR131001	IN SITU HEATING	WESTINGHOUSE ELECTRIC CORP	750	0	0
SR131002	PLANNING FOR PHASE-OUT OF SAVANNAH RIVER INTEGRATED DEMONSTRATION	WESTINGHOUSE ELECTRIC CORP	500	0	0

VOLATILE ORGANICS IN ARID SOILS INTEGRATED DEMONSTRATION

Integrated Demonstrations (IDs) are part of an innovative program by the U.S. Department of Energy (DOE) to speed up the development and demonstration of new technologies for cleaning up hazardous and radioactive wastes. DOE has found that existing technologies are not sufficient to do the job. In some cases the necessary technologies don't yet exist, and in other cases the existing technologies are too costly, slow, or ineffective. New technologies are being evaluated based on technical, economic, regulatory, and public acceptability criteria. The goal is that these new technologies will provide DOE with a better way to accomplish its cleanup mission.

The Volatile Organic Compounds-Arid Integrated Demonstration focuses on technologies to clean up volatile organic compounds (VOCs) and associated contaminants in soil and groundwater at arid sites. The initial host site is the 200 West Area at DOE's Hanford site in southeastern Washington state. The primary VOC contaminant is carbon tetrachloride, in association with heavy metals and radionuclides. An estimated 580-920 metric tons of carbon tetrachloride were disposed of between 1955 and 1973, resulting in extensive soil and groundwater contamination.

Cross sectional view of the VOC Arid ID site.

The VOC-Arid Integrated Demonstration is demonstrating technologies for all phases of remediation. These include: drilling, site characterization and monitoring, retrieval of contaminants, above-ground treatment of contaminants, and in-ground treatment of contaminants.

Drilling: Techniques are needed that can gain access to underground contamination to obtain samples, place monitoring sensors, retrieve contaminants, or treat contaminants in place. Cable tool drilling is the current baseline technology being used at many arid sites. Techniques are being pursued that are faster, easier to use, and safer. Two that have successfully met these criteria through demonstration are the cone penetrometer and sonic drilling. Since neither technology uses drilling fluids, no secondary waste is generated. A cone penetrometer has been deployed at Hanford and will be transferred to other arid sites. Sonic drilling has been adopted by the Hanford Environmental Restoration Program and transferred to other sites. A third innovative technology, directional drilling, will be demonstrated in FY 1993 and 1994. This technology enables access to areas that vertical drilling cannot reach (e.g., under a building).

Site Characterization and Monitoring: To design an effective method for site cleanup, an engineer must know the types, location and concentration of contaminants, and the hydrogeology and microbiology of the site. Typically, site characterization and monitoring techniques are time intensive (e.g., samples are sent offsite for analysis) and expensive. Several technologies have been successfully demonstrated at the VOC-Arid ID that can accelerate characterization and monitoring. For example, the Unsaturated Flow Apparatus™ is a centrifuge system that measures the movement of contaminants in arid soils. It is much faster than standard techniques available (e.g., days rather than months to years to generate a single data point) and has been validated by the Environmental Protection Agency. An industrial partner has been found to produce the system and it has been transferred to Hanford, Los Alamos National Laboratory, and Industry.

Retrieval of Contaminants: Techniques are needed to more effectively remove VOCs and other associated contaminants from soils and groundwater. Two technologies, soil heating and in situ vapor stripping wells, are being readied for demonstrations in FY 1993 and 1994. Heating enhances volatilization of VOCs from unsaturated soils and improves the performance of soil vapor extraction. This technology is being demonstrated in late FY 1993 through the VOC-Non Arid ID, and will be tested for arid soil applications in FY 1994 at Hanford. In situ vapor stripping wells remove dissolved VOCs from groundwater without the added cost and difficulty of extracting large volumes of water.

Above-ground treatment of contaminants: Once retrieved from soils and groundwater, effective and economical methods for treating contaminants are required. For VOCs, granular activated carbon (GAC) canisters are currently used to trap the contaminants for subsequent off-site destruction. Steam reforming and membrane separation are two technologies being demonstrated in FY 1993 to reduce the cost of off-site GAC regeneration. Other destruction and separations technologies, such as an on-line tunable plasma (low energy E-beam) system, are being readied for demonstration in FY 1994.

In-ground treatment of contaminants: A longer term goal of the ID is to develop and demonstrate in-ground treatment technologies that destroy organics, and immobilize or contain other contaminants. In-ground treatment offers significant economic and performance benefits over retrieval and treatment. Bioremediation is one example of an in-ground process for destruction of VOCs and nitrates in groundwater that is being developed for demonstration in FY 1994 at the host site.

A technology will be judged ready to be deployed in a cleanup if it is technically sound and acceptable to the regulators and the public. Success of an integrated demonstration will be realized if such technologies are transferred, ready for immediate use, to DOE environmental restoration personnel and private industry. In addition, such transfer will help address environmental concerns at other sites and make U.S. industry more competitive in the global marketplace.

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Selected Past Accomplishments

Demonstrated sonic drilling technology which uses a tuned vibrating drill head for placement of characterization, monitoring, and treatment wells. (Implemented this technology at Hanford cleanup sites). Sonic drilling does not use drilling fluids and drilling cuttings are not brought to the surface. This eliminates worker exposure to radioactive or chemically hazardous waste produced by drilling wells. It also eliminates the cost of disposing of these secondary wastes. Sonic drilling is 3 to 5 times faster than the baseline technology, cable-tool drilling, accelerating schedules for start up of cleanup operations. This method allows for continuous core samples. Drilling costs may be reduced by as much as 50 percent at contaminated sites throughout the U.S.

A 10 inch diameter borehole was drilled to a depth of 150 feet into the caliche layer at Hanford. This depth represents the deepest 10 inch hole ever drilled with the sonic method in this type of soil. The hole was then telescoped and drilled with an 8 inch diameter pipe to 238 feet.

Developed and demonstrated the feasibility of using a cone penetrometer in arid soils. As the cone penetrometer is pushed into the ground, onboard sensors instantaneously and continuously collect characterization data. Real time data analysis allows for better placement of subsequent wells. This technology reduces the need for boring during the characterization and monitoring phases, thereby substantially reducing secondary waste. Additionally, for the same cost, the cone penetrometer can characterize 13 times more locations than baseline cable-tool boring. However, many arid site soils are difficult to penetrate due to the coarse gravels and boulders. Recent technical advances and subsequent testing have demonstrated the applicability of cone penetrometer for these soils. Now, the cone penetrometer is suitable for application at over 2,500 Department of Energy (DOE) and Department of Defense (DoD) sites. Use of the cone penetrometer can reduce the cost of site characterization by as much as 60 percent.

Initiated cost/benefit analysis of technologies for above-ground treatment of groundwater.

Completed microorganism screening tests on aquifer samples furthering efforts of groundwater bioremediation for destruction of nitrates and carbon tetrachloride.

Completed first two characterization wells for bioremediation test site.

Completed design studies and bench scale testing for a supported liquid membrane process to remove metals and radionuclides from groundwater.

Numerous sensors tested and demonstrated including the chlorinated hydrocarbon sensor (HALOSNIF) demonstrated on a soil vapor extraction off-gas stream and at Tinker Air Force Base.

In-situ heating/corona destruction pilot test on contaminated soils exceeded expectations.

1993 Accomplishments/Objectives

Demonstrated an off-gas treatment system for contaminants extracted from soil and groundwater that results in the collection of volatile organic compounds as a liquid waste. This allows for either recycle or less expensive destruction of the effluent. This innovative technology also reduces the need for granular activated carbon filters which absorb contaminants and require further offsite shipment and treatment to extract and treat the off-gas contaminants.

Demonstrate in-situ soil heating for Volatile Organic Compound (VOC) removal from contaminated soils.

Demonstrate field analytical techniques for organic co-contaminants.

Complete "cold" (uncontaminated) demonstration of horizontal or directional drilling for application to arid sites.

Complete demonstrations of down-hole Volatile Organic Compound (VOC) monitoring for process control.

Develop cost and performance data for baseline technologies for evaluation of innovative technologies.

Initiate groundwater Volatile Organic Compound (VOC) removal demonstrations to support EM-40 interim remedial action.

1994 Objectives

Complete demonstration of pilot-scale tunable hybrid plasma system.

Complete mixed-waste site cone penetrometer tests and transfer system to EM-40.

Complete in-situ vapor stripping and UVB demonstrations.

Complete bioremediation field test site development and preparations.

Initiate in-situ bioremediation demonstration.

Demonstrate and transfer complete engineering simulator.

Demonstrate and transfer for deployment off-gas Volatile Organic Compound (VOC) destruction technologies to support Volatile Organic Compound (VOC) Expedited Response Action.

1995 Planned Objectives

Complete demonstration of horizontal or directional drilling in contaminated soils.

Demonstrate automated sonic drill rig in deep applications.

Complete in-situ bioremediation demonstrations for the destruction of carbon tetrachloride and transfer to EM-40.

Complete demonstration of supported liquid membrane system for co-contaminants.

Initiate development and demonstration of technologies for remediation/immobilization of co-contaminants (metals and radionuclides).

Initiate in situ redox manipulation demonstration for chromium and other co-contaminants in conjunction with In Situ Remediation Integrated Program (ISR IP).

Demonstrate in well separation techniques for co-contaminants in conjunction with EM-40 program.

Address major co-contaminant issues and provide for progression of Integrated Program technologies to demonstration.

Demonstrate cone penetrometer sensors for real time chemical analysis.

VOLATILE ORGANIC COMPOUNDS (VOCs) IN NON-ARID SOILS INTEGRATED DEMONSTRATION

VOLATILE ORGANIC COMPOUNDS IN ARID SOILS TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
AL221104	PORTABLE ACOUSTIC WAVE SENSOR (PAWS) DOWN HOLE LIQUID/VAPOR PHASE	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	450	400	0
AL221106	DESTRUCTION OF CARBON TETRACHLORIDE (CCL ₄) BY STEAM REFORMING	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	50	150	0
		SYNTHETICA			
CH221108	CONE PENETROMETER (CPT) VADOSE ZONE TESTING FOR SUBSURFACE CONTAMINANTS	ARGONNE NATIONAL LABORATORY	40	85	0
		APPLIED RESEARCH ASSOCIATION			
HQ021145	INTERAGENCY AGREEMENT (IAG) - ENVIRONMENTAL PROTECTION AGENCY (EPA) ARID SITE		0	15	0
HQ031003	ARID INTEGRATED DEMONSTRATION INTERAGENCY AGREEMENT (IAG) - ENVIRONMENTAL PROTECTION AGENCY (EPA)		283	0	0
RL311101	MANAGEMENT AND OPERATIONS OF THE VOLATILE ORGANIC COMPOUNDS-ARID INTEGRATED DEMONSTRATION	PACIFIC NORTHWEST LABORATORY	2648	2155	650
RL311104	RESEARCH AND DEVELOPMENT FOR IN SITU TREATMENT	PACIFIC NORTHWEST LABORATORY	3900	1811	1300
		MASSACHUSETTS INSTITUTE OF TECHNOLOGY			
		IEG TECHNOLOGIES			
		WASHINGTON STATE UNIVERSITY			
		RICE UNIVERSITY			
		STANFORD UNIVERSITY			
		EM FACTORS			
RL311106	DEMONSTRATION, TESTING, AND EVALUATION CHARACTERIZATION AND MONITORING TECHNOLOGY	PACIFIC NORTHWEST LABORATORY	0	540	1210
RL321104	DEMONSTRATION, TESTING, AND EVALUATION (DT&E) FOR DESIGN AND EVALUATION TECHNOLOGIES	PACIFIC NORTHWEST LABORATORY	990	1092	0
RL321105	RESEARCH AND DEVELOPMENT (R&D) CHARACTERIZATION AND MONITORING TECHNOLOGIES	PACIFIC NORTHWEST LABORATORY	1172	536	0
		QUANTA PHYSIKS			
		ENVIRONMENTAL ISSUES MANAGEMENT			
RL321120	IN SITU BIOREMEDIATION OF CHLORINATED SOLVENTS	PACIFIC NORTHWEST LABORATORY	0	35	0
RL331009	INTEGRATED DEMONSTRATION COORDINATOR/INTEGRATED PROGRAM COORDINATOR (IDC/IPC) COORDINATION	PACIFIC NORTHWEST LABORATORY	100	0	0
RL411101	PLANNING AND MANAGEMENT OF VOLATILE ORGANIC COMPOUNDS-ARID INTEGRATED DEMONSTRATION	WESTINGHOUSE HANFORD COMPANY	2600	1079	0

VOLATILE ORGANIC COMPOUNDS IN ARID SOILS TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
RL421103	ARID SITE DRILLING TECHNOLOGY DEVELOPMENT (TD)	WESTINGHOUSE HANFORD COMPANY	930	490	0
		WATER DEVELOPMENT CORPORATION			
		BOVAY NORTHWEST			
		NEW MEXICO STATE UNIVERSITY			
RL421104	VOLATILE ORGANIC COMPOUNDS OFF-GAS MEMBRANE SEPARATION	WESTINGHOUSE HANFORD COMPANY	402	160	0
		MEMBRANE TECHNOLOGY RESEARCH, INC.			

MIXED WASTE LANDFILL INTEGRATED DEMONSTRATION

New Technologies Remediate Old Waste Problems

Sandia National Laboratories is working to solve the problem of hazardous and nuclear waste sites that may leak contaminants into the soil and groundwater. The U.S. Department of Energy's Office of Technology Development (ODT) is looking to Sandia's expertise to evaluate and demonstrate promising new methods to characterize and clean up contaminated waste sites at DOE facilities. Sandia will "integrate" the demonstration of these new technologies which come from various industries, universities, and other federal laboratories. Finally, success will be measured by the implementation of these technologies to clean-up similarly contaminated landfills nationwide.

The mission of Sandia Laboratories' Mixed Waste Landfill Integrated Demonstration (MWLID) is to demonstrate in contaminated sites new technologies for clean-up of chemical and mixed waste landfills that are representative of many sites occurring throughout the DOE complex and the nation. When implemented, these new technologies promise to characterize and remedy past waste disposal practices that have led to contaminated landfill sites across the country. Characterization and remediation technologies are aimed at making clean-up less expensive, safer, and more effective than current techniques. This will be done by emphasizing "in-situ" or "in place" technologies, meaning that soils are not moved while the extent of the contamination is assessed (characterized), and the threat from the contaminant is safely mitigated. Most important, MWLID's success will be shared with other federal, state and local governments, and private industry that face the important task of remediation at waste sites. MWLID will demonstrate technology at two landfills. Sandia National Laboratories' Chemical Waste Landfill received hazardous (chemical) waste from the Laboratory from 1962 to 1985, and the Mixed-Waste Landfill received hazardous waste and radioactive wastes (mixed wastes) over a twenty-nine-year period (1959-1988) from various Sandia nuclear research programs. Both landfills now are closed. Originally, however, the sites were selected because of Albuquerque's arid climate and the thick layer of alluvial deposits that overlay groundwater approximately 480 feet below the landfills. This thick layer of "dry" soils, gravel, and clays promised to be a natural barrier between the landfills and groundwater.

Today we know that additional precautions are necessary to ensure safe disposal. For example, the Chemical Waste Landfill did not have a liner system to stop leakage or any instrumentation to monitor the waste site. Now, all landfills must be designed with such advanced technology. The contamination that has been detected below the Chemical and Mixed Waste Landfills must be characterized, remediated, and monitored. These

landfills are like many in the country, especially in the West. Technology successfully demonstrated here, therefore, can be used at similar sites in arid climates.

MWLID's Solutions

Three major steps must be taken to solve the problem of a contaminated waste site: First the site must be characterized. Second, the site must be remediated and the technology evaluated for its effectiveness. Third, the advancements obtained by remediating the individual site must be integrated into the clean-up efforts of others.

Characterization

Characterization presents a puzzle: What is happening in the ground beneath the waste site? Detailed information must be known about the source of contamination including the types of contaminants, the amount of each pollutant, and the location of the problems. Precise knowledge of the geologic and hydrologic properties of the site also must be determined so scientists can accurately predict how contaminants behave underground. How will pollutants travel? Will the contamination migrate to groundwater? If so, how long will it take? All of these questions and many more must be answered before clean-up methods can be selected.

Scientists have described site characterization as looking at the sky through the hole in a straw and, with no other information, predicting the weather. Until recently, the analogy often was correct. Site characterization often involved drilling numerous holes in the ground, obtaining samples from the soils, and sending the samples to a laboratory for analysis. From such scant information, geologists predicted what lay under their feet. The characterization process was expensive and inefficient. Traditional drilling techniques could introduce additional contamination and expose workers to significant health risks from handling the contaminated by-products.

One of MWLID's primary goals is applying innovative technologies to minimize disturbance at landfills while maximizing information gathered by characterization procedures. Many technologies are being demonstrated. For source characterization, non-intrusive technologies that do not require holes to be drilled or samples to be taken include

ground-penetrating radar, electromagnetic measurements and infrared thermal imagery. New methods of directional drilling (drilling at an angle as opposed to straight down), and horizontal drilling are being demonstrated to minimize the number of holes which are required for characterization and eliminate the problem of contaminated drilling by-products. In addition, worker safety is enhanced because the drilling platform is off to the side of the landfill and the drilling proceeds underneath the landfill. Two of the industry partners for these drilling projects are Charles Machine Works, headquartered in Oklahoma, and Water Development Corporations, headquartered in California. New Mexico State University is a partner in demonstrating a field screening laboratory for the detection of heavy metals in the samples.

The SEAMIST™ membrane liner, developed by Science Engineering Associates, is a promising technology that replaces the rigid casing found in many boreholes. SEAMIST™ has many applications for collection samples, making measurements, and transporting sensors without allowing contact between the instruments and the contaminated soils. Sensors which operate in the holes (Downhole sensors) to detect contamination or measure soil properties reduce the number of soil samples which have to be obtained and sent to a laboratory. Finally, a computerized sampling plan can optimize the data obtained in the field and aid the researcher in formulating a sampling strategy: Where should I sample next? What is the best sensor to use?

Obviously, a single technology cannot address all characterization problems. Therefore, MWLID will develop a system that coordinates all characterization technologies to provide a compatible, complementary, and integrated process to site investigation. It is the intent of the Land Characterization System to do this integration and provide as many of the necessary pieces as possible to the characterization puzzle.

Site characterization provides the information necessary for MWLID to tackle its primary goal: the remediation of heavy

metals using in-situ technologies that will minimize the risk from the landfill contents without excavation of the waste materials and contaminated soils. This innovative remediation mission is based on the premises that (1) moving the landfill to another location only transfers the risk and (2) the national capacity for permitted mixed-waste is limited, thus encouraging management of mixed waste landfills at their current location.

(A) Electrokinetic extracting system

(B) In-situ containment and isolation technologies

(C) Thermal enhanced vapor extraction system

Few in-situ technologies are available to remediate contamination from heavy metals and complex chemical mixtures in the area under a landfill between the surface and the groundwater. This "vadose zone" as it technically is called, is an important area because it provides a barrier between the landfill and groundwater. While the vadose zone can effectively isolate and contain some contaminants, such as heavy metals, other contaminants may move quickly through the vadose zone. When the vadose zone becomes contaminated with fast-moving pollutants, such as volatile organics, scientists often fear pollutants will reach groundwater before intervention can take place.

MWLID focuses on safe, efficient, and effective new methods to remediate contamination in the critical vadose zone. These remediation methods can provide the basis for acceptable clean-up strategy.

First, MWLID is demonstrating innovative extraction technologies. One such system uses an electric field to remove metal ions (electrokinetics). Another extraction system, the Thermal Enhanced Vapor Extraction System (TEVES), will demonstrate vacuum technology combined with soil heating methods to remediate volatile organic wastes that often are found at mixed waste landfills.

Second, MWLID is emphasizing technologies that isolate contaminants. Subsurface liners

or barriers are being developed and demonstrated to better contain wastes in place. Landfill caps are being demonstrated at Hill Air Force Base by Los Alamos National Laboratory and are being evaluated by MWLID. The purpose of these

technologies is to control the moisture balance so that water infiltration will not leach contaminants further into the vadose zone.

Third, MWLID is providing stabilization technologies that ensure the waste does not migrate. Stabilization technologies are those that mix a polymer or cement with the original waste to make it less mobile. Altering soil chemistry also may help pollutants bind to soil and remain stable.

Fourth, MWLID may show some contaminants are best handled by changing the chemistry of the contaminant, a process called "transformation." In some cases, injection of certain materials to alter the chemical form of the contaminant may reduce its toxicity and/or mobility.

Fifth, MWLID is performing a Remedial Options Evaluation that will identify alternative technology areas that show innovation and promise to remediate mixed waste landfills.

Most important, the demonstrated technologies will be evaluated against the base-line of conventional technologies. The comparison will include the cost, efficiency, risk, and feasibility of using the technologies at other sites.

Integration

The MWLID mission is best served by integrating mature and innovative technologies from universities, industry, and research institutions. For example, the TEVES project uses vacuum extraction methods from industry, soil heating methods developed by Illinois Institute of Technology (IIT), and off-gas treatment system designed using technical support from another DOE/OTD Integrated Demonstration at Savannah River Laboratory.

The best technology is of little use if hidden from the public. MWLID is aggressively developing partnerships with state, local, and tribal governments, New Mexico universities, public organizations, and private industry to broaden the knowledge and use of its achievements.

Partnerships are developing with the New Mexico Association of Counties, the New Mexico Municipalities League, citizens groups, the New Mexico Hazardous Waste Management Society, and the All Indian Pueblo Council. Technologies demonstrated by MWLID can be applied to solve existing problems at other landfills. Workshops, informal meetings, and conferences are a few methods offered by MWLID to help others address the issue of improper waste disposal.

DOE has established research partnerships with New Mexico universities, laboratories, and the Navajo Community College through the Waste Management Education and Research Consortium (WERC). MWLID will interface with WERC and will establish internships and graduate research opportunities. In this way, students and educators will be challenged to become involved in the regulatory aspects of implementing

new technologies for site characterization, remediation, and containment.

When Will This Happen?

Prior to May 1992, field demonstrations of the characterization technologies were performed at an uncontaminated site near the Chemical Waste Landfill. In May, we initiated demonstration in the Chemical Waste Landfill with non-intrusive characterization techniques. Future characterization plans include technology demonstrations in stages first at the Chemical Waste Landfill and then at the Mixed Waste Landfill.

Bench scale demonstrations of the electrokinetic remediation method have been completed by Sandia. A pilot field demonstration will occur in 1993 at an uncontaminated site. The first phase of the TEVES project occurred in April 1992 when two holes were drilled and vapor extraction wells were installed at the Chemical Waste Landfill. Obtaining the engineering design and environmental permits necessary to implement this field demonstration will take until about May 1993. Field demonstration of the vapor extraction system will occur from May 1993 to December 1993.

MWLID Organization

MWLID includes several working groups organized to quickly get new, successful technology into the hands of those responsible for restoration of DOE sites and others who face the daunting task of cleaning up chemical and nuclear waste sites. MWLID's Planning Group keeps abreast of the progress achieved at other Integrated Demonstrations being funded by DOE/OTD. New Mexico state and local governments and organizations also work closely with MWLID. Public participation in MWLID's work will forge a partnership between the project and the public to ensure not only technical success, but also broad understanding and use of project advancements. Technology Support Groups help select the technologies MWLID will demonstrate. The Operations Group is responsible for field demonstrations and ensuring compliance with all environmental laws. A Decision Support Group evaluates the value and importance of each demonstration to help target benefits to other federal and private projects. Technology Integration assures that successful technologies get into the hands of those who can use them best.

If you have any questions about the MWLID or the contents of these pages, please let us know. Comments, questions and suggestions can be directed to the following persons:

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Selected Past Accomplishments

Demonstrated infrared imaging at Mixed Waste Landfill.

A field demonstration of sonic drilling technology at Sandia's now closed Chemical Waste Landfill in Tech Area III has successfully assisted in identifying a previously undetected plume of chromium and other metals at the site.

Placed four landfill caps at Hill Air Force Base to contain contaminants in landfills. The operation involved extensive instrumentation to determine moisture movement and to determine effectiveness of landfill caps to prevent migration of contaminants into the surrounding environment.

Commercially demonstrated the SEAMIST hole liner, which allows low-cost, and concise placement of characterization sensors, at the mixed waste landfill site and the Tucson airport and transferred to commercial company.

Demonstrated downhole sensor technology in conjunction with directionally drilled holes lined by SEAMIST plastic liner. This methodology reduces the cost of characterization by reducing the number of holes required and the need for physical sampling. Used in conjunction with the Field Screening Laboratory, real-time results are achieved to reduce the time required to determine the extent of contamination.

Demonstrated a towed array magnetometer as a non-intrusive technique for locating buried waste containers and transferred technology to commercial industry.

Initiated tests of innovative heavy metal characterization system using directional drilling.

Activated a pneumatically emplaced borehole liner equipped with soil pore-moisture absorption pads.

Demonstrated Charles Machine Works (Ditch Witch) directional capabilities in the cold test.

Installed SEAMIST membrane liners in the cold test area and the Chemical Waste Landfill and RB-11 site with horizontal drill.

Demonstrated downhole X-ray fluorescence (XRF) device in horizontal, SEAMIST lined, borehole during the cold test.

Demonstrated cross-borehole electromagnetic imaging during the cold test.

Demonstrated electrokinetics at laboratory scale.

Transferred and implemented the Technology Information System developed at Hanford (previously used by volatile organic compounds (VOCs) in Arid Soils Buried Waste Integrated Demonstration).

Cross-borehole electromagnetic imaging successfully demonstrated by RIMtech.

1993 Accomplishments/Objectives

Conduct engineering scale in situ demonstration of landfill containment barriers and barrier emplacement technologies.

Implement and evaluate an integrated characterization system in both metal contaminated chemical waste landfill (CWL) and the mixed waste landfill (MWL).

Demonstrate downhole drilling monitoring system to integrate radiation detection hardware during drilling.

Develop partnership through workshops and other appropriate means to facilitate application of technologies to solve community problems.

Demonstrated directional sonic drilling.

Transfer magnetometer towed array technology.

Demonstrate electromagnetic imaging.

1994 Objectives

Complete system for characterization of metals and transfer to Environmental Restoration.

Field demonstrate characterization of radionuclides at mixed waste landfill.

Field demonstrate subsurface barrier emplacement technology.

Demonstrate an in situ electrokinetic contaminant removal technology, showing heavy metal and other contaminant concentration and extraction from both wet and dry soils.

Field demonstrate electrokinetic remediation at an uncontaminated site.

Organize demonstration of technologies to community to solve municipal landfill problems.

Transfer Landfill characterization systems for metals.

Transfer directional drilling technologies.

Transfer downhole contaminant detection technologies.

Transfer optimal sampling strategy modeling software and risk assessment software for characterization.

Field demonstrate and transfer cost and design information for Thermal Enhanced Vapor Extraction to State of New Mexico and Environmental Restoration.

Field demonstrate dry air barrier technology.

Initiate landfill cover demonstration.

Complete installation of Mixed Waste Landfill Integrated Demonstration (MWLID)-ProTech within community.

Build on relationships with community, Tribal Council and regulators.

Establish Mixed Waste Landfill Integrated Demonstration (MWLID) role on Sandia National Laboratory (SNL) public working group.

1995 Planned Objectives

Transfer landfill characterization system for mixed waste environments.

Demonstrate vadose zone monitoring system for hazardous and mixed waste landfills.

Demonstrate characterization technologies for determining transport properties and mechanisms.

Complete development of membrane characterization technologies.

Transfer subsurface barrier emplacement.

Transfer dry air barrier technology.

Complete landfill cover demonstration.

Field demonstrate electrokinetics at hot site.

Initiate advanced containment technology demonstration.

Initiate demonstration of Integrated Program remediation technology.

Update ProTech.

Field demonstration on Indian lands or community landfill

MIXED WASTE LANDFILL INTEGRATED DEMONSTRATION MILESTONES

MIXED WASTE LANDFILL INTEGRATED DEMONSTRATION TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY 93	FY92	FY91
AL921101	NEUTRON ACTIVATION LOGGING SYSTEM	UNC GEOTECH INC CHEM-NUCLEAR GEOTECH	241	200	0
AL921102	INTEGRATED GEOPHYSICS PROGRAM	UNC GEOTECH INC CHEM-NUCLEAR GEOTECH	103	110	0
AL121125	BARRIERS AND POST CLOSING MONITORING	LOS ALAMOS NATIONAL LABORATORY DuPONT UNIVERSITY OF HOUSTON UNIVERSITY OF NEW MEXICO	500	1200	0
AL121211	DEMONSTRATION OF BIO-ENGINEERING CAPPING TECHNOLOGY	LOS ALAMOS NATIONAL LABORATORY UNITED STATES DEPARTMENT OF AGRICULTURE ARS COLORADO STATE UNIVERISTY	350	200	0
AL131001	PROTOTYPE DECISION SUPPORT/COVER SYSTEM	LOS ALAMOS NATIONAL LABORATORY UNITED STATES DEPARTMENT OF AGRICULTURE ARS IDAHO NATIONAL ENGINEERING LABORATORY BATTELLE PACIFIC NORTHWEST LABORATORIES WESTINGHOUSE HANFORD OPERATIONS	200	0	0
AL221107	CHARACTERIZATION SYSTEM FOR METAL CONTAMINATION IN ARID SOILS	SANDIA NATIONAL LABORATORIES ALBUQUERQUE NEW MEXICO STATE UNIVERSITY SCIENCE AND ENGINEERING ASSOCIATES TROXLER CORPORATION CHARLES MACHINE WORKS, INC. CHEM-NUCLEAR PACIFIC NORTHWEST LABORATORIES	650	480	0
AL221108	GEOCHEMICAL CONTROLS ON CHROMIUM MOBILITY	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	250	250	0
AL221109	TECHNOLOGY INTEGRATION WORKSHOPS FOR THE MIXED WASTE LANDFILL INTEGRATED DEMONSTRATION	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	0	150	0

MIXED WASTE LANDFILL INTEGRATED DEMONSTRATION TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY 93	FY92	FY91
AL221110	TECHNOLOGY INTEGRATION FOR THE MIXED WASTE LANDFILL INTEGRATED DEMONSTRATION	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	250	180	0
AL221111	EFFECTS OF SITE CAPPING ON CONTAINMENT TRANSPORT	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	110	50	0
AL221112	MIXED WASTE LANDFILL INTEGRATED DEMONSTRATION (MWLID) - PROGRAM DIRECTION AND SUPPORT	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	400	1085	0
AL221114	ADVANCED IN-SITU MOISTURE LOGGING SYSTEM	ENVIRONMENTAL PROTECTION AGENCY			
		SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	0	100	0
		TROXLER CORPORATION			
		ENVIRONMENTAL PROTECTION AGENCY			
AL221115	SEAMIST APPLICATIONS FOR HEAVY METAL	ENVIRONMENTAL MONITORING SYSTEMS LABORATORY			
		SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	380	0	0
AL221116	HORIZONTAL HYBRID DIRECTIONAL BORING	SCIENCE ENGINEERING ASSOCIATION			
		SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	480	300	0
AL221118	HIGH-RESOLUTION INFRARED IMAGING	CHARLES MACHINE WORKS, INC.			
		SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	0	90	0
AL221120	REMEDIAL OPTIONS EVALUATION	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	180	390	0
		COLLEGE OF ENGINEERING, UNIVERSITY OF NEW MEXICO			
AL221121	THERMAL ENHANCED VAPOR EXTRACTION SYSTEM	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	900	500	0
		ILLINOIS INSTITUTE OF TECHNOLOGY RESEARCH INSTITUTE			
		SCIENCE AND ENGINEERING ASSOCIATES			
AL221122	ELECTROKINETIC REMEDIATION	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	0	150	0
AL221123	CROSS BOREHOLE ELECTRO MAGNETIC	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	200	50	0
		STOLAR, INC.			
AL221206	FIELD SCREENING LABORATORY SYSTEM	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	175	73	0
		ADVANCED ANALYTICAL, INC.			
		SPECTRACE INSTRUMENTS			
		VIKING INSTRUMENTS			

MIXED WASTE LANDFILL INTEGRATED DEMONSTRATION TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY 93	FY92	FY91
AL231002	DRY BARRIER APPLICATIONS FOR LANDFILLS	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE COLLEGE OF ENGINEERING UNIVERSITY OF NEW MEXICO STEPHENS & ASSOCIATES, INC.	500	0	0
AL231003	MAGNETOMETER TOWED ARRAY	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE UNITED STATES NAVAL RESEARCH LAB GEOCENTERS, INC.	350	0	0
AL231004	SUBSURFACE BARRIER EMPLACEMENT DEVELOPMENT	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	200	0	0
AL231005	ANGLE DRILLING AND BORING USING SONIC TECHNOLOGY	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE WATER DEVELOPMENT CORPORATION	200	0	0
AL231006	MIXED WASTE LANDFILL INTEGRATED DEMONSTRATION/QUALITY ASSURANCE (QA) AND ENVIRONMENTAL SAFETY AND HEALTH (ES&H) COMPLIANCE	SANDIA NATIONAL LABORATORIES ALBUQUERQUE	420	0	0
CH221102	OPTIMIZATION OF SAMPLING STRATEGIES FOR SOURCE CHARACTERIZATION	ARGONNE NATIONAL LABORATORY CON SOLVE INC.	217	115	0
CH221103	SEAMIST APPLICATIONS FOR HEAVY METAL AND MIXED WASTE CHARACTERIZATION	ARGONNE NATIONAL LABORATORY	0	150	0
CH321101	IN SITU CONTAINMENT AND STABILIZATION OF BURIED WASTE	BROOKHAVEN NATIONAL LABORATORY	325	150	0
RL321112	ON-SITE ANALYSIS OF METALS IN SOILS AND SEDIMENTS USING ABSORPTIVE STRIPPING VOLTAMETRY (ASV)	PACIFIC NORTHWEST LABORATORY NEW MEXICO STATE UNIVERSITY	110	100	0
RL321113	IN SITU DETERMINATION OF RADIONUCLIDE AND METAL CONTAMINANT CONCENTRATIONS AT A LANDFILL	PACIFIC NORTHWEST LABORATORY	150	150	0
RL321114	DETECTION AND QUANTIFICATION OF HIGH-Z (ATOMIC NUMBER) METALS AT THE SANDIA NATIONAL LABORATORY MIXED WASTE LANDFILL BY X-RAY FLUORESCENCE	PACIFIC NORTHWEST LABORATORY SCITEK	185	175	0
SP121101	SEISMIC CHARACTERIZATION	LAWRENCE BERKELEY LABORATORY SCIENCE AND ENGINEERING ASSOCIATES	200	100	0

FERNALD URANIUM SOILS INTEGRATED DEMONSTRATION

Abstract

Uranium compounds have contaminated soils in and around the production areas of the Fernald Environmental Management Project facility of the Department of Energy (DOE). This site was chosen for a technology demonstration project, conducted as part of DOE's integrated demonstration program for environmental remediation. The project will demonstrate new soil remediation technologies with the potential to reduce clean-up costs and time through effective waste management. Enhanced site characterization and precise excavation technologies will be combined with advanced uranium soil decontamination processes to produce a technology system for use at the FEMP and throughout the DOE complex for similar contamination clean-ups.

These pages briefly describe the use of the integrated demonstration approach in satisfying the technology needs of the FEMP Environmental Restoration Program, as well as those of the rest of DOE complex.

What is an Integrated Demonstration?

An integrated demonstration is a management concept developed to facilitate timely and effective application of new and enhanced technologies to meet the Department of Energy's environmental restoration needs. An integrated approach best utilizes government funding and talent by minimizing duplication of effort and assuring rapid evaluation of new technologies. Multiple technologies are assembled and evaluated as tools for a cradle-to-grave solution to a specific problem representative of generic DOE environmental issues.

Entire systems of technologies are evaluated with respect to performance, safety, and cost effectiveness. Through collaborative partnerships with DOE laboratories, universities, federal agencies, and private industries, the developers of each technology are brought together with experts in the many facets of the demonstration. Chemists, hydrogeologists, geophysicists, biologists, environmental engineers, and others involved each approach the project from a unique perspective. Major savings in time and federal tax dollars can be realized by demonstrating multiple technologies at one test site. Site

Figure 1. Locale of the FEMP

characterization, modeling, and monitoring information can be shared, validated, and compared, thereby increasing its technical and interpretive value and improving evaluation of the technologies being demonstrated.

This approach is especially efficient at the environmental sites controlled by the Department of Energy, where multiple demonstrations of new remediation technologies are planned. It allows for quick application of potential remediation technologies and "apples to apples" comparisons of performance. For the difficult environmental remediation problems where no proven methods exist, solutions may be proposed and demonstrated. Benefits include the ability to exploit successful technologies while abandoning less promising ones.

Introduction

A major task for DOE is the management of environmental wastes at its various facilities where radioactive, hazardous, and mixed wastes have accumulated. Some previous disposal practices, once considered state of the art, have proven inadequate or faulty, resulting in potentially serious soil and water contamination. DOE has taken the position that temporary storage of hazardous waste is not a solution; permanent disposal is necessary. Contaminated locales must be cleaned to acceptable levels. DOE's Fernald facility was selected as a site to evaluate uranium removal from soils technologies using the integrated demonstration approach.

The Fernald Environmental Management Project (FEMP) is located on 1050 acres near the Great Miami River, 18 miles northwest of Cincinnati, Ohio. The past mission of the facility was key to national security as the primary production site for uranium metal for defense projects. Following discontinuation of production at the FEMP in July of 1989, environmental restoration became the mission of the site. The FEMP Environmental Restoration Program has already undertaken several remedial actions employing a broad array of innovative technologies to address the site problems.

Project Background

The Department of Energy has been heavily involved with the nation's uranium resources for many years as a means to ensure national security and provide an energy source alternative to fossil fuels. As a result a significant number of DOE and commercial (mining) facilities are faced with contamination of surface soils with uranium compounds resulting from operations.

During 38 years of operations, the FEMP production area soils received varying amounts of uranium contamination resulting from accidental spills and emissions. The site was placed on the National Priorities List as a "Superfund" site, meaning it has a high priority for cleanup attention. An environmental restoration program was established at the site in 1986. The site was divided into five Operable Units to facilitate the cleanup process. Operable Unit 5 is responsible for groundwater, surface water, flora, fauna and the bulk of the site soils.

Operable Unit 5 is scheduled to obtain a Record of Decision (ROD) from the US EPA in August 1995, formally establishing the cleanup standards and the technologies to be used. Operable Unit 5 is currently undertaking a Remedial Investigation and Feasibility Study (RI/FS) to fully identify the nature and extent of contamination of the soils and groundwater and to lab test the applicability of various proven technologies for remediation.

The current baseline soil remediation technology for uranium-contaminated soils relies on general identification of contaminated areas, mass excavation of the areas, and packaging and removal of soils to long-term monitored disposal facilities. Since each of these processes presents an opportunity for technical and economic improvement, DOE has focused key resources to the tasks.

The FEMP has been chosen as the host site for an integrated demonstration of uranium contaminated soil remediation. FEMP soils are representative of the technical challenges which will be faced at many of the DOE sites.

The Fernald Site is an especially good test bed for this integrated demonstration project due to the presence of a variety of types of uranium soil contamination at low levels of radiation, the presence of support facilities and technical staff, on-going remediation efforts at the site, and cooperation and support from the governing environmental regulatory agencies.

The integrated demonstration focuses on more than just the decontamination process. Key technology areas include the characterization (analysis) technologies for soil contaminants, excavation technologies for precise removal, uranium decontamination/removal processes, and processes for treatment of wastes.

Technologies in each of these areas must be tested to develop an advanced group of compatible technologies which can effectively meet the regulatory requirements for soil decontamination in the safest, fastest, cheapest, and best manner possible. Field demonstration of advanced technologies provides evaluation data which ultimately allow the technologies to be considered for incorporation in restoration programs.

Recent advances in soil decontamination technologies show promise toward application to uranium contaminated soils. Soil washing is a generic term for soil decontamination, and

The Fernald Uranium Soils Integrated Demonstration ...evaluates new technologies for the remediation of uranium contaminated soils.

The objectives of the Integrated Demonstration are:

- Demonstration of advanced technologies to decontaminate uranium contaminated soils.
- Demonstration of advanced technologies for field characterization and precision excavation of soils.
- Demonstration of a system of advanced technologies which work effectively together to characterize, excavate, decontaminate, and disposition remaining wastes for uranium contaminated soils.
- Provide a transfer of these technologies into DOE restoration programs and the private sector.

describes a number of processes adapted from mining technologies which result in removal of contaminants from soil using either chemical or physical methods, or a combination. Clean soil is typically returned to the site of excavation, and the remaining contaminated fraction presents a smaller volume of material requiring further dispositioning. Remediation costs can be reduced significantly if soils are readily cleaned.

Soil washing has been used successfully to remove organic chemical and heavy metal contaminants such as lead from soils at several EPA "Superfund" sites. These successes have prompted a surge of interest from private industry. The efficacy of implementing soil washing to radionuclide contamination must be evaluated and quantified.

Just as soil washing and other soil decontamination processes, involving techniques such as magnetic, electrochemical, and biological separation, show economic and technical promise for DOE clean-ups, so do the recent advances in in-field characterization of contaminants. Current methods rely on samples taken in the field and sent to a laboratory for analysis. The process can take days to weeks. Analytical equipment of a variety of types is available in ever smaller (transportable) sizes and of a ruggedness necessary for field use. New techniques allow some samples to be processed without pre-treatment. Accurate results can be obtained in minutes. These breakthrough technologies will permit faster decision-making and higher field productivity, both resulting in lower costs.

The Fernald Uranium Soils Integrated Demonstration

Several research and development efforts will be supported for longer term results; however, the integrated demonstration will primarily concentrate on technologies already developed but as yet undemonstrated in a field application. The integrated demonstration has been organized to focus in six key areas:

Characterization is the process whereby the site is assessed for regulated contaminants. Its effectiveness relies on the timeliness and accuracy of analytical results. Until very recently, the sophisticated equipment required for accuracy was confined to high-tech laboratories at fixed locations. It has recently become possible to obtain in-field analysis results of an accuracy acceptable for many field decisions.

Characterization	Excavation	Decontamination
<ul style="list-style-type: none"> • Quick Turnaround Sampling & Analysis • Process History Model 	<ul style="list-style-type: none"> • Precise Capability 	<ul style="list-style-type: none"> • Process Below Cleanup Limit • Waste Minimization • Process Flow Sheet Organization
Waste Stream Disposal	Performance Assessment	Regulations
<ul style="list-style-type: none"> • Waste Minimization • Waste Segregation • Disposal Parameters 	<ul style="list-style-type: none"> • Risk Assessment • Cost Analysis • Data Evaluation 	<ul style="list-style-type: none"> • Applicable Regulations • Compliance Strategy • Community Relations

Areas of focus for the Integrated Demonstration

The characterization sub-project within the integrated demonstration is focusing on technologies which will be able to deliver real-time (essentially immediate) results in the field. The sub-project has already preliminarily demonstrated mapping of surface soil uranium content using real-time gamma ray spectroscopy (a beta radiation detector will also be demonstrated in FY92). The same concept applied to a bore hole can be used to identify the level and direction of contamination at various depths. This vertical evaluation of the contamination will allow for simpler development of precise excavation plans to minimize the volume of materials removed and processed.

A second process, Mobile Laser Ablated Inductively Coupled Plasma Optical Emission Spectrometry (MLA-ICP-OES) will be demonstrated during the summer of 1992. ICP-OES is a well established laboratory technique to identify the various chemical elements contained within a sample of material. The mobilization of this equipment to the field is a technical challenge, but the potential for highly accurate analysis in the field, in real-time, without sample preparation is a key motivator due to the potential for savings.

Excavation Technologies will be researched to provide precision processes to minimize excess soil removal. Since clean soil need not be processed, and site contamination is in thin layers near the surface, the coupling of in-field characterization results and the ability to precisely remove only contaminated layers will play a key role in influencing the economics of the resulting processes. Available precision excavation equipment will be identified, assessed versus the needs of this project, selected, demonstrated, and evaluated. Remote control of the equipment will be considered as a criteria, since some DOE sites in need of soil remediation present unacceptable hazards to human workers in the area of the contamination.

Decontamination Processes form the centerpiece of the integrated demonstration. A variety of soil decontamination processes are to be demonstrated over a period of several years. The selection of these processes will be made based on the results of soil treatability studies performed by potential vendors and national labs.

Equivalent soil samples will be provided to vendors proposing processes to complete the treatability studies. The results of the physical, chemical, electrochemical and bioremediation treatments completed during the treatability studies, coupled with the readiness of the proposed process for field demonstration, will form the basis for selection of the processes to demonstrate at the FEMP. Technologies will be evaluated with respect to the degree of decontamination achieved, waste volume reduction, physicochemical properties of the "clean soil", stability of final products and regulatory acceptance.

Secondary Waste Treatment efforts will focus on processes to handle wastes remaining from the primary process in the demonstration. However, more importantly, technical personnel working in this arena will participate in the design of primary processes to assure that residual waste production is minimized and of a nature which can be readily dealt with.

The details of secondary waste treatment processes rely heavily on the processes selected for decontamination demonstration. Secondary waste treatment processes will receive active attention late in 1992, after decontamination processes are selected for demonstration.

Regulatory Issues have a major bearing on the acceptability of a remediation process in a given locale. Since DOE does business across the U.S., an overall understanding of local issues across the nation must be factored into the design of demonstrated processes to assure broad acceptability of the final designs. The demonstration will address this need through involvement of regulators and representatives of a variety of DOE sites in the design review and evaluation processes.

Performance Assessment is a front-to-back support process for the demonstration, providing support for experimental planning, identification of information needed from each sub-project within the integrated demonstration. It will also serve as a clearinghouse for data interchange, and performing economic evaluations for the project. The performance assessment group will assure the implementation of these concepts continually throughout the integrated demonstration project design and execution.

**Figure 3. Mobile
Laser ICP-OES
Equipment**

**Figure 4.
Precision
Excavation
Process**

Status

The initial stage of the integrated demonstration (planning and documentation) has been completed:

- Management plan for the demonstration is undergoing final review.
- Site soil sampling has been completed. Samples have been sent for Lab Treatability Testing.
- Documentation required to assure National Environmental Policy Act (NEPA) compliance has been initiated.

In addition, an assessment of the characteristics of the site contamination and the site soils has been completed on samples of site soils from several locations. Site soils are composed of clays, sands, and silts in widely varying proportions. The chemical and physical form of the uranium contamination varies with location and soil type. Soils from two locations on the site have been collected to test a variety of soil decontamination processes. The soils have been blended so that competing processes will have identical soils to treat.

Plans

Lab and field activities for the integrated demonstration are planned for fiscal years 1992-1995:

- Complete Initial Soil Treatability Studies, 1993
- Field Demonstrate Characterization Technologies, 1992
- Field Demonstrate Decontamination Technologies, 1993
- Field Demonstrate Secondary Waste Treatment, 1994
- Demonstrate Optimized System of Technologies, 1995

Participants & Consultants in the Fernald Uranium Soils Integrated Demonstration

- U.S. Department of Energy, Fernald Site Office, Oak Ridge Operations & Headquarters
- U.S. Environmental Protection Agency, RREL
- Westinghouse Environmental Management Company of Ohio
- Oak Ridge National Laboratory
- AMES Labs
- Lawrence Livermore National Laboratory
- Los Alamos National Laboratory
- Sandia National Laboratory
- Pacific Northwest Laboratory
- Argonne National Laboratory
- Brookhaven National Laboratory
- Lawrence Berkeley Laboratory
- Idaho National Engineering Laboratory
- Martin Marietta, HAZWRAP
- Westinghouse Savannah River Company
- BDM, Inc.
- Kaiser Engineering
- ASI, Inc.
- IT Corp.
- REECO

Selected Past Accomplishments

Demonstrated an Integrated Spectroscopy System for characterizing contaminant speciation at Los Alamos National Laboratory.

Completed the initial phase of treatability tests; successfully decontaminating soil activities for 280 pCi/g to less than 10 pCi/g.

Results of a demonstration of new technologies for removing uranium from soils showed on the laboratory level using two separate technologies. The techniques use chemical leaching (ammonium carbonate) to reduce uranium levels by up to 94% and chelation with Tiron to reduce uranium levels by up to 98%.

Demonstrated the feasibility of cleaning uranium from soils, potentially allowing the return of the soil to the site rather than low level waste repository.

Completed characterization of soil samples: this supports Operational Unit Five (OU5) Environmental Restoration Program Treatability studies-issued report in January 1992.

Collected and characterized 15 homogeneous drums of soil for use in chemical and physical treatability tests by the integrated demonstration (ID) and Facility Effluent Monitoring Plan Environmental Restoration (FEMP ER) program. Initiated soil treatability tests.

Demonstrated and field tested four in situ technologies for rapid on-site mapping of radionuclides in soil (August 92).

Identified promising leach solutions to decontaminate soils. Initial treatability tests achieved a decontamination factor of 28.

1993 Accomplishments/Objectives

Demonstrate a prototype on line monitor for process control of ex situ soil decontamination process.

Complete lab-scale treatability tests.

Installation of a field-scale extraction unit-coordinated with Environmental Restoration (ER) program.

Field test chemical extraction method.

Demonstrate precise/remote excavation technique.

Conduct cost-benefit analysis of demonstrated characterization technologies, further develop select technologies.

Initiate revegetation studies on decontaminated soil.

1994 Objectives

Publish a recommended approach methodology to determine cleanup levels for uranium contaminated soils in a scientific journal.

Publish a recommended approach/methodology for utilizing characterization to guide soil decontamination treatability tests.

Complete demonstration/evaluation of rapid onsite mapping of radionuclides in soil.

Complete field scale demonstration of soil decontamination technologies.

Complete characterization of residuals in cleaned soil and of secondary waste streams.

Select and test secondary waste treatment technologies.

Evaluate cost and risk of alternative remediation systems.

1995 Planned Objectives

Complete pilot scale demonstration of secondary waste treatment technologies.

Complete demonstrations of separate elements of the soil decontamination system.

Complete cost benefit evaluation of the separate elements.

Integrate the system elements and demonstrate.

Initiate evaluation of the system.

Select optimum technologies for uranium in soils remediation process including sensing, precision excavation, and uranium extractions.

Initiate evaluation of applicability to other DOE sites.

URANIUM IN SOILS DEMONSTRATION

URANIUM IN SOILS INTEGRATED DEMONSTRATION TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
AL121121	SELECTIVE EXTRACTION/LEACHING	LOS ALAMOS NATIONAL LABORATORY	400	260	0
		NEW MEXICO STATE UNIVERSITY			
		MBC SYSTEMS, INC.			
AL121122	CHARACTERIZATION OF SITE GEOCHEMISTRY IN SUPPORT OF ENVIRONMENTAL RESTORATION	LOS ALAMOS NATIONAL LABORATORY	500	400	0
AL131002	SOIL SURFACE MONITORING USING LONG RANGE ALPHA DETECTOR (LRAD)	LOS ALAMOS NATIONAL LABORATORY	400	0	0
AL131003	HEAP LEACHING OF URANIUM FROM SOILS	LOS ALAMOS NATIONAL LABORATORY	250	0	0
		NEW MEXICO STATE UNIVERSITY			
		UNIVERSITY OF NEW MEXICO			
AL221105	PROCESS HISTORY METHODOLOGY	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	0	150	0
AL231007	COST/RISK PERFORMANCE ASSESSMENT OF CHARACTERIZATION TECHNOLOGIES	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	300	0	0
CH101101	MOBILE INDUCTIVELY COUPLED PLASMA OPTICAL EMISSION SPECTROMETER	AMES LABORATORY	400	300	400
CH131003	AMES MOBILE LABORATORY PROJECT	IOWA STATE UNIVERSITY	1250	0	0
		AMES LABORATORY			
CH221106	AQUEOUS BIOPHASIC TREATMENT OF URANIUM CONTAMINATED SOIL	ARGONNE NATIONAL LABORATORY	400	200	0
CH231003	ANALYTICAL ELECTRON MICROSCOPY (AEM) EXAMINATION OF FERNALD SOILS	ARGONNE NATIONAL LABORATORY	300	0	0
CH331002	SEPARATION COST/BENEFIT	BROOKHAVEN NATIONAL LABORATORY	50	0	0
FN111001	URANIUM SOILS INTEGRATED DEMONSTRATION MANAGEMENT	WESTINGHOUSE MATERIALS OF OHIO	0	0	0
		WEMCO ENVIRONMENTAL			
		MSE IDAHO, INC.			
		MARTIN MARIETTA ENERGY SYSTEMS			
		ETEC INC.			
ID121103	BIOPROCESSING TECHNOLOGIES FOR URANIUM - CONTAMINATED SOILS	IDAHO NATIONAL ENGINEERING LABORATORY	200	200	0
ID431001	REMOTE EXCAVATION SYSTEM DEMONSTRATION	WESTINGHOUSE IDAHO NUCLEAR CO	100	0	0
OR121105	SELECTIVE EXTRACTION/LEACHING OF URANIUM FROM SOIL	OAK RIDGE NATIONAL LABORATORY	225	340	0
		IT CORPORATION			

URANIUM IN SOILS INTEGRATED DEMONSTRATION TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
OR121106	URANIUM SOILS INTEGRATED DEMONSTRATION PERFORMANCE ASSESSMENT	OAK RIDGE NATIONAL LABORATORY	250	150	0
OR131001	EFFLUENT TREATMENT FROM CARBONATE AND CITRIC ACID LEACHING	OAK RIDGE NATIONAL LABORATORY	360	0	0
		UNIVERSITY OF TENNESSEE (SAVANNAH RIVER ECOLOGY LABORATORY)			
OR131003	PHYSICOCHEMICAL AND MINERALOGICAL CHARACTERIZED OF TRANSURANIC SOIL	OAK RIDGE NATIONAL LABORATORY	330	0	0
OR131004	INTEGRATED METHODOLOGY FOR DETERMINING CLEANUP LEVELS FOR URANIUM CONTAMINATED SOILS (UCS)	OAK RIDGE NATIONAL LABORATORY	100	0	0
OR911104	URANIUM SOILS INTEGRATED DEMONSTRATION MANAGEMENT	WESTINGHOUSE MATERIALS OF OHIO	0	1653	1500
RL321103	IN SITU MAPPING OF RADIONUCLIDES IN SUBSURFACE AND SURFACE SOIL	PACIFIC NORTHWEST LABORATORY	625	605	0
SF321106	STATISTICAL SUPPORT	ENERGY TECHNOLOGY ENGINEERING CENTER	200	150	0
SF231003	INTEGRATED METHODOLOGY FOR DETERMINING CLEANUP LEVELS FOR URANIUM CONTAMINATED SOILS (UCS)	LAWRENCE LIVERMORE NATIONAL LABORATORY	100	0	0
SR121105	SOIL CONTAMINANT EXTRACTION/LEACHING	WESTINGHOUSE ELECTRIC CORP	150	120	0

DYNAMIC UNDERGROUND STRIPPING INTEGRATED DEMONSTRATION

Lawrence Livermore National Laboratory (LLNL) is collaborating with the University of California, Berkeley College of Engineering, to develop and demonstrate a system of thermal remediation and underground imaging techniques for use in rapid cleanup of localized underground spills. This system is called "Dynamic Stripping" to reflect the rapid and controllable nature of the process. The system will combine steam injection, direct electrical heating, and tomographic geophysical imaging in a cleanup of the LLNL gasoline spill. In the first eight months of the project, a clean site engineering test was conducted to prove the field application of the techniques before moving to the contaminated site in FY 1992.

Background of the Project

The Dynamic Stripping Project was initiated in November 1990. An engineering test at a clean site was completed in FY 1991, heating 8,000 cubic meters at a depth of 44 meters (135 feet) to over 100°C. Imaging methods were used to accurately delineate the steam zone boundaries.

Installation of monitoring and treatment facilities is underway at the LLNL Gasoline Spill Site. Remediation operations are planned to begin with electrical heating in August 1992, and steam injection in October 1992.

Dynamic Stripping Technique

The concentrated plume is surrounded by injection wells, with one or more extraction wells located in the center. The injection wells are screened in the more permeable areas, and in less permeable areas the wells are completed for electrical current (conductive packing material and a stainless steel electrode). Remediation begins with an electrical pre-heat of the impermeable clay layers, using electrode assemblies placed in the impermeable layers to pass 480V current at several hundred amperes per electrode. The impermeable layers themselves act as the heating element. This is followed by steam injection at up to 60 psi, depending on depth.

Dynamic Underground Stripping - Section Through Injection Circle

As steam is forced into the formation, the earth is heated to the boiling point of water. Near the steam-condensate front, organics are distilled into the vapor phase, transported to the steam condensation front, and condensed there. The advancing steam zone displaces the water and condensed contaminants toward the recovery well where they are pumped to the surface. The amount of heat required to bring the ground to 100°C is the principal control on how much steam must be injected.

When the steam reaches the extraction well, vacuum extraction becomes the most important removal mechanism. As steam input stops, a drop in steam zone pressure slightly reduces the boiling point of any residual water or contaminants, forcing them to boil and convert to removable vapor. Electrical heating is continued, which heats the clay and fine-grained sediments and causes water and contaminants trapped within to vaporize and be forced into the steam zones, where the vacuum extraction can remove them. Simulations indicate that about 1 month is required for the electrical pre-heat, and 1-2 weeks for the initial steam injection.

The goal of the combined processes is to achieve a hot, dry, contaminant-free cylinder of earth. This creates a great contrast for geophysical imaging techniques to use in observing the areas that have and have not been heated. Among the methods tested at the clean site were electrical resistance tomography (ERT), seismic tomography, induction tomography, passive seismic monitoring, and temperature and conventional geophysical well logging.

Uses of the Technology

Underground stripping is particularly useful to remove free-phase contaminants, such as non-aqueous phase liquids (NAPLs). It can be used to remediate concentrated underground

organic contaminant plumes, such as those from leaking underground storage tanks. The plumes may include dense NAPLs (DNAPLs), which sink through aquifer, and light NAPLs (LNAPLs), which float on the water table. With dynamic stripping, rapid cleanup can be achieved both above and below the water table. The NAPL portion of spills can be removed in a matter of months.

Dynamic Underground Stripping is applicable to all types of free organic plumes below 7 meters (20 feet) deep, beyond excavation. Mixed wastes, organics and metals, may be treated in future tests. The estimated total cost for remediation is \$50 per cubic meter. The energy portion of total cost is approximately \$2 cubic meter for steam heating, or \$5 cubic meter for electric heating.

For arid zone spills with a NAPL core, we estimate that Dynamic Stripping can reduce operating costs for removal by 50%.

For more information, please contact:

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U.S. DOE
(301) 903-7922

Roger Aines
Principal Investigator
(510) 423-7184

Selected Past Accomplishments

Demonstrated, at a clean site, the potential effectiveness of steam stripping and electrical heating for removal of volatile organic compounds from soils. As a result of the successful demonstration the process was relocated to an actual gasoline spill site at Lawrence Livermore National Laboratory. Over 8000 gallons of gasoline are believed to be below ground with some 5000 gallons trapped below the water table making remediation by conventional methods all but impossible. The combination of steam stripping and electrical heating affords an effective, efficient alternative.

Clean site engineering test completed successfully: operation, engineering, safety issues tested and resolved, and tested steam and electrical heating systems.

Completed field test of Derivative Ultraviolet Absorption Spectroscopic Monitoring (DUVAS) instrument.

Imaging and control of heated zones established.

Heated 10,000 cubic yards of soil at depth of 135 feet to above boiling.

Gasoline spill cleanup demonstration removed approximately 3,000 gallons of gasoline in initial steam pass.

Energy costs of \$2/yard³ (steam) and \$5/yard³ (electric) established, overall remediation cost estimated \$50/yard³.

Projects ends with FY 93

DYNAMIC UNDERGROUND STRIPPING INTEGRATED DEMONSTRATION

Clean Site Characterization	┌───┐			
Gas Pad Characterization	┌──────────┐			
Clean Site Equipment Installation	┌──┐			
Initial Effluent Treatment System	┌──────────────────┐			
Clean Site Testing	┌────────┐			
Install Gas Pad Equipment		┌──────────┐		
Gas Pad Equipment Testing			┌──┐	
First Steam/Heating Cycle at Gas Pad				┌──┐
Post Test Characterization				┌──┐
Second Steam/Heating Cycle at Gas Pad				┌──┐
Post Test Characterization				┌──┐
Dismantling				┌──┐
Final Report Issued				▲

DYNAMIC UNDERGROUND STRIPPING INTEGRATED DEMONSTRATION TECHNICAL TASK PLANS

NUMBER	TITLE	CONTRACTOR	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
OR101101	IN SITU FIBEROPTIC DERIVATIVE ULTRAVIOLET ABSORPTION SPECTROSCOPIC (DUVAS) MONITORING OF AROMATIC CONTAMINANTS	OAK RIDGE NATIONAL LABORATORY	35	140	0
SF211104	DYNAMIC UNDERGROUND STRIPPING DEMONSTRATION PROJECT	LAWRENCE LIVERMORE NATIONAL LABORATORY	4850	3045	3000

CHARACTERIZATION, MONITORING, AND SENSOR TECHNOLOGY (CMST) INTEGRATED PROGRAM

What is an Integrated Program ?

The Integrated Program (IP) and Integrated Demonstration (ID) are management concepts created by the U.S. Department of Energy, EM Office of Technology Development (EM-50) to promote systematic development and effective application of advanced technologies to meet the U.S. Department of Energy's (DOE) environmental restoration and waste management needs. An Integrated Program focuses on one major technology area, and provides funds for specific technology development. An Integrated Demonstration focuses on a cradle-to-grave solution to a particular problem, and often requires development of several technology areas. Both IDs and IPs disseminate information on developing technology throughout the DOE.

The CMST Integrated Program

The CMST IP was established in FY91 to ensure that new and effective Characterization, Monitoring, and Sensor Technologies (CMST) are provided to the Department of Energy. The program conceives, supports, and manages efforts in research, development, demonstration, testing and evaluation (RDDT&E) to characterize DOE sites and their waste and to monitor EM-related activities and processes. CMST focuses in the short-term on matching and adapting available characterization, monitoring, and sensor technologies to help solve EM problems at DOE sites. In the long-term, the program aims to stimulate, coordinate, and sponsor relevant

research and development, and to promote and publicize available baseline and emerging CMST technologies. The CMST program is designed to increase the effectiveness of known remediation approaches, and the viability of new options now limited by unacceptable characterization. A strategy is being developed to evaluate and establish priorities for rapid development, demonstration and transfer of technologies, and to evaluate criticality of needs, cost savings, risk level, and regulatory concerns.

CMST Program in Action

The focus of the CMST program is to develop new, or extend existing technologies, e.g., field-deployable instrumentation and noninvasive methods which address an identified need at a specific DOE site, and are transferable to other waste streams and sites in the DOE complex. Research and development emphasis has been placed on remote and minimally-intrusive characterization, in situ measurements, and field-deployable instrumentation. The program also coordinates the transfer of characterization information, especially EM-50 sponsored RDDT&E, within EM-50 throughout DOE and to industry. Factors influencing priorities for technology development within the CMST IP include: the benefit/cost ratio, potential overall savings to EM, Records of Decision (RODs) at DOE sites, the critical nature of the particular needs, the ability of the

Radar

Data Acquisition

Seismology

Resistivity

Magnetics

Electro-Magnetic Induction

development to be utilized by multiple DOE sites, and the degree to which the development represents an advance over baseline technologies.

The key strategic goal of the IP is to deliver, in a timely fashion, appropriate characterization, monitoring, and sensor technologies to DOE clients charged with environmental restoration and waste management. The R&D priorities are currently being established. These include:

- Remote Sensing Systems Development and Application
- Noninvasive Geophysical Characterization Technology
- Field Deployable Instrumentation for Organic and Radioactive Contaminants
- In-ground Chemical and Radiochemical Sensors for Monitoring of Organics, Transuranics, and RCRA Metals
- Real-time Analytical Techniques for Characterization of Storage Tank Waste Systems
- Advanced Continuous Air Monitors
- Data Fusion
- On-line Waste Processing Diagnostics and Controls

Technology areas of interest to the CMST IP include information management and display systems, sensors for detection, location and quantification of chemical contaminants in soils and groundwater and monitors for remediation activities such as decontamination and decommissioning, site restoration, and waste processing.

Future Challenges

Characterization is not only the key first step in any environmental restoration or waste operation activity, it is necessary during each step in the process. Characterization is considered to be the technology area of greatest potential cost savings to DOE, through the application of timely and effective technology development. Currently the Office of Environmental Restoration and Waste Management spends between 40 and 50 percent of their multi-billion dollar budget on characterization activities. An advanced system, capable of noninvasively imaging the elemental contents of sealed containers in three dimensions, is an example of technology currently under development by CMST IP which promises tremendous future cost savings to DOE. The DOE complex can meet its deadline for complete remediation by the year 2019 if numerous characterization technologies can be rapidly developed soon.

For more information, please contact:

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Integrated Program Coordinator
(515) 294-4986

Caroline Purdy
U.S. DOE Program Manager
(301) 903-7672

Selected Past Accomplishments

Initiated research into locating buried waste sites from the air using state of the art infrared and electromagnetic methods.

Increase the field deployability of the ion-trap mass spectrometer.

Completed optrode (sensor to detect chemicals in groundwater) demonstrations in both the laboratory and the field and developed a system for reagent replenishment at the optrode's tip.

Initiated research on laser ablation coupled to advanced mass spectrometry for characterization transuranics.

Selected and tested new optrodes to determine hydrocarbon detection limitations.

Field-demonstrated a portable photoacoustic analyzer for volatile organic contaminants in solids, liquids, and gases.

Tested and lab-demonstrated a non-invasive imaging system based on neutron and gamma ray interrogation that examines the interiors of sealed containers, display the locations, shapes, and sizes of their contents in 3-D image format, and identifies their elemental compositions.

Completed a prototype Ground Penetrating Radar (GPR) Imaging system.

Lab demonstrated a continuous emission monitor for incineration.

1993 Accomplishments/Objectives

Performed a thorough literature review of chemical sensor technologies under development in the United States and abroad.

Demonstrated airborne remote sensing technologies transferred from other agencies, such as remote multispectral scanning.

Demonstrated coherent laser radar for three dimensional surface mapping for decontamination and decommissioning activities of DOE Facilities (chemical analysis capability will be demonstrated in FY95).

Continued development of fiber optic chemical sensors, Photoacoustic Sensors, and Surface Acoustic Wave Sensors (SAWS).

Demonstrated a data fusion workstation integrating historical imagery into a geographic information system.

Demonstrated the Expedited Site characterization Methodology at a U.S. Department of Agriculture CERCLA site and invited representatives from other government agencies, industry and universities to observe.

demonstrated a remote sensing laser induced fluorescence system to identify uranium on the surface of soils and on wall and machinery systems at the Oak Ridge Reservation. Development continues for demonstration of an airborne system.

1994 Objectives

Continue development of air monitors including Continuous Air Monitors (CAMs) for incinerators, LIDAR, and others in response to 1992 Clean Air Act amendments.

On-site, demonstration, testing, and evaluation of Associated Particle Imaging System for barrels of waste.

Continue development of in situ sensors and monitors for contaminants in soils and groundwater (e.g., sensors for use in cone penetrometer and neutron probes).

Continue development and demonstration of airborne remote sensing technologies including advanced image processing for electromagnetic data, LIDAR, thermal, ultra-, hyper- and multispectral scanners, contaminant signature determination for important contaminants for relevant remote sensing technologies, advanced change detection techniques, and digitized land maps for DOE Sites will be pursued.

Full-scale demonstration of Secondary Ion Mass Spectrometers (SIMS) for on-site contaminant detection.

Continue development of advanced mass spectrometers shown best suited to DOE problems in FY 93 comparison demonstration.

Continue to integrate innovative characterization technologies into the Expedited Site Characterization Methodology.

Complete instrumentation development and field screening methods for Ion Trap Mass Spectrometer.

Demonstrate prototype data fusion workstation for characterization activities at two DOE Sites.

Demonstrate at Oak Ridge National Laboratory (ORNL) a prototype fiber-optic-coupled range and applied pressure measurement system (coherent laser radar) for mapping activities during decontamination and decommissioning processes.

Demonstrate multispectral neutron borehole logging system instrumentation.

1995 Planned Objectives

Demonstrate coherent laser mapping of contaminants for decontamination and decommissioning activities.

Complete prototype field deployable ion mass spectrometer for real time analysis of semi-volatile and nonvolatile organic components.

Demonstrate airborne laser to detect depleted uranium oxide contamination.

Complete development of software for quantitative analysis on the multispectral neutron logging system.

CHARACTERIZATION, MONITORING, AND SENSOR TECHNOLOGY INTEGRATED PROGRAM

Target Schedule	91	92	93	94	95
Field test (for EPA methods approval) an FTIP System to Monitor Incinerator Exhaust					
Field Demonstrate a Secondary Ion Mass Spectrometer for Non & Low Volatile Organics					
Develop and Demonstrate a Down-Hole Multi-Element Logging System					
Demonstrate With EPA Approval a Complete Expedited Site Characterization Methodology					
Deliver a Prototype Associate Particle Imaging (API) System					
Complete Prototype Field Deployable Inductively Coupled Plasma Mass Spectrometer					
Demonstrate a Field-Deployable, Photoacoustic Infrared Spectrometer for VOCs					
Demonstrate a Field Instrument for Real-Time Measurement of the Fission Isotope Sr 90					
Demonstrate a Data Fusion Workstation for 3-D Visualization of Contaminant Plumes					

CHARACTERIZATION, MONITORING, AND SENSOR TECHNOLOGY TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
AL031001	MULTI-SPECTRAL NEUTRON LOGGING	ALBUQUERQUE OPERATIONS OFFICE	95	0	0
AL931001	MULTI-SPECTRAL NEUTRON LOGGING: A NEW GENERATION PULSED-NEUTRON	UNC GEOTECH INC	245	0	0
AL111104	NON-INVASIVE SITE CHARACTERIZATION, PHASE 1: PROGRAM PLAN FOR ASSESSING AND INTEGRATING SPACE, AIRBORNE AND SURFACE METHODS	LOS ALAMOS NATIONAL LABORATORY	235	0	0
AL131004	MULTI-SPECTRAL NEUTRON LOGGING: A NEW GENERATION PULSED-NEUTRON	LOS ALAMOS NATIONAL LABORATORY	205	0	0
AL131006	CHLORINATED AND AROMATIC HYDROCARBON THIN FILM SENSORS	LOS ALAMOS NATIONAL LABORATORY MOTOROLA CORPORATION	350	0	0
AL131007	AIR QUALITY BOUNDARY MONITORING FOR VOLATILE ORGANIC COMPOUNDS	LOS ALAMOS NATIONAL LABORATORY PURDUE UNIVERSITY	250	0	0
AL2003D	INSITU CHARACTERIZATION OF WASTE - ION TRAP MASS SPECTROSCOPY	LOS ALAMOS NATIONAL LABORATORY	0	0	350
ALNEW	NON-INVASIVE SITE CHARACTERIZATION, PHASE I	LOS ALAMOS NATIONAL LABORATORY	0	0	500
AL231010	TOMSK EXPLOSION CHANGE DETECTION STUDY	SANDIA NATIONAL LABORATORIES - NEW MEXICO	40	0	0
CH101103	IMPROVEMENTS IN INDUCTIVELY - COUPLED PLASMA MASS SPECTROMETRY	AMES LABORATORY	155	265	150
CH101104	ON-SITE INFRARED ANALYZES FOR COMPLEX INORGANIC/ORGANIC MIXTURES	AMES LABORATORY	297	301	207
CH111203	INTEGRATED PROGRAM - CHARACTERIZATION AND SENSOR TECHNOLOGY	AMES LABORATORY	400	800	250
CH131001	INFRARED ANALYSIS OF WASTES USING FOURIER TRANSFORM INFRARED SPECTROSCOPY PHOTO ACOUSTIC SPECTROSCOPY (FTIR-PAS) AND TRANSIENT INFRARED SPECTROSCOPY (TIRS)	AMES LABORATORY	300	0	0
CH131002	ZERO TENSION LYSIMETERS	AMES LABORATORY IOWA STATE UNIVERSITY	115	0	0
CH131004	SENSING OF HEAD SPACE GASES AND CONTINUOUS IN SITU MONITORING	AMES LABORATORY	200	0	0
CH131005	AMES INTEGRATION OF INNOVATIVE EXPEDITED SITE CHARACTERIZATION TECHNOLOGY	AMES LABORATORY	300	0	0
CH221202	DEVELOPMENT OF CONTINUOUS EMISSION MONITOR FOR INCINERATORS	ARGONNE NATIONAL LABORATORY	400	400	0
CH231001	TECHNOLOGY PERFORMANCE SPECIFICATIONS	ARGONNE NATIONAL LABORATORY	200	0	0
CH231004	NEW INITIATIVE ON EXPEDITED SITE CHARACTERIZATION	ARGONNE NATIONAL LABORATORY	300	0	0
CH231006	CONE PENETROMETER OPERATIONS	ARGONNE NATIONAL LABORATORY APPLIED SCIENTIFIC ASSOCIATES	125	0	0
HQ020007	BIOREMEDIATION SUPPORT TO ARID INTEGRATED DEMONSTRATION - ENVIRONMENTAL PROTECTION AGENCY (EPA) INTERAGENCY AGREEMENT (IAG)		275	200	0

CHARACTERIZATION, MONITORING, AND SENSOR TECHNOLOGY TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
HQ021131	CHARACTERIZATION OF SOILS ENVIRONMENTAL PROTECTION AGENCY INTERAGENCY AGREEMENT		120	120	0
HQ031005	NATIONAL SECURITY AGENCY (NSA)		60	0	0
HQ031008	CHLOROFLUOROCARBON (CFC) TRACER STUDY - UNITED STATES GEOLOGICAL SURVEY		100	0	0
ID121110	IN SITU SECONDARY ION MASS SPECTROSCOPY (SIMS) ANALYSIS	IDAHO NATIONAL ENGINEERING LABORATORY	163	400	0
ID121112	MARTIN MARIETTA ENERGY SYSTEMS CORPORATION THERMAL MEASUREMENTS (FLYOVER)	IDAHO NATIONAL ENGINEERING LABORATORY	250	500	0
ID121113	ANALYSIS OF PLUME	IDAHO NATIONAL ENGINEERING LABORATORY	0	250	0
ID421102	TECHNOLOGY EVALUATION AND ASSESSMENT	WESTINGHOUSE IDAHO NUCLEAR CO	0	200	0
NV001102	REMOTE SENSING SYSTEMS DEVELOPMENT AND APPLICATIONS	NEVADA OPERATIONS OFFICE UNIVERSITY OF ARIZONA DESERT RESEARCH INSTITUTE	1085	991	700
NV021102	CHARACTERIZATION WORKSHOP FOR HETEROGENEOUS WASTE-PHASE II	NEVADA OPERATIONS OFFICE	60	200	0
NV031002	DEFINING REQUIREMENTS/EVALUATION AND TESTING OF CHARACTERIZATION TECHNOLOGY	NEVADA OPERATIONS OFFICE	800	0	0
OR101102	CHARACTERIZATION SITES FIELD ANALYTICAL METHODS - DEMONSTRATION	OAK RIDGE NATIONAL LABORATORY	210	220	233
OR111105	CHARACTERIZATION SITES FIELD ANALYTICAL METHODS - RESEARCH AND DEVELOPMENT	OAK RIDGE NATIONAL LABORATORY	190	150	100
OR121101	SPECTROELECTROCHEMICAL SENSORS FOR DEPARTMENT OF ENERGY (DOE) SITE CHARACTERIZATION	OAK RIDGE NATIONAL LABORATORY EIC LABORATORIES	190	200	0
OR121112	SENSOR CHARACTERIZATION SUPPORT HAZARDOUS WASTE PLANT (HZWP)	OAK RIDGE NATIONAL LABORATORY ANALYTICAL SERVICES INC.	0	1000	0
RL301102	DEFENSE LOW- LEVEL WASTE TECHNICAL SUPPORT - LYSIMETERS	PACIFIC NORTHWEST LABORATORY	0	50	0
RL331001	PARSONS SUPERFUND SITE IN SITU VITRIFICATION DATA	PACIFIC NORTHWEST LABORATORY	498	0	0
RL331007	DIRECT MEASUREMENT OF STRONTIUM-90 IN SUBSURFACE SOILS	PACIFIC NORTHWEST LABORATORY	225	0	0
RL331008	TOMSK EXPLOSION CHANGE DETECTION STUDY	PACIFIC NORTHWEST LABORATORY	60	0	0
SF211107	ADVANCED FIBER-OPTIC SENSOR SYSTEMS	LAWRENCE LIVERMORE NATIONAL LABORATORY	0	0	0
SF221104	IMPROVED REVERSIBLE CARBON TETRACHLORIDE SENSOR FOR ON-LINE AND DOWN-WELL MEASUREMENTS	LAWRENCE LIVERMORE NATIONAL LABORATORY	400	250	0
SF231004	MULTI-ANALYTE, SINGLE FIBER OPTICAL SENSOR	LAWRENCE LIVERMORE NATIONAL LABORATORY TUFTS UNIVERSITY	210	0	0

IN SITU REMEDIATION INTEGRATED PROGRAM

Introduction

The U.S. Department of Energy (DOE) Office of Technology Development (EM-50) In Situ Remediation Technologies Integrated Program (ISR IP) focuses research and development (R&D) on the treatment in place of contaminated environmental media, such as soil and groundwater, and the containment of contaminants to prevent their spread through the environment. ISR technologies do not require the contaminated media to be excavated or removed. These technologies address environmental and waste management problems such as buried waste, contaminated soils, contaminated groundwater, containerized hazardous and radioactive wastes, and underground detonation sites. The contaminants found in these areas are volatile and non-volatile organics, including chlorinated solvents; radionuclides; heavy metals and nitrates; and highly explosive materials.

Using in situ remediation technologies to clean up DOE sites minimizes adverse health effects on workers and the public by reducing contact exposure. They also reduce the costs for cleanup by orders of magnitude by eliminating the need for waste excavation, transport, and disposal; and enable the remediation of relatively inaccessible areas, such as the deep subsurface and areas beneath structures.

The ISR IP has three primary DOE customers for its technologies: EM-50 Integrated Demonstrations, the Office of Environmental Restoration (EM-40), and the Office of Waste Management (EM-30). The ISR IP is intended to link with fundamental and applied R&D organizations to minimize duplication of effort and identify technology gaps. The objectives of the ISR IP are to: 1) develop and manage in situ remediation technology R&D activities; 2) coordinate R&D to avoid duplication of effort and maximize communication; 3) develop in situ remediation technologies to the point of field demonstration and transfer the technologies to the users; 4) support the assessment of innovative technologies; and 5) expand ongoing in situ remediation technology R&D.

Program Technical Areas

Environmental and waste management problems may be remediated better, faster, more safely, and more cheaply by new technologies in three major ISR program areas: Treatment, Containment, and Subsurface Manipulation.

Bioremediation Uses Natural Biological Processes to Remove Contaminants from Ground Water

Treatment Technologies will be developed and evaluated for in situ destruction, enhanced in situ removal and extraction, and in situ immobilization. Supplementary process monitoring and control technologies will also be developed. In situ destruction R&D will lead to demonstration of biological, chemical, and thermal technologies that destroy contaminants without harming the environment. Technologies may include in situ bioremediation, in situ chemical oxidation, and in situ electrochemical oxidation. In situ removal and extraction can be enhanced by thermal, chemical, or biological subsurface treatments to extract contaminants for destruction or immobilization above ground. Under consideration are in situ soil flushing, dynamic steam stripping, in situ heating, and electrokinetics. In situ immobilization R&D will initially focus on in situ precipitation, in situ redox manipulations, in situ solidification, and in situ grouting.

Containment Technologies will be evaluated to isolate or contain contaminants prior to and during treatment, including: 1) the remediation of heterogeneous waste sites such as landfills; 2) closure of engineered waste systems such as grout vaults and active burial trenches; 3) interim containment of "leaking structures"; and 4) the surface control of contaminant dispersal during in situ remediation. The goal is to develop physical systems to prevent contaminant dispersal into the air, surface water, or groundwater. The technologies under consideration include hydraulic isolation, cryogenics, in situ grouting technologies, vitrified subsurface barriers, and the permanent isolation barrier system. Process monitoring and control techniques will also be developed.

Subsurface Manipulation will evaluate physical control systems for avoiding dispersal of contaminants, or assisting dispersal of treatment agents during in situ remediations. Technologies may include electrokinetic migration of contaminants, hydraulic isolation, auger or jet mixing, hydro- or cold-fracturing, pneumatic fracturing, and vacuum-vaporizer well systems.

Fiscal Year 1993 R&D Technology Areas

Promising areas for DOE funding of in situ remediation technology R&D include: physical and chemical in situ treatment, in situ bioremediation, in situ electrokinetics, and in situ containment. The ISR IP is now accepting R&D proposals in these areas.

Physical and Chemical In Situ Treatment R&D will focus on in situ treatment of contaminants in groundwater and soils by various means. Among these are chemical, electrochemical

and thermal destruction of TCE, PCE, and carbon tetrachloride, chemical and electrochemical reduction of chromium, uranium, and nitrate and treatment of radionuclides. In situ container destruction will be considered as pretreatment for buried waste; as well as subsurface manipulations - addition, dispersion, and recovery of materials in soil; permeable barriers for containment of residual contaminants in groundwater; and in situ combustion of buried waste.

In Situ Bioremediation R&D will focus on techniques to evaluate the extent of bioremediation and the fate of the contaminants. The program will examine bioremediation of mixed wastes: bioimmobilization of metals and radionuclides, bioleaching for mobilization of specific metals and radionuclides, and biological destruction of organics and/or nitrates in the presences of radionuclides/metals; delivery to and mixing of nutrients and/or microorganisms with contaminants for efficient in situ treatment. Bioremediation of chlorinated solvents; development of standardized treatability studies; and bioremediation of nonaqueous phase liquid (NAPLs) will also be conducted.

Electrokinetics R&D will focus on soils contaminated with heavy metals and radionuclides. R&D in this area will include treatability tests using arid and humid soils; studying the effects of soil heterogeneity on contaminant migration, effects of contaminant speciation, and controlling parameters for contaminant migration; a system for the removal of contaminants within the soils and at the electrodes; and engineering the scale-up of the technology.

In Situ Containment R&D will focus on hydraulic and diffusion barriers in the vadose zone surrounding waste areas; asphalt barrier technology for optimum performance of infiltration barriers; physical and chemical fixation of surface contamination; subsidence control for buried waste; and physical, chemical or biological control of contaminant transport in the vadose zone.

Successful completion of these R&D activities will result in the advancement of physical and chemical in situ treatment, in situ bioremediation, electrokinetics and in situ containment technologies to field demonstration in appropriate Integrated Demonstration test beds.

For more information, please contact:

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Selected Past Accomplishments

Proof-of-concept research was completed for the In Situ Biological Filter. An in situ biological filter is an engineered substance filter that has been inoculated with bacteria carrying enzymes. These enzymes will destroy contaminants in ground water as it flows through the filter. This technology is a low cost alternative to pump and treat methods that will reduce the contaminant standard to release levels without creating a secondary waste stream.

Developed trichloroethylene (TCE) sponges and in situ microbial filter concepts.

Demonstrated the feasibility of the microbial biofilter approach for trichloroethylene using methylosinus microbes in two proof of concept experiments (in situ microbial filters).

Developed in situ fiber optic derivative ultraviolet absorption spectroscopy.

Initiated demonstration of cometabolic biodegradation (with Air Force).

Demonstrated, on a laboratory scale, a method to concentrate heavy metals and radionuclides in soils using electrically induced migration (electrokinetic extraction). Such demonstrations represent a practical application of electrokinetics to remediate heavy metal and radionuclide (including uranium, chromium, and arsenic compounds) contaminated soil in situ. In many cases, particularly for deeply buried contaminants, excavation is impractical and prohibitively costly. Sites contaminated with these targeted compounds have been widely identified across the DOE complex. Significant reduction in contamination levels by applying electrokinetics will potentially allow DOE to meet regulatory requirements under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and Resource Conservation and Recovery Act (RCRA).

Demonstrated the "Mag-Sep" (magnetic separation) technology for the efficient removal of metals from ground and surface water.

Incorporated in situ vitrification into demonstration and technology selection plans for specific waste sites at Hanford and Oak Ridge National Laboratory (ORNL).

1993 Accomplishments/Objectives

Demonstrate wax-based grouting material (to be completed in FY 94) for application at the Chemical Waste Landfill - Sandia National Laboratory).

Develop co-metabolic bio-reactor for the destruction of trichloroethylene (TCE) in surface waters.
Develop and field test uranium bio-sorption.

Develop protocols for bioventing.

Install frozen soil test bed in non-arid soils.

Develop bioremediation and chemical oxidation/reduction destruction technologies for application to hazardous organics and nitrates in the presence of radionuclides and heavy metals.

Develop removal and extraction technologies for electrokinetics, and soil flushing with application to organics and metals.

1994 Objectives

Complete the wax-based grout technology and transfer to demonstration status; the potential demonstration sites include the Chemical Waste Landfill (Sandia National Laboratory), buried waste sites at Idaho National Engineering Laboratory (INEL), and underground tanks at Hanford.

Develop process monitoring and control schemes to support both in situ treatment and in situ containment technology performance evaluation in order to achieve regulatory acceptance and technology implementation.

Initiate field testing activities for in situ bioremediation (Hanford), electrokinetics (Savannah River and Sandia National Laboratory sites), and permeable treatment barrier for uranium in ground water (Monticello).

Develop permeable barrier treatment methods for containment of residual contaminants in groundwater.

Conduct R&D on in situ bioremediation, focusing on techniques for delivery of nutrients and/or microorganisms to contaminants and the mixing of the three, and the coupling of anaerobic and aerobic processes in the vadose zone.

Support R&D on the bioremediation of chlorinated solvents and on Dense Non-aqueous Phase Liquids (DNAPLs).

Develop standardized treatability studies for in situ bioremediation.

Field test a permeable biofilter for the remediation of groundwater to provide a more passive and economical treatment than pump and treat methods.

Initiate field testing of the electrokinetics technology in humid and arid soils to economically concentrate ionic contaminants before removal (Savannah River Site and Sandia National Laboratory).

Conduct R&D on the use of hydraulic and diffusion barriers, flowable grouts, and viscous liquids for in situ containment; target demonstration sites are landfills at Sandia National Laboratory (SNL), Buried Waste at Idaho National Engineering Laboratory (INEL), Underground Tanks at Hanford and Buried Waste/Trenches at Oak Ridge National Laboratory (ORNL).

Initiate development of a horizontal barrier, utilizing jet grouting techniques with horizontal drilling, for eventual demonstration at Fernald.

Continue applied R&D for the resolution of technical issues associated with the in situ vitrification technology.

Demonstrate the In Situ Magnetic Separation Process for the removal of radionuclides and heavy metals from contaminated groundwater for application at the Resource Recovery Project and Savannah River Site (SRS).

Continue R&D on the Macrophyte Biomass Processing System for plant uptake and subsequent destruction of organics in soil.

Demonstrate in situ containment barrier technologies to enable confinement and contamination while final remediation technologies are developed and applied.

1995 Planned Objectives

Develop temporary barriers using viscous liquids, polymer gels, soil freezing, and associated process control/monitoring techniques.

Develop bioremediation methods using indigenous microbe systems to destroy chlorinated solvents and immobilize metals/radionuclides in soils and groundwater.

Develop microbes for flooding soil to destroy organic contaminants.

Develop subsurface manipulation methods such as electrokinetic methods for reagent or nutrient delivery, hydraulic fracturing and hydraulic control methods.

Complete the In Situ Microbial Filters Project, a technology for destruction of trichloroethylene (TCE) in groundwater, and transfer it to the Office of Environmental Restoration.

Develop phytoremediation technologies for soils and waters contaminated with heavy metals, radionuclides and hazardous wastes.

Scale-up in situ technologies for anaerobic degradation of carbon tetrachloride, for eventual application to Hanford groundwater remediation.

Continue demonstration of in situ aerobic degradation of trichloroethylene using alternative microbial systems.

Develop ion-specific chromatography method for sequential removal of heavy metals from aqueous solution (i.e. resource recovery).

Develop soil remediation by heap leaching.

Document passive bioremediation of hydrocarbons at selected sites.

Develop methods such as chemical flooding for the removal of metals from soils.

Do Proof of Concept experiments in bioremoval of heavy metals and radionuclides from contaminated waters.

Complete the In Situ Magnetic Separation Process and transfer to 1) the Resource Recovery Project where it will be used for removal of metals from surface water and 2) Environmental Response at Savannah River (SRS) for use at the F or H basis.

Develop Bioleaching/bioimmobilization of heavy metals for contaminated subsurface sites.

Conduct in situ experiments on staged anaerobic-aerobic biotreatment of mixed chlorinated organics for application at Rocky Flats.

Develop new containment methods such as controllable grouts and "skin" barriers for underground tanks (a technique for applying barrier material to the outside surface of buried structures) for eventual application to such sites as Los Alamos or Sandia National Labs.

Develop a biological plugging method, wherein organisms are grown in situ, producing a pore-plugging substance.

Expand bioremediation to include mixed chlorinated solvents, semi-volatile contaminants and metals which are difficult to degrade in either aerobic or anaerobic conditions. Develop microbes for injection, aerobic/anaerobic bioremediation applications, nutrient delivery systems, and bioconcentration of metals in soil.

Develop physical and chemical treatment methods for the removal of Dense Non-Aqueous Phase Liquids (DNAPLs) from fine-grained soils.

Continue to develop and transfer permanent and temporary containment technologies, focusing on barriers which can be vertically and horizontally emplaced in the subsurface.

Develop Chemically Enhanced Barriers, which will provide to the Hanford site the data necessary to evaluate permeable treatment barriers for the removal of Strontium from groundwater at the N Reactor Springs site.

Install and apply viscous liquid barriers during in situ treatment activities.

Continue to develop permeable barriers which will remove contaminants from liquid streams allowing clean liquid to flow out of the barrier.

Demonstrate In Situ Chemical Treatment techniques which will destroy or immobilize the contaminants at Hanford, Sandia National Laboratory (SNL) or Fernald.

Develop methods for deep subsurface bioremediation and methods for bioconcentration of metals (e.g. Cr, Sr90, Cs137) in groundwater, for subsequent removal and treatment.

Ex situ treatment systems which complement In Situ Remediation will be evaluated, such as ex situ treatment of contaminants removed via electrokinetics or via bioconcentration of metals.

Develop contaminant-specific technologies, such as for mercury, tritium and polychlorinated biphenyls (PCBs).

Demonstrate pilot-scale "Reactive Barrier" technology to remediate flowing groundwater without pumping groundwater to the surface.

IN SITU REMEDIATION INTEGRATED PROGRAM

Technology Window Flowchart	1990	1995	2000	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Containment													
• Flowable Grout													
• Viscous Liquids													
• Chemical Barriers													
• Hydraulic/Diffusion Barriers													
• Frozen Soil Barriers													
• Horizontal Barriers													
• Wax-Based Grout													
Subsurface Manipulation/ Process Control													
• Electrokinetic Migration													
• In Situ Redox Manip.													
Bioremediation													
• In Situ Microbial Filters													
• Co-Metabolic Techniques													
• Plant Uptake													
Physical/Chemical Treatment													
• In Situ Magnetic Separation													
• In Situ Chemical Treatment													
• DNAPLS Initiative													

IN SITU REMEDIATION INTEGRATED PROGRAM TECHNICAL TASK PLAN

NUMBER	TITLE	CONTRACTOR	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
AL921201	CRYOGENIC BARRIERS	UNC GEOTECH INC	800	500	0
AL931002	CHEMICAL BARRIERS FEASIBILITY AND FIELD DEMONSTRATION	UNC GEOTECH INC	500	0	0
AL932003	GEOPHYSICAL TEST PIT AT RABBIT VALLEY	UNC GEOTECH INC	200	0	0
AL111102	IN SITU REMEDIATION INTEGRATED PROGRAM- LOS ALAMOS NATIONAL LABORATORY TECHNICAL SUPPORT	LOS ALAMOS NATIONAL LABORATORY	0	25	15
AL131005	DEVELOPMENT OF BIOREMEDIATION SUB-PROGRAM	LOS ALAMOS NATIONAL LABORATORY	200	0	0
AL221126	ELECTROKINETIC REMEDIATION IN ARID SOILS	SANDIA NATIONAL LABORATORY	0	50	0
AL231008	EVALUATION OF TWO NEW FLOWABLE GROUT TECHNIQUES FOR IN SITU BARRIER CONSTRUCTION	SANDIA NATIONAL LABORATORY	500	0	0
		GOLDEN ASSOCIATES			
		MIBRAG/DBI			
		SOCIETE FRANCAISE HOESCHT			
AL231009	ELECTROKINETIC REMEDIATION OF HEAVY METAL CONTAMINATION IN UNSATURATED SOIL	SANDIA NATIONAL LABORATORY	400	0	0
		UNIVERSITY OF WASHINGTON			
		MIT			
CH221110	IN SITU REMEDIATION INTEGRATED PROGRAM SUPPORT	ARGONNE NATIONAL LABORATORY	0	15	0
CH231002	IN SITU REMEDIATION - INTEGRATED PROGRAM PEER REVIEW MANAGEMENT	ARGONNE NATIONAL LABORATORY	150	0	0
CH231005	IN SITU MAGNETIC SEPARATION	ARGONNE NATIONAL LABORATORY	1650	0	0
		RUST TEMEDIAL SERVICES			
		BRADTEC US			
		BABCOCK & WILCOX NUCLEAR SERVICE			
CH331001	REGULATORY ISSUES AND ASSUMPTIONS ASSOCIATED WITH BARRIERS IN VADOSE ZONE	BROOKHAVEN NATIONAL LABORATORY	350	0	0
FN131003	DEVELOPMENT AND DEMONSTRATION METHOD OF PLACING IN SITU HORIZONTAL GROUT BARRIERS	WESTINGHOUSE MATERIALS OF OHIO	900	0	0
HQ031004	ELECTROKINETIC REMOVAL OF HEAVY METAL AND MIXED WASTE		250	0	0
HQ031006	INTERAGENCY AGREEMENT WITH ENVIRONMENTAL PROTECTION AGENCY FOR HAZARDOUS SUBSTANCE RESEARCH CENTER PROGRAM AT STANFORD		180	0	0
HQ031007	IN SITU REMEDIATION INTEGRATED PROGRAM - UNIVERSITY AND ENVIRONMENTAL PROTECTION AGENCY - EPA PEER REVIEW SUPPORT		50	0	0

IN SITU REMEDIATION INTEGRATED PROGRAM TECHNICAL TASK PLAN

NUMBER	TITLE	CONTRACTOR	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
ID121106	IN SITU REMEDIATION INTEGRATED PROGRAM (INTEGRATED DEMONSTRATION): PROVIDE FOR MANAGEMENT OF IN SITU REMEDIATION INTEGRATED PROGRAM - INCLUDING DEVELOPING RESEARCH AND DEVELOPMENT INITIATIVES AND TRANSFERRING TO INTEGRATED PROGRAM, INTEGRATED DEMONSTRATION SUPPORT GROUPS, INTERACT WITH DEPARTMENT OF ENERGY - ENVIRONMENTAL RESTORATION	IDAHO NATIONAL ENGINEERING LABORATORY	0	15	15
ID131001	INTERNATIONAL BIO-HYDROMETALLURGY CONFERENCE SUPPORT	IDAHO NATIONAL ENGINEERING LABORATORY	20	0	0
OR101108	DEMONSTRATION OF CO-METABOLIC TECHNIQUES	OAK RIDGE NATIONAL LABORATORY	380	320	350
		ENVIROGEN			
		AF CIVIL ENGINEERING SUPPORT AGENCY			
OR111107	IN SITU REMEDIATION INTEGRATED PROGRAM	OAK RIDGE NATIONAL LABORATORY	100	109	48
OR121110	BIOREMEDIATION OF POLYCHLORINATED BIPHENYLS CONTAMINATION	OAK RIDGE NATIONAL LABORATORY	300	300	0
OR121114	APPLICATION OF SURFACTANT TO IN SITU BIOREMEDIATION	OAK RIDGE NATIONAL LABORATORY	0	45	0
OR121117	PROTOCOLS FOR IN SITU BIOVENTING	OAK RIDGE NATIONAL LABORATORY	0	80	0
OR131006	MERCURY WORKSHOP	OAK RIDGE NATIONAL LABORATORY	50	0	0
OR131007	REMEDATION OF DENSE NON-AQUEOUS PHASE LIQUID IN LOW PERMEABILITY MEDIA	OAK RIDGE NATIONAL LABORATORY	250	0	0
OR221102	IN SITU REMEDIATION BY ELECTROKINETICS HAZARDOUS WASTE PLANT (HZWP)	OAK RIDGE NATIONAL LABORATORY	50	675	0
PE021102	WATER, AIR, SOIL TEST AND EVALUATION CENTER	PITTSBURGH ENERGY TECHNOLOGY CENTER	350	20	0
PE031002	BEFTTO PROCESS/MACROPHYTE REMEDIATION OF CONTAMINATED SOILS	PITTSBURGH ENERGY TECHNOLOGY CENTER	1000	0	0
		BUREVESTNIK SCIENTIFIC RESEARCH INSTITUTE			
RL311103	IN SITU REMEDIATION TECHNOLOGY INTEGRATED PROGRAM: COORDINATION PROGRAM DEVELOPMENT & TECHNOLOGY EVALUATION TASKS	PACIFIC NORTHWEST LABORATORY	800	0	140
RL331002	CHEMICALLY ENHANCED BARRIERS/VADOSE ZONE	PACIFIC NORTHWEST LABORATORY	570	0	0
		EBASCO SERVICES			
		NEW MEXICO STATE UNIVERISTY			
		WASHINGTON STATE UNIVERSITY-TRICITIES			
RL331005	IN SITU REDOX MANIPULATION	PACIFIC NORTHWEST LABORATORY	425	0	0

IN SITU REMEDIATION INTEGRATED PROGRAM TECHNICAL TASK PLAN

NUMBER	TITLE	CONTRACTOR	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
RL331006	IN SITU CORONA/TREATMENT OF NONVOLATILE ORGANIC CONTAMINANTS	PACIFIC NORTHWEST LABORATORY	250	0	0
		EM FACTORS			
RLNEW	IN SITU BIOREMEDIATION TECHNIQUES	RICHLAND OPERATIONS OFFICE	0	0	500
RL431001	IN SITU CHEMICAL TREATMENT	WESTINGHOUSE HANFORD COMPANY	170	0	0
SF131001	PHYSICAL BARRIERS FORMED FROM VISCOUS LIQUIDS EMPLACED	LAWRENCE BERKELEY LABORATORY	262	0	0
		TEXAS A&M UNIVERSITY			
		MIT			
SF201101	IN SITU MICROBIAL FILTERS	LAWRENCE LIVERMORE NATIONAL LABORATORY	1033	0	0
SF211105	IN SITU REMEDIATION TECHNOLOGY INTEGRATED PROGRAM - TECHNICAL SUPPORT	LAWRENCE LIVERMORE NATIONAL LABORATORY	0	25	15
SF231001	OPTIMAL REMEDIATION DESIGN:	LAWRENCE LIVERMORE NATIONAL LABORATORY	200	0	0
SF231002	DEVELOPMENT OF SUBSURFACE MANIPULATION/PROCESS CONTROL SUB-PROGRAM	LAWRENCE LIVERMORE NATIONAL LABORATORY	150	0	0
SR111105	INTEGRATED DEMONSTRATION FOR CLEANUP OF ORGANICS IN SOILS AND AT NON ARID SITES CHARACTERIZATION	WESTINGHOUSE ELECTRIC CORP	0	0	15
SR121108	BIOREMOVAL OF HEAVY METALS	WESTINGHOUSE ELECTRIC CORP	0	275	0
SR121110	TEMPERATURE SENSORS FOR USE DURING IN SITU HEATING	WESTINGHOUSE ELECTRIC CORP	0	20	0
SR131003	IN SITU REMEDIATION BY ELECTROKINETICS	WESTINGHOUSE ELECTRIC CORP	500	0	0

MINIMUM ADDITIVE WASTE STABILIZATION

Abstract

The minimum additive waste stabilization (MAWS) technology remediates multiple waste streams in one integrated treatment system that is cost-effective and produces an environmentally sound waste form for disposal. A technology system that utilizes the MAWS concept is being demonstrated at the Fernald Environmental Management Project of the Department of Energy. At Fernald, 350,000 m³ of residue from uranium ore processing was buried in waste pits. Pit sludge and the surrounding soil and groundwater are contaminated and require remediation. The MAWS concept integrates vitrification with soil washing and ion-exchange wastewater treatment and uses various wastes for resources as additives for vitrification, minimizing the use of purchased additives. As a result, waste loading is increased, and the final waste volume, as well as the disposal cost, can be significantly reduced. The soil washing and wastewater treatment remediates contaminated soil and groundwater whereas the vitrification system incorporates the pit sludge and resulting contaminated soil concentrates and spent ion-exchange resins into a final, stabilized glass waste form. This systematic approach further maximizes waste loading while eliminating secondary waste streams. Use of the MAWS system at Fernald is expected to save 55% compared with the conventional treatment method (cementation).

Introduction

The minimum additive waste stabilization (MAWS) technology is being demonstrated at the Department of Energy (DOE) Fernald Environmental Management Project (FEMP) in Fernald, Ohio. The MAWS system integrates into one single process three primary treatment technologies that are usually employed separately for site remediation: vitrification, soil washing, and ion-exchange wastewater treatment. The MAWS system is centered on vitrification and incorporates all primary and secondary waste streams into a final, stabilized glass waste form. The integrated system is innovative because the waste streams are viewed as additive resources to vitrification, and a "portfolio" approach is adopted to maximize the economic benefit.

Figure 1. OU-1 Waste Pit Area - Pit 5 in foreground

Vitrification has been used in the DOE Complex for treatment of low-volume, high-level radioactive wastes with low waste loading and high treatment cost. However, the economic attractiveness for treating large volumes of low-level waste/mixed waste (by maximizing waste loading) and the feasibility of production-scale processing have yet to be demonstrated. This program will demonstrate both the economics of total life cycle cost savings, through increased waste loading and final waste volume reduction, and the production-scale feasibility of vitrification of large volumes of low-level waste/mixed waste through a synergistic approach. In addition, it will demonstrate the capability of producing a leach-resistant (long-term) waste form, clean soil and water for placement back into the environment, and an off-gas effluent that meets regulatory requirements.

Background

The FEMP is a federal facility that previously produced pure uranium for DOE. Production ended in 1989, and the site's mission has since been dedicated to environmental restoration. Process wastes containing low concentrations of uranium and thorium were stored in five on-site waste pits designated as Operable Unit 1 (OU-1); a significant portion of the FEMP wastes are listed as hazardous under the Resource Conservation and Recovery Act (RCRA) because they contain certain RCRA

Figure 2. Minimum Additive Blending - Laboratory Crucible Studies

components. Studies have indicated that uranium contamination is present in the pit sludges and in the surrounding soils and groundwater.

The major factor affecting remediation cost at OU-1 is the large quantities of wastes needing remediation - i.e., approximately 350,000 m³ of pit wastes; up to 540,000 m³ of soil under the pits, in the cap, and in the berms; and about 2.3 million gallons of contaminated surface wastewater. Because MAWS has been identified as a potentially cost-effective treatment approach, the MAWS technology has been adopted as one of the treatment options for OU-1 to be studied as input to the Record of Decision (ROD) scheduled for December 1994.

In July 1992, a joint venture was established between the Office of Technology Development and the Office of Environmental Restoration within Environmental Restoration and Waste Management (EM) of DOE to demonstrate the MAWS process at the Fernald OU-1. The contractors participating in this demonstration include GTS Durateck Corporation (vitrification testing and wastewater treatment), Catholic University of America (vitrification testing), and Lockheed Environmental Services Corporation (soil washing). On-site support will be provided by FEMP management and their subcontractors. Contract management and glass durability testing will be provided by Argonne National Laboratory.

MAWS Technologies

Laboratory Studies

The MAWS technology was adopted by FEMP for demonstration because the site wastes (contaminated soils and sludges) contain both the glass former and the flux resources necessary for glassmaking. Waste characterization studies

have been conducted to identify these glass-forming components. A glass composition variability study has been designed for combinations of soil-wash concentrates, OU-1 sludges, spent ion-exchange media, and other identified waste - with and without the addition of chemical additives. Extensive laboratory crucible melt studies have been conducted to determine the optimal blend of the wastes that will satisfy processing parameter constraints (mainly melt viscosity, electrical conductivity, and liquids temperature) and at the same time produce a leach-resistant, durable glass waste form with high waste loading. Extensive glass property characterization and modeling is used in these studies to rapidly and efficiently determine optimized target feed compositions. Characterization

and laboratory development will also provide information about any components in the waste that may hinder the vitrification process and, thus, indicate when pretreatment of the waste may be necessary. Small-scale testing (10-kg/d glass output) in a continuous joule-heated melter is also being conducted to obtain processing and off-gas performance data.

Vitrification

The vitrification process uses high temperatures (typically between 1100 and 1600°C) to chemically incorporate wastes into a glass matrix. At elevated temperatures, glass becomes electrically conductive, and the current passing between the electrodes in the vitrifier causes the conductive glass to heat and maintains the glass in a molten state. This process is known as joule heating. Most inorganics oxidize and dissolve in the molten glass because the great majority of oxides are soluble in silicate glasses; organics rapidly oxidize at the high temperatures and form simple gases (mostly carbon dioxide and water vapor) that are collected and treated in the off-gas system.

A vitrification system (GTS Durateck Duramelter) capable of producing at least 100-kg/d of vitrified waste from radioactive feed materials is located at the Vero State Laboratory of Catholic University of America. This system will provide critical large-scale process data necessary for the development of process controls and operating protocols for the 300-kg/d system to be installed at FEMP and off-gas system performance evaluation. Process data will include throughput rates, cold cap formation, and information on foaming events. Additionally, supporting data for scale-up to the larger pilot-scale and full-size units will continue to be collected from 10-kg/d and 100-kg/d units in conjunction with the 300-kg/d system to be used for the demonstration.

The vitrification system to be demonstrated at FEMP will produce 300-kg/d of glass from radioactive waste. An extensive on-site testing program will be conducted to provide the essential system performance and operating data necessary for treatment technology selection at FEMP. These data will also provide the basis for scale-up to larger pilot-scale and full-scale treatment systems. Additional tests will be performed to support delisting of the vitrified waste, which would result in further cost savings for storage and monitoring. The FEMP vitrification system has been designed to handle a blend of pit sludges, spent resins, and soil concentrates. Site fly ash will also be tested as a source of silica. It is expected that the system may also be capable of vitrifying asbestos and Transite with little or no modification, which would be advantageous for application to other needs of the DOE Complex because such wastes are widespread. The MAWS system will be capable of dispensing the vitrified product into drums in the form of glass gems. The gems will be of various sizes to facilitate packing and enhance volume reduction while maintaining easy handling of the vitrified product.

The off-gas system will have an advanced two-stage scrubbing system designed to produce no secondary waste streams. The off gases will then be treated by high-efficiency particulate air filtration to meet regulatory requirements for release. Monitoring equipment will also be provided.

Soil Washing

Soils, primarily contaminated with uranium, will be washed with the TRUClean process to separate them into clean soils and soil concentrates. This will be accomplished by passing a slurry of the contaminated soils through a series of scrubbers, gravimetric separators, and hydrocyclone separators. Laboratory studies of FEMP soils have been performed to specify the demonstration unit, and a carbonate leach step has been added to achieve the target uranium cleanup level. The demonstration unit at FEMP will be able to process 0.25 yd³/h of soil. The soil concentrates will be used as feed for the vitrification. All input and output streams will be analyzed for contaminants to determine the success of the soil washing for radionuclide removal and other RCRA contaminants, if appropriate. Mass balance calculations will verify final

disposition of the contaminants. These studies are being conducted in close collaboration with the laboratory water treatment studies to ensure that the effluent from the process can be treated in the ion-exchange system and then recycled to the melter for ultimate stabilization of the contaminants in the vitrification system.

Ion-Exchange Water Treatment

The water treatment system will treat contaminated wastewater from the vitrification and soil washing systems. Uranium and thorium contaminants will be stripped off by a traditional organic ion-exchange resin and redeposited onto a glass resin that can be fed to the vitrifier, allowing for conventional disposal of the spent organic resin. The success and economics of this process will be evaluated and documented at the end of the FEMP demonstration. If necessary, the process can be modified to remove hazardous constituents, such as toxic metals, to ensure that all water quality standards are met for water discharged from the system. An acid-stripping process will be developed for regenerating the Dowex 21K organic ion-exchange resin used in the water treatment system. The stripped uranium will then be collected and used as feed for the melter.

A 10- to 100-gpm water treatment system, capable of removing uranium from the influent to levels below 20 ppb, will be installed at FEMP. Operating parameters for the system will be optimized by performing laboratory studies using soil wash waters as the influent.

Integration of Technologies

Process feasibility evaluating will be performed for each technology as well as for the overall integrated system. The key objective of evaluating the capability and performance of each individual technology is to determine the system parameters necessary to optimize the performance of the overall integrated system. Optimum performance of a system involving multiple and interactive steps is generally *not* obtained by optimizing each step individually. Performance itself is a multi-attribute variable composed of factors including leach resistance of the final waste form, overall waste volume reduction, waste loading, system throughput rates, and capital, operating, and waste disposal costs. Economic feasibility studies will be conducted for the integrated system on the basis of cost estimates for the overall process over the life cycle of the program.

Figure 4. MAWS System

Remedial Investigation/ Feasibility Studies and Economics

A database on vitrification process parameters for FEMP wastes will be developed from the MAWS program, as well as from other vitrification studies being carried out as part of the Remedial Investigation/Feasibility Study (RI/FS) process at FEMP. This information will permit a detailed comparative analysis of processing and economic feasibility relative to alternative stabilization technologies, specifically cementation, and will provide the basis for vitrification process scale-up and design. A preliminary life cycle cost analysis comparing MAWS vitrification to cementation of the OU-1 sludges indicated cost savings of \$720 M or 55%.

Glass Characterization and Durability

Even if the MAWS concept proves to be technically feasible and economical, further testing will be needed to demonstrate that the vitrified waste product will endure with time and will be protective of the environment. The MAWS program will include extensive testing to provide a database of quality, consistency, homogeneity, leachability, and durability of the vitrified waste product. Expected long-term performance of the glass will be determined and documented. These data may then be used to supplement the existing database on glass performance (mainly high-level waste glass) for use in studies to determine whether it is possible to place the treated waste in less expensive disposal facilities, thus further reducing site remediation costs.

A three-tiered leach testing approach for durability will be used: (1) standard toxicity characteristic leach procedure (TCLP) and project consistency testing for inorganics, (2) service condition testing, and (3) accelerated testing. This tiered approach will identify and conduct practical testing methods that can be used to determine the performance of the vitrified product (including elemental and radionuclide release characteristics) under disposal conditions. A variety of other leach testing methods will also be used in conjunction with detailed surface analyses by analytical electron microscopy, scanning electron microscopy, secondary ion mass spectrometry, and optical microscopy. The objective of these tests will be to establish a meaningful testing approach and database for demonstrating the durability of the glass product.

Delisting the Glass Waste Form

Although the high temperatures of the vitrification process are expected to destroy the organic components responsible for RCRA listing and the final glass waste form is expected to be highly leach-resistant, the glass will remain a listed waste (mixed waste). This listing presents additional storage costs,

as well as concerns for FEMP during bench-scale and pilot-scale studies, and will ultimately affect the type of disposal facility selected. For these reasons, the MAWS program will collect a large number of samples of the glass waste form produced in this program for subsequent characterization by independent EPA-certified laboratories to support a delisting application.

This vitrification system demonstration will potentially provide a basis for the adoption of in-furnace vitrification as the EPA best demonstrated available technology (BDAT) for selected multiple waste streams, such as raffinate sludges and soils (similar to adoption of vitrification for high-level wastes). If adopted as BDAT it could expedite remediation programs at many DOE sites that may otherwise be forced to deal with demonstrating leach-resistance to satisfy potential requirements for mixed waste forms (beyond passing the TCLP tests), an area in which appropriate regulations, and even consensus test methods, are conspicuously lacking.

Future Plans

- Initiate the 300 kg/day melter system
- After the process is stabilized, use the RI/FS data to support the ROD schedule for December 1994.
- Demonstrate the fully optimized process by 1994.
- Expand the MAWS program to other sites, as applicable.

For more information, please contact:

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1992 Accomplishments/Objectives

Contract was put in place including bridge contract to jump start flow of information between Fernald and contractor.

Initiated crucible studies and specification of the 100 kg/day melter.

Performed initial bench scale testing using 10 kg/day melter of Fernald uranium pit sludge to efficiently contain it (high waste loading) in stable and durable waste forms.

Proof of concept of bench scale vitrification with high waste loading and production of quality waste form using the MAWS approach.

Proof of concept of high metal waste loading with plasma technology.

Initiate MAWS integrated system (vitrification, soil washing, and water treatment) demonstration at Fernald.

Initiate application of MAWS concept to other DOE environmental restoration sites, identify applicable wastestreams and technology needs and assess relevant technologies for development.

Complete technology assessment report to identify and evaluate potential technologies for high temperature MAWS application for implementation in FY 94.

1993 Accomplishments/Objectives

Completed laboratory crucible studies of Fernald wastes (sludges, soil concentrates, flyash). Achieved up to 93% waste loading while producing quality glass.

Completed bench scale testing in 10 kg/day melter with Fernald surrogate and radioactive wastes. Achieved excellent off-gas performance for hydrogen fluoride and recycle of off-gas sludge to melter.

Radioactive glass produced in the 10 kg/day melter passed TCLP (Toxicity Characteristic Leaching Procedure) for toxic metals and exceeded the high level waste standard for radionuclides.

100 kg/day melter system has been assembled and operated with radioactive wastes.

Installed laboratory-scale water treatment system and successfully operated for laboratory washing tests.

Completed soil washing treatability studies and specifications for soil washing demonstration unit.

Completed specification, construction, and delivery of the 300 kg/day field demonstration melter system. Bake-out of the melter has been initiated and preparations for surrogate and radioactive Fernald waste streams are underway.

Will complete plasma testing to define the upper level of scrap metal content in waste while producing an acceptable final waste form. Initial tests are being conducted using various blends of soils, stainless steel and carbon steel with small amounts of lead, chromium, chloride, and cerium oxide as a plutonium surrogate.

Draft technology assessment report completed.

Demonstrate fully optimized pilot scale process at Fernald.

Lab testing of other DOE complex specific waste streams to define process compositional envelope for varying site needs. Initial identified waste streams include contaminated soils (including soil concentrates from soil washing activities) and sludges contaminated with toxic metals, radionuclides, and potentially organic materials. Wastes for testing are to be selected using the preliminary waste assessment as a basis as well as site compliance urgency.

Potential Wastes: Organic and Inorganic Sludges and Solids, Soils, Debris, Multiple Wastes

Treatment Category: Stabilization (radionuclides and toxic metals in vitrified form)- STABL, Organic Destruction-ORDST

Initiate/continue development of bench scale high temperature vitrification system capability for the MAWS technology based on technology assessment report and planning documentation.

Potential Wastes: Organic and Inorganic Liquids, Sludges and Solids, Soils, Debris, Lab Packs, Multiple Wastes, Other Wastes

Treatment Category: STABL, ORDST

Initiate/continue long term durability testing to include evaluation of waste forms from joule melter, plasma, and other high temperature vitrification testing. Tests include Toxicity Characteristic Leaching Procedure (TCLP), Product Consistency (8-day leach) Test (PCT), vapor phase testing as a minimum, as well as other compositional analyses used to determine quality, leachability and long term durability.

1995 Planned Objectives

Continue lab crucible studies and complete compositional envelope development, data produced will be transferred to clean-up user.

Continue development and demonstrate high temperature vitrification technologies using the MAWS concept for remediation needs. Testing is planned for at least two technologies.

Complete long term durability testing and provide data on glass/slag produced from compositional studies and technology testing.

Conduct life cycle cost studies for the MAWS technology system.

Select site for MAWS demonstration and initiate compositional studies for waste streams selected.

MINIMUM ADDITIVE WASTE STABILIZATION (MAWS) PROGRAM

Target Schedule	92	93	94	95	96	97	98	99	00
Phase 1 (Fernald)									
• Crucible Composition Study	■	■							
• Run 10 Kg/d Melter Hot	■	■							
• Run 100 Kg/d Melter Hot	■	■							
• Install 300 Kg/d Melter FEMP	■	■							
• Run 300 Kg/d Melter Cold	■	■							
Phase 2 (Fernald)									
• Run 300 Kg/d Melter Hot		■	■						
Window of Opportunity (Fernald)	■	■	■						
Window of Opportunity (DOE Complex)	■	■	■	■	■	■	■	■	■
Other MAWS Activities									
• Plasma Tests		■	■						
• Compositional Envelope Study		■	■	■					
• Select and Test Additional Technologies Based on Waste Stream Needs			■	■	■				
• Durability Testing		■	■	■	■				
• Life Cycle Cost Analysis			■	■					

MINIMUM ADDITIVE WASTE STABILIZATION TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
CH231007	MINIMUM ADDITIVE WASTE STABILIZATION (MAWS) COMPOSITIONAL ENVELOPE	ARGONNE NATIONAL LABORATORY GTS DURATEK CUA	1400	0	0
CH221203	MINIMUM ADDITIVE WASTE STABILIZATION/FERNALD	ARGONNE NATIONAL LABORATORY GTS DURATEK/ CUA LESC	(\$3400K)		
PE021105	MINIMUM ADDITIVE WASTE STABILIZATION (PLASMA)	PITTSBURGH ENERGY TECHNOLOGY CENTER RETECH	(\$400K)		
CH231008	MINIMUM ADDITIVE WASTE STABILIZATION (PLASMA)	ARGONNE NATIONAL LABORATORY MSE RETECH	175	0	0

RESOURCE RECOVERY

Introduction and Objectives

The Resource Recovery Project (RRP) was funded in August 1992, by the DOE, Office of Technology Development under Research, Development, Demonstration, Testing, and Evaluation (RDDT&E) Innovation and Support. In 1994, Resource Recovery is funded in Groundwater and Soils Cleanup. The purpose of the project is to evaluate, test and demonstrate technologies, at pilot scale, for recovery of both surface and groundwater from dilute heavy metal aqueous solutions. The project will emphasize recovery of valuable mineral resources, including heavy and/or precious metals, as well as industrial minerals. Economic analyses of each technology and the resources recovered will be used to project resource recovery and/or remediation costs of similar DOE and industrial sites using similar technologies. The project will focus on resource conservation and end-use applications of the recovered resources by maximizing resource utilization and minimizing non-useable byproducts. Resource utilization will address industrial, commercial, municipal/ governmental, agricultural and recreational uses of the water, metals and other resources.

Economic and technical feasibility analyses of each technology demonstrated will be conducted. The analyses will include potential revenues from sale of water and mineral resources. Cost/benefit analyses will be an integral part of the project. The data gathered from these demonstrations will be applicable throughout the nation-wide DOE complex of facilities, where the removal of heavy metals from aqueous solutions has been demonstrated to be a major and immediate remedial/resource recovery task. The data will demonstrate at pilot scale, which technologies are the most effective at recovering resources and remediating contaminated waters, and which are the most cost efficient, including the costs realized from resource utilization.

The primary goal of the RRP is to develop data through demonstrations that will allow DOE and other project managers, engineers, and scientists to screen and select "off-the-shelf" technologies for the recovery of ground and surface waters containing dilute heavy metals. The data generated will address the effectiveness, implementability, limitations, and costs of the technologies demonstrated. The information developed will allow for the timely, confident, and cost-effective selection of appropriate reclamation technologies at various sites throughout the DOE complex. Through technology transfer, the information generated can also be applied to non-DOE sites.

The Resource Recovery Project will attempt to minimize non-useable byproducts of water treatment, e.g., waste sludges, by identifying potential end use applications of all treatment

byproducts. Resource utilization will identify potential opportunities for "value-adding" of recovered minerals to further enhance the utilization potential of the treatment byproducts.

Test Bed

The Berkeley Pit, an inactive open pit copper mine in Butte, Montana, has been selected as the RRP test bed. The Berkeley Pit and surrounding groundwater systems were de-watered by active mining operations for over 100 years. In April 1982, the de-watering pumps located approximately 3,900 feet below surface were shut off. Groundwaters and surface waters are now recharging. The Berkeley Pit is acting as a collection point, or "sink", for the recharging waters. Currently, the Berkeley Pit alone is estimated to contain over 20 Billion gallons of acidic, highly mineralized water. The Pit is filling at a rate of approximately 5 million gallons per day. The EPA has estimated that the Pit will contain as much as 56 Billion gallons of contaminated water at its maximum water level. Average contaminant concentrations in the Berkeley Pit are shown in Table 1.

Project Description

To satisfy DOE needs, the RRP has been broken into seven tasks. Each is described briefly below.

Task 1: Resource Characterization

In this task, the waters of the Berkeley Pit and its associated groundwater systems are described and characterized in great detail.

Task 2: Issue Identification and Analysis

This task identifies, characterizes, and analyzes issues relevant to resource recovery efforts. Four subtasks will be completed as part of this task. (1) **DOE Needs** for resource recovery will be continuously identified and analyzed for application throughout the DOE complex. (2) **Regulatory-Compliance Issues** associated with RRP are identified and plans are made to assure compliance. Issues include state and Federal permitting requirements, NEPA requirements; water end-use criteria (drinking water, municipal, industrial, commercial, and agricultural); water discharge standards; and waste management issues. (3) **Legal Issues** pertaining to resource recovery projects are also addressed. These issues include comprehensive Environmental Response, Compensation, and Liability Act

Contaminant	Average Concentration
Iron	1000 mg/L
Zinc	540 mg/L
Aluminum	270 mg/L
Copper	185 mg/L
Manganese	180 mg/L
Cadmium	1.60 mg/L
Arsenic	0.70 mg/L
Lead	0.05 mg/L
Sulfate (SO ₄ ⁻²)	7900 mg/L
pH	2.63 s.u.

Contaminant	Average Concentration
Iron	1000 mg/L
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pH	2.63 s.u.

Average Berkeley Pit Water Quality

(CERCLA) liability issues; water and mineral rights; the use and demonstration of proprietary technologies; intellectual property and confidentiality issues; and patenting and licensing issues. (4) **Economic Issues** pertaining to resource recovery projects will be identified and analyzed. Economic issues include reclamation costs; water utilization costs; costs for bringing other resources to market; waste disposal costs; and cost benefits for "value-adding". Many of these issues are technology-specific.

Task 3: Technology Evaluation Screening and Selection

In this task, technologies potentially applicable to the recovery of resources from dilute heavy metal solutions are identified, evaluated, screened, and ultimately selected for demonstration under the RRP.

Task 4: Technology Demonstration and Development

In this task, those technologies selected will be demonstrated. Demonstrations may take place at the Berkeley Pit facility or at some remote location provided by a technology vendor. The scale of demonstration may vary depending on the technology.

Task 5: Facility Development and Construction

A facility for obtaining water from the Berkeley Pit and conducting demonstrations will be developed and constructed in this task. The facility development will begin with facility siting, proceed to facility design, and ultimately be constructed.

Task 6: Technology Transfer

Information gathered during the RRP will be compiled and transferred throughout the DOE complex and throughout the nation. Emphasis will be placed on water recovery and utilization of all recoverable resources.

Task 7: Formation of Technical Support Groups

Due to the many entities with existing interests in the Berkeley Pit, and the wealth of knowledge that has been developed by these entities, a Technical Support Group (TSG) has been formed to advise the RRP managers on the issues of technology screening and selection. The purpose of the TSG is to advise the RRP managers of recommended project directions, with the ultimate goal of keeping the project focused and targeted on maximizing and utilizing the knowledge gained.

1993 Accomplishments/Objectives

Technology selection criteria established and technology selection committee formed.

Identified markets for clean water and recovered minerals.

Initiated government and industry partnerships for technology implementation.

Initiated demonstration of selected technologies.

1994 Objectives

Complete initial technology demonstrations and optimize technologies for implementation and transfer to users.

Develop conceptual design for full scale operation of technologies tested.

Conduct technology transfer for DOE Sites, private industry, and other Federal agencies.

Demonstrate 3 to 5 additional technologies.

1995 Planned Objectives

Complete demonstration of 3-5 technologies and assess economic and technical feasibility for each technology using systems approach.

Develop conceptual design for full scale operation of each technology tested.

Conduct technology transfer for DOE sites, private industry, and other Federal Agencies.

Select technologies for demonstration in FY 96.

RESOURCE RECOVERY PROJECT

Target Schedule	92	93	94	95	96	97
Resource Description and Characterization		┌───┐				
Issue Identification and Analysis		┌──────────┐				
Technology Evaluations, Screening, and Selection		┌──┐				
Technology Development and Demonstration		┌──┐				
Technology Transfer		┌──┐				
Management and Reporting		┌──┐				
Formation of Technical Support Groups (TSGs)		┌───┐				

RESOURCE RECOVERY PROJECT TECHNICAL TASK PLANS

NUMBER	TITLE	CONTRACTOR	FUNDING (\$ IN THOUSANDS)		
			FY 93	FY 92	FY 91
PE021104	RESOURCE RECOVER PROJECT	PETC MSE, INC. - BUTTE, MT	2000	0	0

RDDT&E FY93 PROGRAM SUMMARIES

BURIED WASTE INTEGRATED DEMONSTRATION

Introduction

The U.S. Department of Energy (DOE) and its predecessor agencies have operated numerous facilities throughout the United States for both nuclear and non-nuclear research, development, and production. As a result of these operations, there are numerous sites throughout the DOE Complex where wastes have been buried in the ground or stored for future disposal. These sites include the Idaho National Engineering Laboratory (INEL), the Hanford Reservation, the Oak Ridge National Laboratory (ORNL), the Savannah River Site (SRS), the Los Alamos National Laboratory (LANL), Sandia National Laboratory (SNL), the Fernald Environmental Management Project (FEMP), and the Nevada Test Site (NTS).

Early disposal practices allowed the commingling of various types of waste. Much of this buried waste includes transuranic (TRU) waste, low-level radioactive waste (LLW), hazardous

waste, mixed TRU waste, and mixed LLW. In addition, many of the original containers have degraded significantly, resulting in contamination of adjacent soil.

The DOE is committed to remediating contaminated sites resulting from past disposal practices. This effort is spearheaded by the DOE Office of Environmental Restoration and Waste Management (EM). Effective implementation of DOE environmental restoration programs necessitates that remediation technologies be screened, developed, and demonstrated for retrieval, ex situ, and in situ treatment of various types of wastes.

In order to identify technology deficiencies, and develop and demonstrate appropriate technologies, the DOE Office of Technology Development (EM-50) has established the Buried

Figure 1. Cryogenic Retrieval: Cryogenic Freeze pipes positioned in cold test pit at Idaho National Engineering Laboratory. Liquid nitrogen is circulated through the pipes to freeze buried waste and thereby minimize dust generation and possible contaminant migration during retrieval efforts. (92-334-2-13)

Waste Integrated Demonstration (BWID) at the Idaho National Engineering Laboratory. The INEL was selected as the host site for the BWID, since a significant volume (approximately 30%) of the DOE Complex's buried transuranic-contaminated (TRU) waste is located there.

The Buried Waste Problem

The INEL TRU-contaminated waste is buried at the Subsurface Disposal Area (SDA) of the Radioactive Waste Management Complex (RWMC). The SDA is a 96-acre tract of land containing over two million cubic feet of buried waste. This waste was disposed at the site between 1952-1970 and includes LLW, TRU waste, Greater-Than-Class-C (GTCC) waste, hazardous waste, and mixed waste. This waste is made up of construction and demolition materials, such as lumber, concrete blocks, steel plates; laboratory equipment, including hoods, desks, tubing, and glassware; process equipment, e.g. heat exchangers, valves ion exchange resins, HEPA filters; maintenance equipment, such as hand tools, cranes, oils and greases; and decontamination materials, consisting of paper, rags, plastic bags, etc.

A variety of containers were used for shipment of waste to the SDA. These containers included 30, 40, and 55-gallon steel drums; cardboard cartons; and wooden boxes up to 105 x 105 x 214 inches in size. Larger individual items were disposed of separately as loose trash. Degradation of these waste containers is believed to have resulted in contamination of the immediately surrounding soil. Estimates of the amount of contaminated soil are on the order of 8-million cubic feet. The wastes and several characteristics of this site are generally representative of other DOE buried-waste sites. Therefore, remediation technology demonstrations performed here under the sponsorship of DOE have significant potential for applications at other DOE buried waste sites.

BWID's Approach

The mission of the BWID is to advance innovative technologies for the retrieval and treatment of DOE Complex-wide buried waste. BWID will accomplish this mission by employing a systems approach to support the development of a suite of advanced and innovative technologies for the effective and efficient remediation of buried waste. The BWID systems approach includes technologies for the entire remediation cycle, cradle to grave. Specifically, BWID supports technology development in the following categories: site and waste characterization, retrieval, preprocessing, ex situ treatment, in situ treatment, packaging, transportation, storage, and disposal. Examples of several technologies being developed by the BWID include those involved in: Aerial Surveillance, Robotic Site Characterization, Cryogenic Retrieval, Remote Sizing, and Thermal Treatment.

BWID supports DOE environmental restoration programs and has been integrated into various remediation schedules, such as the Idaho National Engineering Laboratory (INEL) Federal Facility Agreement and Consent Order, and the Hanford Interagency Agreement.

BWID will accomplish its objectives by involving participants and technology sponsors from throughout the DOE complex, other Federal agencies, private industry, and the universities. This collaborative effort is being implemented to reduce duplication of effort, accelerate technology demonstrations, improve the remediation technology baseline, and leverage DOE funding.

For more information, please contact:

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Selected Past Accomplishments

Conducted pilot demonstration of plasma arc processing of waste at Butte to meet Resource Conservation and Recovery Act (RCRA) compliance criteria.

Conducted pilot scale demonstration of CEPD.

Demonstrated lab scale non-destructive evaluation technology for radiological and hazardous buried waste.

Assembled a field deployable rapid monitoring unit that conducts near real-time analyses of alpha-emitting radionuclides, including plutonium, released when mixed wastes are retrieved from buried sites. This is a portable unit which can be moved from site to site to provide early detection of alpha particles. It enhances worker safety and protection of the environment.

Demonstrated cryogenic retrieval of buried waste to reduce the amount of airborne and dust contamination during retrieval activities and reducing worker exposure. This technology may be best used for "hot spot" retrieval or interim corrective action activities at the Idaho National Engineering Laboratory (INEL) Cold Test Pit.

Demonstrated a Rapid Geophysical Surveyor to map boundaries of buried waste areas.

Completed the pad A treatability study.

Completed Funnel Dump Testing for Contamination Control.

Completed Aerial Surveillance of Subsurface Disposal Area to Demonstrate Non-intrusive Characterization Techniques.

Completed Bench Scale Testing of Ice Electrode.

Completed Pilot Scale Testing on Buried/Stored transuranic (TRU) Treatment Plasma Hearth Furnace.

1993 Accomplishments/Objectives

System demonstrate the Rapid Geophysical Surveyor, as well as a Rapid Monitoring Unit, a Contamination Unit, a Remote Characterization System, and a Remote Excavator System.

Engineering scale experiment on electrostatic enclosure and ventilation system for contamination control during retrieval.

Demonstrate the Remote Excavation System (RES) and overburden removal.

Demonstrate the non-intrusive sensing characterization system.

Demonstrate the multi-axis crane control.

Complete of the contamination migration control: fixation of soil surface large scale demonstration.

Complete of Remote Characterization System (RCS) Demonstration.

Complete of field deployable dust control unit demonstration.

Complete of field deployable rapid monitoring unit demonstration.

Complete of proof-of-concept digface characterization system.

Complete of test melt campaign on electric arc furnace.

Initiate the definition of final waste form and establishment of waste form performance tests.

Complete of Rapid Geophysical Surveyor (Cesium Magnets) field demonstration.

1994 Objectives

Demonstrate characterization and retrieval systems for contaminated buried waste.

Demonstrate and evaluate a suite of technologies for the cradle-to-grave remediation of Transuranic (TRU) contaminated waste pits in support of the compliance agreements in place of Idaho National Engineering Laboratory (INEL).

Focus on field deployment of technology systems.

Determine if "HOT" (contaminated with radionuclides) demonstrations are needed for "COLD" demonstrated technologies.

Integrate characterization, retrieval, and treatment technologies including robotics, cryogenics, and thermal treatment processes developed by or under development by DOE, national laboratory, or private industry.

1995 Planned Objectives

Initiated "HOT" demonstration of characterization, retrieval, and treatment technologies.

Develop and demonstrate the Digface Characterization and Monitoring System in support of retrieval activities, containment activities and surgical removal technologies, and continue demonstration of the thermal technologies.

Continue intrusive and non-intrusive characterization, surgical and non-surgical retrieval, treatment demonstrations.

Focus on field deployment and technology systems.

Continue demonstration of thermal technologies.

Significant return on investment in incorporating Buried Waste Integrated Demonstration (BWID) developed technologies in the Remedial Investigation/Feasibility Study - Record of Decision (RI/FS-ROD) process at Idaho National Engineering

Laboratory (INEL) transuranic (TRU)-Contaminated Waste Pits and Trenches, Hanford Site 100 and Oak Ridge.

Initiate data fusion/virtual reality to support environmental restoration in characterization, remedial action plan, and remediation technology selection.

Initiate arid site containment and stabilization technology demonstrations.

BURIED WASTE INTEGRATED DEMONSTRATION

BURIED WASTE INTEGRATED DEMONSTRATION

BURIED WASTE INTEGRATED DEMONSTRATION

Target Schedule	91	92	93	94	95	96	97
Contamination Control	■						
Dust Control Unit	■	■	■	■			
Rapid Monitoring Unit	■	■	■	■			
Funnel Dump Test Directed Airflow Dust Control	■	■	■				
Soil Fixation	■	■	■	■			
Overburden Removal	■	■	■	■			
Remote Excavation System	■	■	■	■			
Multi-Axis Crane Control	■	■	■	■	■		
End-Effector Evaluation	■	■	■	■	■	■	
Electrostatic Enclosure	■	■	■	■			
Waste Isolation	■	■	■	■			
PRETREATMENT/TREATMENT							
Cryofracture Processing	■	■	■				
Cryogenic Retrieval	■	■	■				

BURIED WASTE INTEGRATED DEMONSTRATION

Target Schedule	91	92	93	94	95	96	97
CHARACTERIZATION							
Robotics Characterization Demo	■						
Non-Destructive Evaluation Lab Scale Demo	■	■					
Aerial Surveillance	■	■					
Integrated Borehole Geophysical System Field Operational	■	■					
Broadband Electromagnetic Geophysical Survey	■	■	■	■			
Rapid Geophysical Survey	■	■	■	■			
Non-Intrusive Sensing	■	■	■	■			
End Effector Evaluation	■	■	■	■			
Remote Characterization	■	■	■	■			
Dig Face Characterization	■	■	■	■	■		

BURIED WASTE INTEGRATED DEMONSTRATION

BURIED WASTE INTEGRATED DEMONSTRATION

BURIED WASTE INTEGRATED DEMONSTRATION TECHINICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY 93	FY 92	FY 91
AL021201	GAS CONTAMINATION TECHNOLOGY STATUS REPORT	ALBUQUERQUE OPERATIONS OFFICE	0	225	0
AL911201	NON-INTRUSIVE SENSING OF ENVIRONMENTALLY IMPORTANT OBJECTS	UNC/GEOTECH INC UNITED STATES GEOLOGICAL SURVEY	1064	100	0
AL121208	SUPER CRITICAL WATER OXIDATION TECHNOLOGY STATUS REPORT	LOS ALAMOS NATIONAL LABORATORY	0	25	0
AL121209	TECHNOLOGY FOR IMPROVED TRANSURANIC WASTE ASSAY TECHNICAL STATUS REPORT	LOS ALAMOS NATIONAL LABORATORY	0	825	0
AL121210	REALTIME MONITORING DURING RETRIEVAL TECHNOLOGY STATUS REPORT	LOS ALAMOS NATIONAL LABORATORY	0	25	0
AL132012	IMPROVED TRANSURANIC WASTE ASSAY - CONTINUOUS THERMAL AND EPI THERMAL NEUTRON	LOS ALAMOS NATIONAL LABORATORY	400	0	0
AL221202	ELECTROSTATIC AEROSOL SAMPLER TECHNICAL STATUS REPORT	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	0	25	0
AL232006	REMOTE CHARACTERIZATION SYSTEM DEMONSTRATION	SANDIA NATIONAL LABORATORIES NORTHERN ILLINOIS UNIVERSITY	50	0	0
AL232007	REMOTE EXCAVATION SYSTEM DEMONSTRATION	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	25	0	0
CH121201	NON DESTRUCTIVE EVALUATION (NDE) AND NON DESTRUCTIVE ASSAY (NDA) PEER REVIEW	AMES LABORATORY	0	160	0
CH201202	ULTRASONIC PROCESS FOR DETOXIFYING GROUNDWATER AND SOIL: FOR CHLORINATED ORGANICS AND OTHER RCRA COMPENENTS	ARGONNE NATIONAL LABORATORY	0	87	200
CH211203	SECOND GENERATION WASTE FORMS	ARGONNE NATIONAL LABORATORY	0	0	70
ID111201	BURIED WASTE INTEGRATED DEMONSTRATION (BWID) PROGRAM COORDINATION:	IDAHO NATIONAL ENGINEERING LABORATORY	0	317	10125
ID121202	SYSTEMS ANALYSIS OF DEPARTMENT OF ENERGY (DOE) BURIED WASTE TECHNOLOGICAL NEEDS AND OPTIONS	IDAHO NATIONAL ENGINEERING LABORATORY	0	287	0
ID121203	CRYOGENIC RETRIEVAL DEMONSTRATION FOR BURIED WASTE	IDAHO NATIONAL ENGINEERING LABORATORY EG & G LAS VEGAS	579	2500	0
ID121205	TREATABILITY STUDY	IDAHO NATIONAL ENGINEERING LABORATORY	0	400	0
ID121210	CONTAMINATION CONTROL TECHNOLOGY STATUS REPORT	IDAHO NATIONAL ENGINEERING LABORATORY INHALATION AND TOXICOLOGY RESEARCH INSTITUTE	895	960	0
ID121211	ICE ELECTRODES	IDAHO NATIONAL ENGINEERING LABORATORY	45	289	0
ID121212	RADIOLOGICAL AND HAZARDOUS MATERIALS MEASUREMENT SYSTEM TECHNOLOGY STATUS REPORT	IDAHO NATIONAL ENGINEERING LABORATORY	400	600	0

BURIED WASTE INTEGRATED DEMONSTRATION TECHINCAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY 93	FY 92	FY 91
ID121213	BURIED WASTE INTEGRATED DEMONSTRATION (BWID) FIELD DEMONSTRATIONS OF CHARACTERIZATION TECHNOLOGIES: DEVELOPED BY OTHER INTEGRATED DEMONSTRATIONS THAT ARE APPLICABLE TO BURIED WASTE	IDAHO NATIONAL ENGINEERING LABORATORY	70	635	0
ID132003	BURIED WASTE INTEGRATED DEMONSTRATION (BWID) DIG-FACE CHARACTERIZATION	IDAHO NATIONAL ENGINEERING LABORATORY GEONICS LTD., COLORADO SCHOOL OF MINES, ECOLOGY INTERNATIONAL UNITED STATES GEOLOGICAL SURVEY GRAND JUNCTION PROJECT OFFICE	1187	0	0
ID132006	BURIED WASTE INTEGRATED DEMONSTRATION (BWID) FINAL WASTE FORM CRITERIA: TREATMENT AND PRE-TREATMENT WASTE FORM INTEGRATION	IDAHO NATIONAL ENGINEERING LABORATORY EG&G ROCKY FLATS ARGONNE NATIONAL LABORATORY	540	0	0
ID132007	BURIED WASTE INTEGRATED DEMONSTRATION (BWID) RETRIEVAL RELATED TECHNOLOGIES	IDAHO NATIONAL ENGINEERING LABORATORY EG&G LAS VEGAS	839	0	0
ID132008	BURIED WASTE INTEGRATED DEMONSTRATION (BWID) REGULATORY COORDINATION	IDAHO NATIONAL ENGINEERING LABORATORY	1220	0	0
ID132010	BURIED WASTE INTEGRATED DEMONSTRATION (BWID) THERMAL KINETIC PROCESSES	IDAHO NATIONAL ENGINEERING LABORATORY	450	0	0
ID132011	BURIED WASTE INTEGRATED DEMONSTRATION (BWID) ARC MELTER VITRIFICATION	IDAHO NATIONAL ENGINEERING LABORATORY UNITED STATES BUREAU OF MINES AMERICAN SOCIETY OF MECHANICAL ENGINEERS	650	0	0
ID132015	TECHNICAL ACADEMIC REVIEW GROUP FOR BURIED WASTE INTEGRATED DEMONSTRATION	IDAHO NATIONAL ENGINEERING LABORATORY	300	0	0
ID132016	TECHNICAL TESTING PROTOCOL FOR BURIED WASTE INTEGRATED DEMONSTRATION (BWID) AND ENVIRONMENTAL PROTECTION AGENCY (EPA)	IDAHO NATIONAL ENGINEERING LABORATORY	500	0	0
ID132017	MODIFICATION TO DEPARTMENT OF ENERGY (DOE) UNITED STATES GEOLOGICAL SURVEY (USGS) INTERAGENCY AGREEMENT (IAG) - TIME DOMAIN ELECTROMAGNETIC OPT	IDAHO NATIONAL ENGINEERING LABORATORY UNITED STATES GEOLOGICAL SURVEY	60	0	0
ID132018	ELECTROMAGNETIC IMAGING/APPLIED TO MAPPING AND CHARACTERAZATION OF BURIED WASTE	IDAHO NATIONAL ENGINEERING LABORATORY	95	0	0

BURIED WASTE INTEGRATED DEMONSTRATION TECHINICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY 93	FY 92	FY 91
ID132019	BURIED WASTE INTEGRATED DEMONSTRATION (BWID) GEOPHYSICS WORKSHOP	IDAHO NATIONAL ENGINEERING LABORATORY UNITED STATES GEOLOGICAL SURVEY UNIVERSITY OF ARIZONA GRAND JUNCTION PROJECT OFFICE COLORADO SCHOOL OF MINES SCIENTIFIC MEASUREMENT SYSTEMS	20	0	0
ID132020	HIGH SPEED DIGITAL RADIATION AND COMPUTED TOMOGRAPHY OF WASTE DRUMS	IDAHO NATIONAL ENGINEERING LABORATORY	175	0	0
ID132021	HAZARDOUS CHEMICAL WASTE SEPARATION AT RADIOACTIVE WASTE MANAGEMENT COMPLEX (RWMC) EXCAVATION SITES	IDAHO NATIONAL ENGINEERING LABORATORY	200	0	0
ID132022	THREE DIMENSIONAL (3-D) DYNAMIC GRAPHIC SIMULATION/RETRIEVAL CONFIGURATION OPTIONS	IDAHO NATIONAL ENGINEERING LABORATORY	80	0	0
ID032002	DEPARTMENT OF ENERGY (DOE)-INTEGRATED DEMONSTRATION (ID)/UNITED STATES GEOLOGICAL SURVEY (USGS) INTERAGENCY (IAG)/SUPPORT OF TENSOR MAGNETIC GRADIOMETER DEVELOPMENT	IDAHO OPERATIONS OFFICE COLORADO SCHOOL OF MINES JAMES CONSULTING, LAKEWOOD, COLORADO	175	0	0
ID332001	BURIED WASTE INTEGRATED DEMONSTRATION (BWID) REMOTE CHARACTERIZATION SYSTEM (RCS)	WESTINGHOUSE IDAHO	289	0	0
ID332002	BURIED WASTE INTEGRATED DEMONSTRATION (BWID) MULTI-AXIS CRANE CONTROL SYSTEM	WESTINGHOUSE IDAHO	330	0	0
ID332004	BURIED WASTE INTEGRATED DEMONSTRATION (BWID) REMOTE EXCAVATING SYSTEM (RES) DEMONSTRATION	WESTINGHOUSE IDAHO	330	0	0
OR101202	BASE - CATALYZED DESTRUCTION OF POLYCHLORINATED BIPHENYLS (PCBS) IN MIXED WASTES	OAK RIDGE NATIONAL LABORATORY	0	375	0
OR121201	RAPID AND COST-EFFECTIVE LUMINESCENCE SPOT TEST (LST) FOR SCREENING POLYCHLORINATED BIPHENYLS (PCBS)	OAK RIDGE NATIONAL LABORATORY	0	280	0
OR132013	REMOTE CHARACTERIZATION SYSTEM DEMONSTRATION	OAK RIDGE NATIONAL LABORATORY SPAR AEROSPACE	110	0	0
OR132014	REMOTE EXCAVATION SYSTEM DEMONSTRATION	OAK RIDGE NATIONAL LABORATORY	245	0	0
OR021201	LINAC-BASED CHARACTERIZATION OF REMOTED (RH) TRANSURANIC (TRU) WASTE	OAK RIDGE OPERATIONS OFFICE	0	25	0
PE021201	BUTTE CENTRIFUGAL PLASMA FURNACE	PITTSBURGH ENERGY TECHNOLOGY CENTER	0	261	0
PE021203	BURIED WASTE INTEGRATED DEMONSTRATION (BWID) PLASMA ARC TESTING	PACIFIC NORTHWEST LABORATORY	0	1020	0
RL321207	REGULATORY AND PUBLIC ACCEPTANCE METHODOLOGY	PACIFIC NORTHWEST LABORATORY	0	120	0
RL321210	ADVANCED MIXED WASTE ASSAY SYSTEM	PACIFIC NORTHWEST LABORATORY	0	20	0

BURIED WASTE INTEGRATED DEMONSTRATION TECHINICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY 93	FY 92	FY 91
RL321211	GRAPHITE DIRECT CURRENT ARC PLASMA AND GLASS MELTER TECHNOLOGY STATUS REPORT	PACIFIC NORTHWEST LABORATORY MASSACHUSETTS INSTITUTE OF TECHNOLOGY (MIT) ELECTRO-PYROLYSIS, INC.	900	656	0
RL321212	VITRIFICATION OF TRANSURANIC (TRU) MIXED WASTE	PACIFIC NORTHWEST LABORATORY	0	33	0
RL332016	REMOTE CHARACTERIZATION SYSTEM DEMONSTRATION	PACIFIC NORTHWEST LABORATORY	190	0	0
RL332017	REMOTE EXCAVATION SYSTEM DEMONSTRATION	PACIFIC NORTHWEST LABORATORY	25	0	0
RL332019	BURIED WASTE INTEGRATED DEMONSTRATION (BWID)/EM-40 INTERFACE/TECHNOLOGY TRANSFER	PACIFIC NORTHWEST LABORATORY	100	0	0
RL332020	ELECTROMAGNETIC RAPID GEOPHYSICAL SURVEYOR	PACIFIC NORTHWEST LABORATORY	100	0	0
RL332021	MICROWAVE PLASMA ANALYZER FOR REAL-TIME OFF-GAS ANALYSIS	PACIFIC NORTHWEST LABORATORY	850	0	0
RL401204	TREATMENT TECHNOLOGY FOR TRANSURANIC (TRU) WASTE	WESTINGHOUSE HANFORD COMPANY	0	25	200
RL421212	MONOLITH CONFINE RADIOACTIVE WASTE MANAGEMENT CONTAMINATION: MONOLITHIC CONFINEMENT OF RADIOACTIVE WASTE MANAGEMENT CONTAMINATED GEOLOGIC MEDIA	WESTINGHOUSE HANFORD COMPANY	0	445	0
RL421213	COMPLEX BURIED WASTE ASSESSMENT	WESTINGHOUSE HANFORD COMPANY	0	400	0
RL432002	BURIED WASTE INTEGRATED DEMONSTRATION (BWID) FIXATION OF SOIL SURFACES	WESTINGHOUSE HANFORD COMPANY	150	0	0
RL9205	TRANSURANIC (TRU) WASTE CHARACTERIZATION	WESTINGHOUSE HANFORD COMPANY	0	0	500
SF121201	MODELING LINKED FLUID FLOW AND ROCK MECHANICS IN SUBSURFACE	LAWRENCE BERKELEY LABORATORY	0	5	0
SF150101	CONTINUOUS MEASUREMENTS OF TRICHLOROETHYLENE (TCE), PERCHLOROETHYLENE (PCE), CARBONTETRACHLORIDE (CCL ₄), AND OTHER CONTAMINANTS USING FIBER OPTICS	LAWRENCE LIVERMORE NATIONAL LABORATORY	0	0	50
SF211208	MOLTEN SALT PROCESSING	LAWRENCE LIVERMORE NATIONAL LABORATORY	0	0	700
SF221206	NON DESTRUCTIVE EVALUATION (NDA) AND NON DESTRUCTIVE ASSAY (NDA) CHARACTERIZATION OF MIXED TRANSURANIC (TRU) LOW-LEVEL WASTE (LLW) WASTE TECHNOLOGY STATUS REPORT (TSR)	LAWRENCE LIVERMORE NATIONAL LABORATORY	0	25	0
SF221209	NON DESTRUCTIVE ASSAY (NDA) AND NON DESTRUCTIVE EVALUATION (NDE) CHARACTERIZATION OF TRANSURANIC (TRU) LOW-LEVEL WASTE (LLW) WASTE DRUMS	LAWRENCE LIVERMORE NATIONAL LABORATORY	400	500	0
SF232001	REMOTE CHARACTERIZATION SYSTEM DEMONSTRATION	LAWRENCE LIVERMORE NATIONAL LABORATORY	95	0	0
SF232002	REMOTE EXCAVATION SYSTEM DEMONSTRATION	LAWRENCE LIVERMORE NATIONAL LABORATORY	40	0	0

UNDERGROUND STORAGE TANK INTEGRATED DEMONSTRATION

Abstract

In developing technology to clean up underground nuclear waste storage tanks, the U.S. Department of Energy identified a number of unique technology needs. The underground storage tanks contain waste generated by nuclear defense production that began in the 1940s. Some tanks were built as long as fifty years ago, and were constructed without future access to the tanks in mind. Today, access to the tanks is essential to DOE's environmental restoration mission.

The Underground Storage Tank Integrated Demonstration (UST-ID) Program was created in February 1991 to conduct additional development, testing, and evaluation on current and emerging technologies. The UST-ID Program effort is being led by the Department of Energy, Richland Field Office and the Westinghouse Hanford Company. The UST-ID Program is focusing on the needs of several participating sites simultaneously. Thus, ensuring that technologies under development are applicable to more than one site, thereby minimizing the cost of development.

These pages describe the use of the integrated demonstration approach to clean up the underground storage tanks.

What is an Integrated Demonstration?

An integrated demonstration is a management concept developed to facilitate timely and effective application of new and enhanced technologies to meet the Department of Energy's environmental restoration needs. An integrated approach best utilizes government funding and talent by minimizing duplication of effort and assuring rapid evaluation of new technologies. Multiple technologies are assembled and evaluated as tools for a cradle-to-grave solution to a specific problem representing a generic environmental issue.

Entire systems of technologies are evaluated with respect to performance, safety and cost effectiveness. Through collaborative partnerships with DOE laboratories, universities, federal agencies, and private industries, the developers of each technology are brought together with experts in the many facets of the demonstration. Chemists, geohydrologists, geophysicists, biologists, drilling engineers, environmental engineers, environmental modelers, materials scientists, and others involved in the project each approach the project from a unique perspective. Major savings in time and federal tax

dollars can be realized by demonstrating multiple technologies at one test bed. Site characterization, modeling, and monitoring information can be shared, validated, and compared, thereby increasing its technical and interpretive value and improving evaluation of the technologies being demonstrated.

Technologies and systems to be demonstrated are selected by a team of experts based on a number of criteria such as readiness for demonstration, likelihood of success, cost effectiveness, benefits of the new technology as compared to conventional technology, etc. All technologies and systems demonstrated are compared to one another and to conventional technology to assure effective evaluation. Successfully demonstrated systems are then transferred for full-scale implementation at government and industrial sites. Cooperative efforts between government, universities, and industry are an integral part of the program.

Introduction

The DOE's Office of Technology Development has created several integrated demonstrations to efficiently bring the best technologies to bear on the environmental restoration needs of the DOE waste complex. The major emphasis of the integrated demonstration is the single-shell storage tanks located at the Hanford Site. The Hanford Site is located in the southeastern section of Washington State near the cities of Richland, Kennewick and Pasco. It has operated since 1943 with a primary mission of producing plutonium isotopes. Plutonium was produced by irradiation of enriched uranium in eight nuclear reactors located along the Columbia River. The plutonium was separated from the remaining uranium and fission products by chemical processes. There are five technology focus areas within the UST-ID tasked with assisting in the clean up of the DOE's underground storage tanks.

The development of technologies in the UST-ID is currently being targeted toward potential use in remediation action at DOE sites: Hanford (host site), Fernald, Idaho, Oak Ridge and Savannah River. The five focus areas are:

- Characterization
- Low-level waste treatment and disposal
- Retrieval, transfer and storage
- Waste separation/pre-treatment
- Site Closure

The Underground Storage Tank Integrated Demonstration

... involves new technologies for the remediation of large volumes of stored waste.

- Demonstration of new technologies to remediate stored waste in tanks.
- Demonstration of new technologies for characterization, monitoring, and modeling for environmental restoration activities.
- The development of standards for future DOE integrated demonstrations.

Project Background

The five participating sites began operations between 1943 and the early 1950s. They originally supported nuclear fuels production, operation, and research programs as part of the development of nuclear weapons started during and subsequent to World War II. Most of the site missions have evolved from production to peaceful uses of nuclear power, research and development and environmental clean up.

There are more than 332 underground storage tanks across the DOE complex. At Hanford, the waste generated by the different chemical separation processes has been stored in 177 underground storage tanks at Hanford for future retrieval and treatment for final disposal. There are eight UST design types, ranging in age from six to forty-nine years. Of the 177 USTs, 149 are of a single, carbon-steel shell with a reinforced concrete shell. The remaining twenty-eight tanks have dual, carbon-steel liners, and range in capacity from 50,000 to 1 million gallons. The waste has four general physical forms: sludge, liquid, salt cake, and slurry. All of the waste is alkaline with a large percentage of sodium nitrate, nitrite salts and metal oxides.

Characterization of tank wastes has traditionally been limited by high analytical costs and the inability to obtain data from many points in the tanks. Tasks have been selected to develop sensors that will decrease laboratory analytical time, and to develop a means for deploying these sensors inside the tank. Laser raman spectroscopic sensors being developed will first be used in the analytical laboratory and, when proven, will be configured for in-tank use.

Waste retrieval techniques will be tested using a light-duty utility arm. Designed for in-place deployment, this articulated, remotely-operated arm will deploy characterization devices and test some features of waste retrieval technology on actual tank waste. It is expected that this arm will be able to deliver characterization tools, such as optical sensors and physical measurement devices, to obtain data of much higher statistical certainty than is presently possible.

Waste separation work represents heavy investment in technologies with a high probability for success. Smaller efforts are expended for development of advanced techniques that have high potential payoff. A long-term strategy has been developed to feed demonstrated separation techniques to the user according to the user schedule.

Technology Description

Because of the number of focus areas requiring attention in the remediation of underground storage tanks, the number of different technologies being considered at this time is great. Here are some examples of the more promising technologies that are being evaluated as part of the integrated demonstration.

Characterization - Technologies that will provide information about the type and the extent of pollutants inside and surrounding the tank.

Laser raman spectroscopy has been chosen to identify radioactive tank wastes in DOE storage tanks, prior to cleaning up the storage tanks themselves.

Laser raman spectroscopy analyzes storage tank wastes without physical retrieval of tank waste sample.

Analysis of tank waste without waste retrieval is accomplished after probes, attached to fiber optic wires, are sent into a storage tank to shoot laser beams into tank wastes. A reflection of the laser beams is transmitted by the fiber optic cables from the inside of the storage tank, back to a computer on the surface. The computer, after receiving the laser beams' reflection of the tank's wastes, creates raman spectra of the tank wastes from the laser beams' reflection. These raman spectra help characterize the tank waste by creating unique spectral patterns, characteristic of particular radioactive wastes from the laser beams' reflection of the tank wastes.

Low-level Waste Treatment - Technologies that will produce a waste form that provides long-term stability of low-level waste.

Polyethylene encapsulation is a technology, within the low-level waste form development area, aimed at stabilizing radioactive and hazardous tank waste. This method, developed at Brookhaven National Laboratory, is being evaluated for stabilization of low-level tank wastes.

Polyethylene is an inert thermoplastic material. The encapsulation process heats the polyethylene above its melting point, mixes it with waste, and allows it to cool. The result is a monolithic solid waste form.

This process is designed to improve the encapsulation of radioactive, hazardous, and mixed wastes. It is being developed as an alternative to the baseline grout method currently used by DOE sites. It is a versatile method capable of processing several different types of waste. It also can encapsulate more, offering potential significant reductions in final waste form volume. In fact, polyethylene encapsulated waste has seventy percent less final waste form volume than grouted waste. The reduction in volume will create a dramatic cost advantage.

Results of testing have shown that the encapsulated material was able to withstand harsh chemicals, high radiation doses, freeze-thaw cycling and saturated soil conditions. The process has also been successfully applied to various types of waste, such as nitrate salts, sludges and incinerator ash.

Retrieval, Transfer and Storage - Technologies that will remove and transport the contents in the tank.

Before tank wastes can be removed, their physical and chemical properties must be assessed. Placing sophisticated sensors inside the large tanks requires a manipulator with long reach (9 feet or more), a capacity to lift at least 50 pounds, and the ability to fit through the small 12-inch diameter access port.

Existing manipulators do not fully meet these requirements, nor do they conform to the stringent safety requirements at each site. The new light-duty utility arm will place instruments that allow evaluation of waste properties without removing the waste from the tanks. This provides data much more rapidly, over a wide area of the tank, without exposing workers to a radioactive sample.

The arm will deliver characterization tools such as optical sensors and physical measurement devices into the tanks. The arm also will place hardware inside the tanks as well as test-retrieval techniques.

The main purpose of the light-duty utility arm is to provide safe, controlled access to underground storage tanks containing highly radioactive waste.

Waste Separation - Technologies that will separate the waste in the tank into low-level, transuranic and high-level waste.

The tank waste remediation strategy includes a permanent disposal option involving the concentration of the radioactivity into forms acceptable for feed to final high-level waste form. For example, the Hanford Site's current strategy involves concentrating the radioactivity into feed stock for a vitrification

plant and incorporating the residuals in a feed stock for a plant to make a low-level waste form presently designated as grout.

Waste separations development areas include the following: 1) removing radioactivity from the supernate, 2) destruction of organics to prevent the buildup of hydrogen, 3) ferrocyanide removal/destruction, and 4) strontium removal from the sludge.

Site Closure - Technologies that will contain waste before and during retrieval operations, as well as technologies such as barrier cover systems that provide long-term closure protection.

The goal of barrier technology development is to control the migration of contaminants by isolating the waste from the environment.

A subsurface confinement barrier is needed for current remediation activities, such as waste retrieval. One of the dangers of removing waste from the tanks is the possible rupturing of tank walls by retrieval equipment and processing. Existing leaks may also be aggravated by these activities. The objective of the subsurface barrier is to contain the tanks prior to and during retrieval actions. A subsurface barrier will create a subsurface confinement boundary that contains the contaminated tank area. Among those materials being considered for construction of the subsurface barrier are cement, grout, and metal sheet piling. It is very likely that the subsurface barrier will be some combination of these materials. Other processes that could provide additional protection are being explored and considered for future development.

Materials and equipment are now being developed for the subsurface barrier, with the hopes that field testing can begin in 1995.

A permanent isolation surface barrier also isolates the waste. Natural material such as fine soil, sand, asphalt, gravel and clay is placed in layers over a tank area to produce an above-ground protective cap. This engineered barrier will reduce waste contact with the environment. The goal of the permanent isolation barrier is to protect the tank area from erosion, water drainage, and plant, animal, or human intrusion for a minimum of a thousand years.

Summary

Across the DOE complex, over 322 underground storage tanks have been used to capture, process, and store radioactive and chemical mixed waste generated from weapons materials production. To date, little of this waste has been treated and disposed of, and a large inventory exists - more than 100 million gallons of high-level and low-level radioactive liquid waste. The tanks vary in age, size, design and contain highly radioactive sludges, salt cake and supernate. The major chemical constituents are as follows: 1) nitrate and nitrite salts, 2) hydrated metal oxides, 3) phosphate precipitates, 4) transuranics and 5) isotopes of strontium, iodine and cesium. The initial UST-ID focus is on those technologies that can provide near-term benefits toward remediation of USTs. The

current technical work is directed toward three fundamental problem areas that are shared by most of the participants sites: 1) waste characterization, 2) waste retrieval, and 3) waste separations.

For the UST-ID to be successful, there must be a widespread transfer and use of the demonstrated technologies by the DOE complexes and sites in the private sector. This will require that the technologies be better, cheaper, faster and safer than current baseline technologies. These technologies and associated databases must also be defensible to the public regulators, and the technical community.

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Selected Past Accomplishments

Completed laboratory-scale ferrocyanide study.

Initiated fluidized bed zeolite system that will pneumatically inject zeolite sequestering agents into area of contaminated soil and groundwater to encapsulate and stabilize the contaminants.

Selected and assembled end effectors for robotic retrieval systems.

Demonstrated end effector system in dislodging surrogate waste.

Identified and evaluated interim stabilization alternatives for waste retrieval in Hanford Tank 241-C-106.

Established co-management and co-funding between EM-50 and EM-30 toward development of technologies in support of underground storage tank remediation.

Transfer of Long Reach Arm technology to EM-30 in support of tank waste retrieval at Hanford.

Successfully demonstrated and transferred to EM-40 the pile driven cone penetrometer, which was used in identifying a waste stream previously unknown to the site.

Acceptance by EM-30 of development of Compact Processing Unit (CPU) for cesium/strontium removal leading to in-field hot demonstration at Hanford.

Developed patentable process (the NAC Process: Nitrate to Ammonia and Ceramic) to destroy nitrates and immobilize residuals in one step which will lead to reduced waste volume and an alternative low-level waste form to grout.

Demonstrated and transferred ultrasonic sensors for 101-SY in-tank deployment on a mixer pump by EM-30.

Demonstrated retrieval dislodging and conveyance technology.

1993 Accomplishments/Objectives

Demonstrated Raman spectrometer and infrared spectroscopy system on actual waste in a hot cell leading to the development of a multi-sensor system for placement in tanks.

Initiated procurement of Light Duty Utility Arm (LDUA) System to support characterization retrieval technology development and began limited subsystem qualification for hot operations by deploying and operating end effectors to perform surveillance, inspection and waste characterization tasks. Customers at Idaho and Hanford have ordered these devices before final demonstration based upon Underground Storage Tank Integrated Demonstration (UST-ID) plans and evaluations.

Conducted extensive tests of the waste dislodging and conveyance end effectors for the First Generation Long Reach Arm.

Design and develop a Compact Processing Unit (CPU) for cesium removal by ion exchange to be field deployed at Hanford.

Gathered data on the transuranic extraction (TRUEX) process on Oak Ridge National Laboratory (ORNL) waste stream which will lead to validation of Generic TRUEX Model developed by Argonne National Laboratory (ANL) to predict process results.

Initiated hot cell testing of liter quantity volumes of sludge and supernate for processing leading to demonstration at Oak Ridge National Laboratory (ORNL) using Oak Ridge Melton Valley Storage Tank wastes in support of Hanford tank waste processing/pre-treatment needs.

Demonstrated calcination/dissolution process for destruction of organics, FeCNs, nitrate/nitrite in tank wastes using simulant wastes.

Completed leachability tests for Nitrate to Ammonia and Ceramic (NAC) process low-level waste form.

Completed leachability tests for both polyethylene and low level waste forms.

1994 Objectives

Demonstrate an integrated long reach arm system (controls, end effectors, arm) in cooperation with the Robotics Program.

Demonstrate a pilot-scale patentable process, with an industrial partner, for destruction of sodium nitrate wastes (Nitrate to Ammonia and Ceramic - NAC) resulting in significant waste volume reduction and an alternative waste form to grout.

Validate generic Transuranic Extraction (TRUEX) Model through actual waste separation and chemical analyses.

Demonstrate sludge partitioning and treatment of actual waste representative of Hanford tank wastes.

Complete one year assignment to evaluate French technologies for treatment of high level waste (HLW).

Initiate development of organic-nitrate destruction compact processing unit for field deployment.

Engineering-scale test of resorcinol/formaldehyde resin in Skid-mounted ion exchange demonstration (SKID) test unit at Savannah River.

Transfer resorcinol-formaldehyde resin to the Radiochemical Engineering Development Center (REDC) at Oak Ridge for waste cleanup.

Laboratory-scale tests of mobile evaporation/concentration processing.

Test subsurface barrier system critical features.

Deploy in a tank the Laser Range Finder Rapid Tank Surface Mapping System with EM-30.

Demonstrate (cold) the near infrared (IR) hot cell system with co-funding from EM-30 user.

Demonstrate (cold) Raman probe end effector for Light Duty Utility Arm (LDUA) with participation from EIC, Inc., Naval Research Laboratory (NRL), University of South Carolina, and Florida State University.

Design specification for Raman probe for cone penetrometer, with EIC, Inc., Naval Research Laboratory (NRL), University of South Carolina, and Florida State University.

Demonstration hot cell laser ablation with EM-30 user co-funding.

Demonstrate Light Duty Utility Arm (LDUA) end effector and data acquisition; supervising control system; and decontamination system.

1995 Planned Objectives

Complete hot cell characterization.

Complete characterization field support system trailer and deliver for testing with Light Duty Utility Arm (LDUA).

Cold system test and demonstrate the Light Duty Utility Arm (LDUA).

Complete conveyance mechanical design and fabrication.

Cold demonstrate cesium (Cs) Compact Processing Unit (CPU).

Evaluate use of Compact Processing Unit (CPU) for cesium (Cs) removal at Savannah River.

Define Compact Processing Unit (CPU) for organic, nitrate, and sludge waste streams.

Demonstrate hot cell sludge partitioning and treatment.

Demonstrate (cold) an engineering scale subsurface barrier.

UNDERGROUND STORAGE TANK INTEGRATED DEMONSTRATION

AIM

Association for Information and Image Management

1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910
301/587-8202

Centimeter

Inches

MANUFACTURED TO AIM STANDARDS
BY APPLIED IMAGE, INC.

2 of 3

UNDERGROUND STORAGE TANKS INTEGRATED DEMONSTRATION TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY 93	FY 92	FY91
AL221205	UNDERGROUND STORAGE TANKS (UST) WASTE DISLODGING AND CONVEYANCE TECHNOLOGY DEVELOPMENT	SANDIA NATIONAL LABORATORIES - ALBURQUERQUE QUEST CHAMPION HYD. UNIVERISTY OF MISSOURI - ROLLA	600	250	0
AL232001	LONG REACH ARM (LRA)-COMPUTER INTERFACE	SANDIA NATIONAL LABORATORIES - NEW MEXICO	330	0	0
AL232002	COMPUTER INTERFACE - END EFFECTOR	SANDIA NATIONAL LABORATORIES - NEW MEXICO	400	0	0
AL232003	CONFINED SLUICING	SANDIA NATIONAL LABORATORIES - NEW MEXICO	190	0	0
AL232008	EARLY DEPLOYMENT SYSTEM	SANDIA NATIONAL LABORATORIES - NEW MEXICO	350	0	0
AL232009	CHARACTERIZATION SYSTEM INTEGRATION	SANDIA NATIONAL LABORATORIES - NEW MEXICO	75	0	0
CH232001	TRANSURANIC EXTRACTION (TRUEX) MODEL VALIDATION	ARGONNE NATIONAL LABORATORY	300	0	0
CH321201	POLYETHYLENE ENCAPSULATION OF LOW- LEVEL SINGLE SHELL TANK WASTE (LLSSTW)	BROOKHAVEN NATIONAL LABORATORY	225	350	0
HQ032005	ORGANICS DESTRUCTION	HEADQUARTERS	129	0	0
ID121204	BIOLOGICAL DESTRUCTION OF PLUTONIUM NITRATE WASTE	IDAHO NATIONAL ENGINEERING LABORATORY	300	200	0
ID432001	EARLY DEPLOYMENT SYSTEM	WESTINGHOUSE IDAHO NUCLEAR CO	150	0	0
ID432002	LONG REACH ARM (LRA) - MAINTENANCE AND DECONTAMINATION	WESTINGHOUSE IDAHO NUCLEAR CO	150	0	0
ID432003	LONG REACH ARM (LRA) - TECHNICAL INTERFACE	WESTINGHOUSE IDAHO NUCLEAR CO	200	0	0
OR111203	RADIOACTIVE SODIUM NITRATE WASTE TREATMENT	OAK RIDGE NATIONAL LABORATORY	600	500	0
OR132001	LONG REACH ARM (LRA) - CONTROL SYSTEM	OAK RIDGE NATIONAL LABORATORY	275	0	0
OR132008	COMPREHENSIVE SLUDGE/SUPERNATE DEMONSTRATION, TESTING AND EVALUATION (DT&E)	OAK RIDGE NATIONAL LABORATORY	2350	0	0
OR132018	EARLY DEPLOYMENT SYSTEM	OAK RIDGE NATIONAL LABORATORY	175	0	0
RL321205	SIMULANTS FOR RETRIEVAL TASKS	PACIFIC NORTHWEST LABORATORY	100	300	0
RL321221	COMPACT PROCESSING UNIT DEMONSTRATION	PACIFIC NORTHWEST LABORATORY SEATTLE UNIVERSITY	1000	300	0

UNDERGROUND STORAGE TANKS INTEGRATED DEMONSTRATION TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY 93	FY 92	FY91
RL322001	LASER RANGE FINDER	PACIFIC NORTHWEST LABORATORY	400	0	0
RL332001	EARLY DEPLOYMENT REMOTE CHARACTERIZATION	PACIFIC NORTHWEST LABORATORY	325	0	0
RL332002	LIGHT DUTY UTILITY ARM SAMPLING END-EFFECTOR	PACIFIC NORTHWEST LABORATORY	300	0	0
RL332003	MULTI-FUNCTION SCARIFIER/CONVEYER	PACIFIC NORTHWEST LABORATORY	800	0	0
		QUEST			
		WASHINGTON STATE UNIVERSITY			
RL332004	LONG REACH ARM-KINEMATICS	PACIFIC NORTHWEST LABORATORY	375	0	0
RL332006	HYDRAULICS TECHNOLOGY	PACIFIC NORTHWEST LABORATORY	100	0	0
RL332011	TANK WASTE PROCESSING ANALYSIS	PACIFIC NORTHWEST LABORATORY	550	0	0
		AITKEN			
RL401203	UNDERGROUND STORAGE TANKS INTERIM STABILIZATION TREATMENT TECHNOLOGY; DEVELOPMENT OF ALTERNATIVES TO PARTIAL RETRIEVAL FOR IN SITU INTERIM STABILIZATION OF UNDERGROUND STORAGE TANKS (USTS)	WESTINGHOUSE HANFORD COMPANY	2400	621	200
RL401206	WASTE ANALYSIS WITH LASER RAMAN SPECTROSCOPY	WESTINGHOUSE HANFORD COMPANY	600	450	300
RL421201	WASTE DISLODGING AND CONVEYANCE TECHNOLOGY	WESTINGHOUSE HANFORD COMPANY	1035	650	0
		FLORIDA STATE UNIVERSITY			
RL421206	SURFACE CHARACTERIZATION/MAPPING OF TANK WASTES	WESTINGHOUSE HANFORD COMPANY	0	129	0
RL421207	UNDERGROUND STORAGE TANK INTEGRATED DEMONSTRATION (UST-ID) MANAGEMENT AND DEMONSTRATION OPERATIONS	WESTINGHOUSE HANFORD COMPANY	1120	2430	0
		EBASCO			
RL421211	INSTRUMENTS FOR IN SITU CHARACTERIZATION OF TANK WASTES; AN INTEGRATED INSTRUMENT PLATFORM FOR SAFE ENTRY INTO THE HANFORD SINGLE SHELL TANKS (SSTS)	WESTINGHOUSE HANFORD COMPANY	425	500	0
RL421216	CALCINATION/DISSOLUTION PROCESSED DEVELOPMENT	WESTINGHOUSE HANFORD COMPANY	300	130	0
		WESTINGHOUSE			
		S&T			

UNDERGROUND STORAGE TANKS INTEGRATED DEMONSTRATION TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY 93	FY 92	FY91
RL432001	LONG REACH ARM - SYSTEMS COORDINATION AND DEFINITION	WESTINGHOUSE HANFORD COMPANY	770	0	0
RL5177RD	UNDERGROUND STORAGE TANK TECHNOLOGY DEVELOPMENT	WESTINGHOUSE HANFORD COMPANY	0	0	1500
RL9711	PLANNING FOR UNDERGROUND STORAGE TANKS INTEGRATED DEMONSTRATION	WESTINGHOUSE HANFORD COMPANY	0	0	500
SF211203	ADVANCED FIBER-OPTIC SPECTROSCOPY FOR INORGANIC CONTAMINANTS	LAWRENCE LIVERMORE NATIONAL LABORATORY	230	350	100
SP221205	UNDERGROUND STORAGE TANK (UST) WASTE DISLODGING AND CONVEYANCE TECHNOLOGY DEVELOPMENT	LAWRENCE LIVERMORE NATIONAL LABORATORY	300	250	0
SR132001	BASELINE TECHNOLOGIES FOR UNDERGROUND STORAGE TANK (UST) REMEDIATION	WESTINGHOUSE ELECTRIC CORP	100	0	0
		QUEST			
		INTEGRATED, INC.			
SR132002	CESIUM (CS) EXTRACTION TESTING	WESTINGHOUSE ELECTRIC CORP	250	0	0
SR132003	ACOUSTICAL OPTICAL TUNEABLE FILTER SPECTROSCOPY	WESTINGHOUSE ELECTRIC CORP	330	0	0
SR132006	EARLY DEPLOYMENT SYSTEM	WESTINGHOUSE ELECTRIC CORP	100	0	0

DEACTIVATION, DECOMMISSIONING AND RECYCLE

Problem

The aging of DOE Complex facilities, along with the changing DOE Complex missions, are resulting in a need to deactivate and decommission a large number of surplus facilities.

These facilities currently contain radionuclide, hazardous, mixed and special contaminants. For the radionuclide contaminants, these facilities are similar to the commercial nuclear plants being deactivated and decommissioned (Fort St Vrain, Shoreham, Yankee Rowe). For the hazardous (lead, mercury) and special contaminants (asbestos, transite), these facilities are similar to the shipyards and bases being deactivated and decommissioned by the Department of Defense.

Limited deactivation and decommissioning activities are underway at Fernald, Hanford, Idaho, Mound, Oak Ridge, Princeton, Rocky Flats, Savannah River and Weldon Spring.

Although the exact quantities of all building and scrap material at the DOE Complex sites have not been identified, some site estimates result in about 600,000 tons of scrap steel, stainless steel, nickel, aluminum and copper being available for reuse and recycle.

Major Drivers

The major drivers for the project are:

- Little reuse and recycle of valuable building and scrap material.
- Declining worker safety.
- High deactivation costs.
- High surveillance and maintenance costs.
- High decommissioning costs.
- High burial costs.

Mission

This project has the mission to:

Develop processes to reduce the costs of facility deactivation and decommissioning by the reuse and recycle of building and scrap material, and develop processes for the bulk/volumetric decontamination of metal and concrete; the surface decontamination of concrete and equipment; the deactivation

of facilities; and the dismantlement of facilities that exceed the performance of today's baseline methods in terms of worker exposure, cost, schedule and effectiveness.

Objectives

This project has two objectives:

To develop and compare processes for material reuse and recycle, and for facility deactivation, characterization, decontamination and dismantlement.

To develop a comprehensive system of characterization, decontamination, dismantlement, recycle and disposition processes that are available for the deactivation and decommissioning of facilities.

Obstacles

There are five major obstacles to the success of this project:

Lack of release standards for bulk/volumetric contaminated material.

Reluctance to use release standards for surface contaminated material.

Public understanding of the risks associated with the reuse and recycle of contaminated material (hazardous, radiological, mixed, special).

Public understanding of the risks associated with facility, deactivation, surveillance and maintenance, and decommissioning.

Lack of confidence in the DOE's ability to adequately assess risk, protect worker health and safety, and protect public health and safety.

Technology Assumption

For FY 1993, it is assumed that the following processes have no known technology barriers, worker safety, or public health limitations:

Surface decontamination of concrete using a microwave process.

Surface decontamination of metal using a laser process.

In addition, for FY 1994, it is assumed that the following processes have no known technology barriers, worker safety or public health limitations:

Bulk/volumetric decontamination of concrete using a electroosmosis process.

Bulk/volumetric decontamination of stainless steel using a refining process.

In addition, for FY 1995, it is assumed that the following processes have no known technology barriers, worker safety or public health limitations:

Bulk/volumetric decontamination of mild steel using a refining process.

Surface decontamination (internal) of equipment using a gas phase process.

Bulk/volumetric decontamination of transite/asbestos using a melting process.

Issues

De minimis criteria for the unrestricted/restricted release of bulk/volumetric contaminated material have not been established. Since the release of surface decontaminated material required 100 percent access for surveys, little building and scrap material is currently being reused or recycled.

Strategy

The strategies to be used in accomplishing future objectives include:

- Use expertise in the private sector.
- Develop industrial capacity for the reuse and recycle of contaminated material.
- Identity market incentives (both domestic and international) for the reuse and recycle of contaminated material.
- Gain stakeholder acceptance.
- Integrate Technology Development activities with the programs in other governmental agencies and the private sector.

Selected Past Accomplishments

Demonstrated the surface decontamination of concrete using a bench scale microwave process in the laboratory.

Demonstrated the surface decontamination of metal coupons using a bench scale laser process in the laboratory.

Demonstrated near real time monitoring of metal surface during surface decontamination using laser process.

1993 Accomplishments/Objectives

Demonstrate the surface decontamination of concrete using a microwave process mounted on a tethered vehicle in the laboratory.

1994 Objectives

Demonstrate the surface decontamination of concrete using a microwave process mounted on a self-propelled, remotely operated vehicle in the laboratory.

Demonstrate the bulk/volumetric decontamination of stainless steel using a bench scale refining process in the field.

Demonstrate the bulk/volumetric decontamination of concrete using a bench scale electro-osmosis process in the laboratory.

1995 Planned Objectives

Demonstrate the bulk/volumetric decontamination of stainless steel using a pilot scale refining process in the field.

Demonstrate the surface decontamination of concrete using a microwave process mounted on a self-propelled, remotely operated vehicle in the field.

Demonstrate the bulk/volumetric decontamination of concrete using a pilot scale electro-osmosis process in the field.

Demonstrate the surface decontamination of process and non-process equipment using a pilot scale gas phase process in the field.

Demonstrate the bulk/volumetric decontamination of transite and asbestos using a bench scale process in the field.

Demonstrate the surface characterization, the surface decontamination and dismantlement of a facility being decommissioned using pilot scale processes in the field.

DECONTAMINATION AND DECOMMISSIONING OF FACILITIES

DECONTAMINATION AND DECOMMISSIONING TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
CH111201	LASER DECONTAMINATION AND RECYCLE OF METALS	AMES LABORATORY	135	200	275
OR101204	MICROWAVE CONCRETE DECONTAMINATION SYSTEM	OAK RIDGE NATIONAL LABORATORY	1100	400	160
OR221103	DECONTAMINATION AND DECOMMISSION (D&D) COORDINATION	OAK RIDGE NATIONAL LABORATORY	425	600	0
OR221104	DEMONSTRATION TESTING AND EVALUATION (DT&E) DECONTAMINATION DECOMMISSION AND RECYCLE	OAK RIDGE NATIONAL LABORATORY	0	500	0
OR111104	DECONTAMINATION AND DECOMMISSION (D&D) INTEGRATED DEMONSTRATION (ID) PLANNING	OAK RIDGE NATIONAL LABORATORY	0	250	150
		THETA TECHNOLOGIES			

EFFICIENT WASTE SEPARATION PROCESSES

Introduction

The U.S. Department of Energy (DOE) sponsors research and development (R&D) in advanced radiochemical separations to reduce the volume of high-level waste (HLW) that must be disposed in deep geological repositories, and to cut the toxicity and volume of low-level waste (LLW) acceptable for near-surface disposal. These R&D activities are sponsored through the DOE Office of Technology Development Efficient Separations and Processing Integrated Program (ESPIP). ESPIP also develops separation processes to extract high-value materials and non-radioactive hazardous components from nuclear waste and will transfer separations processing to commercial markets.

Technical Focus

ESPIP R&D activities are designed to remove radionuclides and hazardous materials and chemicals from radioactive defense wastes. Radionuclides and other materials under consideration for separation include transuranic (TRU) elements such as neptunium, plutonium, americium, and cerium, highly radioactive elements (Sr-99 and Cs-137), and long-lived soluble fission products including technetium-99 and iodine-129. Separation processes will also be developed to extract the long-lived soluble activation product carbon-14; aluminum, phosphorous, and chromium, the elements that degrade borosilicate glass waste forms; the strategic metals rhodium, palladium, and ruthenium; and *Resource Conservation and Recovery Act* elements and compounds.

The program oversees efficient separations R&D for DOE sites. Current priorities are the cleanup of high-level wastes (HLW) in underground storage tanks at Hanford Production Operations, Hanford, WA, and the cleanup of HLW at Idaho National Engineering Laboratory (INEL), Idaho Falls, ID. Many of the technologies developed for HLW will be applicable to other waste streams throughout the DOE Complex and ESPIP will transfer technologies as appropriate.

The Payoff of Advanced Separations

Hanford High Level Waste

The acidic liquid HLW from reprocessing defense reactor fuels for plutonium, which began in 1944, was made alkaline (pH 14) by adding caustic soda and was stored in underground concrete storage tanks lined with carbon steel. Over the years, 149 of these single-shell tanks (SST) were built and eventually some began to leak. Today, 66 SSTs are known to be or suspected of leaking, posing a threat to contaminate the groundwater. The 149 SSTs contain 165,500m³ of waste, all of which is currently treated as HLW, approximately 2.5 x 10⁸kg. The maximum migration of these SST wastes into the ground is estimated to be 75m. When the SSTs began to leak, new underground double-shell tanks (DST) were built, and there are now 28 DSTs, none of which have leaked. These tanks contain 79,300m³ of HLW, approximately 100,000Mg.

Idaho High-Level Waste

Most INEL HLW is reprocessed naval reactor fuel. Acidic liquid waste is stored in underground stainless steel tanks that are housed inside concrete vaults. The waste is then converted into a calcine powder and stored retrievably in stainless steel bins inside reinforced concrete vaults. There are 3,500m³ of HLW stored as calcine, containing 90 percent of the radioactivity, and 8,500 m³ of liquid HLW containing ten percent of the radioactivity. The INEL waste is uniform and well characterized, but will not meet Land Disposal Requirements (LDRs).

Economic Benefits

Currently the preferred waste form for permanent disposal of HLW is vitrified borosilicate glass inside a stainless steel canister. Approximately 25 to 30 volume percent of the vitrified glass is HLW and the balance is glass frit, unless the HLW contains aluminum, phosphorous, or chromium.

Recent estimates for the Hanford SST and DST HLW disposal indicate that sludge wash of the waste, primarily to rid the waste of sodium nitrate and other soluble compounds without further separations and processing, would require 40,000 canisters. If advanced separations are implemented to separate TRU elements, cesium, strontium, and technetium, from the non-radioactive chemicals, the number of canisters is expected to be reduced to 2,000. Less than 10 m³ are radionuclides.

The sludge wash and advanced separations is expected to generate 940,000 m³ of aqueous LLW, which will be disposed of as 1,600,000 m³ of cement grout in 300 near-surface concrete vaults. The cost of LLW disposal is projected to be \$5,800 per m³ of liquid or \$3,400 per m³ of grout. The cost of vitrification and disposal of a m³ of HLW, which requires six canisters, is about \$6M; or over 1000 times the cost of disposal of a m³ of LLW.

Since the INEL HLW is in calcine form, processing the waste with aqueous solvent extraction would require dissolving the

calcine in nitric acid, which would generate a large volume of aqueous LLW. As an alternative, ESIIP is exploring a glass-ceramic waste form and the possibility of pyrochemical processing. The glass-ceramic waste form would reduce the number of logs from 9,500 to 3,770. If pyrochemical processing was used with a glass waste form, the number of logs generated would be less than 900.

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Selected Past Accomplishments

Prepared glass-ceramic waste forms with leach rates comparable to borosilicate glass.

Completed systems total-mass-balance analysis model for Hanford underground storage tanks and evaluated Transuranic Extraction (TRUEX) option.

Demonstrated utility of molecular mechanics in designing highly specific sequestering agents.

1993 Accomplishments/Objectives

Define and test candidate radiochemical separations processes on high-level waste (HLW) and transuranic (TRU) wastes at Hanford.

Complete preliminary feasibility laboratory tests for pyrochemical treatment of Idaho high-level waste (HLW) calcine.

Complete Phase I of industrial contracts to develop cesium and strontium removal techniques, evaluate potential of developing technologies.

Start Phase II-test of promising industrial-contract materials on high-level waste.

Initiate new industrial contracts in separations or sludge treatment technologies.

Begin R&D on treatment processes for high-level waste (HLW) sludges present in underground storage tanks at Hanford and Oak Ridge.

Continue international dialogue and technical exchanges on separations technologies; sponsor high-level waste (HLW) treatment R&D in Russia.

1994 Objectives

Begin extension of new technologies developed for High-level waste (HLW) to contaminated soil and groundwater cleanup via selective extraction and separation of transuranics (TRUs) and toxic metals.

Continue international dialogue and technical exchanges on separations technologies.

Initiate separations needs assessment for low-level and mixed wastes.

Transfer an industrial cesium/strontium removal technology to customer (EM-30).

Initiate sludge treatment testing on actual waste.

Continue studies of pyrochemical processing and equipment feasibility tests; make go/no-go decision on whether to further pursue pyroprocessing/transfer to EM-30 if go decision.

Begin development of separations technologies for extraction of heavy metals and technetium from high-level waste and low-level waste as needed.

Begin R&D on noble metal separation/recovery from high-level waste to insure vitrification reliability and glass quality and for possible monetary value.

Begin evaluation of separation methods developed for high-level waste for treating mixed wastes, soils, groundwater, and toxic wastes.

Initiate collaborative industrial/DOE laboratory efforts to develop methods for toxic and noble metal removal from contaminated waters such as the Berkeley Pit with a molecular recognition technology.

1995 Planned Objectives

Initiate/continue R&D for processing of mixed and low-level wastes. Particular emphasis on adaptation of technologies developed for high-level waste treatment to these needs.

Continue work on sludge treatment processes and testing on actual wastes. Develop database on results for range of actual waste compositions to provide input for treatment of dissolved sludges.

Expand work on industrial cesium/strontium removal technologies completed in FY 94 to other waste streams and radionuclides.

Continue development of technology selection tool for Idaho National Engineering Laboratory and Rocky Flats.

Continue work on advance processing schemes, incorporating data on new technologies and sludge treatment studies developed in program.

Initiate/continue study of separations/processing methods for removing radioactive materials and toxic metals from soils/groundwater.

Begin studies of selective leaching of example mixed-waste sludges.

Continue development of technologies for technetium and heavy metal extraction.

Continue R&D on noble metal separations from high-level waste; assess needs other than high-level waste.

Continue extension of new processing technologies developed for high-level waste to other waste streams, such as decontamination and decommissioning streams, heavy metal removal from wastewaters and groundwaters/streams, etc.

Initiate expansion/modification of industrial technologies for high-level waste to other waste streams.

Initiate development of technologies of removal treatment of tritium, carbon-14, and radioactive iodine.

Complete assessment of organic/nitrate destruction technologies and make recommendation to EM-30.

Transfer one or more generally applicable separations technologies to industry.

Develop database on sludge treatment based on results of testing actual wastes/make recommendations for treatment of dissolved sludge.

Assess needs for recovering contaminants from decontamination fluids and recycling of reagents.

Initiate studies of selecting chelating leach materials for removing contaminants from metal surfaces.

Assess separations/processing opportunities for increasing the acceptable waste loading of conventional waste forms.

Begin studies of new waste forms, particularly forms that can handle concentrated contaminants that are not retained effectively by conventional waste forms.

Complete development of polymer-based sequestering agents for transuranic removal of Rocky Flats Plant and transfer results to underground storage tanks and EM-50.

EFFICIENT SEPARATIONS AND PROCESSING

Target Schedule	90	91	92	93	94	95	96	97	98	99
Identify EM-30 Needs and Establish Coordination Network										
Pyroprocess for Calcine HLW										
Develop/Implement Technology Selection/Systems Analysis Tool										
Cesium and Strontium Removal from Supernates										
Organic/Nitrate Treatment										
Transuric and Fission Product Removal from Aqueous Wastes										
HLW Sludge Treatment										
Identify EM-40 Needs and Establish Coordination Network										
Heavy Metal Removal										
Noble Metal Removal										
Tritium, Carbon-14, Iodine-29 Separation										
Transfer to Industry										

EFFICIENT SEPARATIONS INTEGRATED PROGRAM TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
AL932002	COBALT DICARBOLLIDE SUPPORT	UNC GEOTECH INC	224	0	0
AL111701	WASTE TO MEDICALLY IMPORTANT ISOTOPE CONVERSION	LOS ALAMOS NATIONAL LABORATORY	0	42	1400
AL121207	WASTE TO MEDICALLY IMPORTANT ISOTOPE CONVERSION (CHEMICAL SEPARATIONS AND TRANSMUTATION TECHNOLOGIES FOR ATW)	LOS ALAMOS NATIONAL LABORATORY	0	518	0
AL121217	SEQUESTERING AGENTS/REMOVAL OF TRANSURANIC FROM RADIOACTIVE WASTE	LOS ALAMOS NATIONAL LABORATORY UNIVERSITY OF NEW MEXICO UNIVERSITY OF TENNESSEE NEW MEXICO STATE UNIVERSITY TEXAS TECHNOLOGICAL UNIVERSITY	0	50	0
AL132008	SEPARATION OF CESIUM AND STRONTIUM FROM HIGH LEVEL RADIOACTIVE WASTE	LOS ALAMOS NATIONAL LABORATORY UNIVERSITY OF NEW MEXICO	495	0	0
AL132009	ACTINIDE SEPARATIONS/ADVANCED PROCESSING OF AQUEOUS WASTES	LOS ALAMOS NATIONAL LABORATORY	864	0	0
AL132010	FISSION PRODUCT CHEMISTRY	LOS ALAMOS NATIONAL LABORATORY	693	0	0
AL132011	ASSESSMENT FRAMEWORK DEVELOPMENT AND SEPARATIONS INTEGRATION	LOS ALAMOS NATIONAL LABORATORY	700	0	0
AL121216	EFFICIENT SEPARATION AND PROCESSING INTEGRATED PROGRAM	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	107	0	0
AL211701	THE RENUW DRY HALIDE PROCESS FOR NUCLEAR FUEL REPROCESSING	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	0	1	0
AL232004	WASTE SEPARATION AND PRETREATMENT USING TITANATE ION EXCHANGE	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE TEXAS A & M UNIVERSITY	300	0	0
CH232003	SLUDGE TECHNOLOGY ASSESSMENT	ARGONNE NATIONAL LABORATORY	50	0	0
CH232004	IN SITU MAGNETICALLY-ASSISTED CHEMICAL SEPARATION	ARGONNE NATIONAL LABORATORY BRADTEC	300	0	0
CH232005	ADVANCED PROCESSING FOR CLEAN OPTION	ARGONNE NATIONAL LABORATORY	200	0	0
CH232006	AQUEOUS BIPHASIC SYSTEMS/RADIOACTIVE WASTE PRETREATMENT	ARGONNE NATIONAL LABORATORY NORTHERN ILLINOIS UNIVERSITY	300	0	0
ID101302	FT. ST. VRAIN FUEL WASTE MINIMIZATION EFFORTS	IDAHO NATIONAL ENGINEERING LABORATORY	0	65	260

EFFICIENT SEPARATIONS INTEGRATED PROGRAM TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
ID133502	BAR CODING FOR ROCKY FLATS SURVEY	IDAHO NATIONAL ENGINEERING LABORATORY	60	0	0
ID421201	PYROCHEMICAL TREATMENT OF IDAHO CHEMICAL PROCESSING PLANT HIGH-LEVEL CALCINE; CONTINUE DEVELOPMENT OF A MASS-BALANCE MODEL FOR A TOTAL "CRADLE TO GRAVE" WASTE TREATMENT SYSTEM	WESTINGHOUSE IDAHO NUCLEAR CO	500	370	0
OR121204	TRANSURANIC EXTRACTION PILOT TEST ASSESSMENT	OAK RIDGE NATIONAL LABORATORY	0	50	0
OR132012	SLUDGE WASHING AND DISSOLUTION OF OAK RIDGE NATIONAL LABORATORY MVST WASTE	OAK RIDGE NATIONAL LABORATORY	1320	0	0
OR132019	ADVANCED SEPARATIONS FROM SUPERNATE/SLUDGE PROCESSING	OAK RIDGE NATIONAL LABORATORY	984	0	0
RL321204	INNOVATIVE CHEMICAL SEPARATION	PACIFIC NORTHWEST LABORATORY	750	200	0
		TEXAS A & M UNIVERSITY			
		3M CORPORATION			
		IBC			
		ALLIED SIGNAL			
RL321215	ADVANCED SEPARATION TECHNOLOGY	PACIFIC NORTHWEST LABORATORY	250	200	0
RL321216	PROCESSING OF HIGH-LEVEL WASTE SLUDGE	PACIFIC NORTHWEST LABORATORY	0	150	0
RL332008	PROGRAM SUPPORT - EFFICIENT SEPARATIONS PROGRAM	PACIFIC NORTHWEST LABORATORY	300	0	0
RL332015	ACT-DE-CON PROCESS SELECTIVE LEACHING OF TANK SLUDGE	PACIFIC NORTHWEST LABORATORY	185	0	0
RL332018	ALKALINE TANK SLUDGE TREATMENT	PACIFIC NORTHWEST LABORATORY	280	0	0
RL411205	ADVANCED CHEMICAL SEPARATIONS	WESTINGHOUSE HANFORD COMPANY	250	200	150
RL432004	CALCINE RESIDUE LEACHING; VOLUME REDUCTION	WESTINGHOUSE HANFORD COMPANY	250	0	0
SF332001	TRANSURANIC REMOVAL FROM AQUEOUS WASTE STREAMS/SOLID-BOUND	ENERGY TECHNOLOGY ENGINEERING CENTER	95	0	0
SF132001	REMOVAL AND RECOVERY OF TOXIC METAL IONS/AQUEOUS WASTE STREAMS	LAWRENCE BERKELEY LABORATORY	100	0	0
SF232003	DERIVATIVES OF NATURAL COMPLEXING AGENTS/REMOVAL OF PLUTONIUM IN WASTE	LAWRENCE LIVERMORE NATIONAL LABORATORY	250	0	0
SR132005	DEVELOPMENT AND EVALUATION OF ELECTROCHEMICAL METHODS OF DESTROYING NITRATES	WESTINGHOUSE ELECTRIC CORP	300	0	0
SR132007	CARBOLLIDE/CDCB PROCESS DEVELOPMENT/RADIOACTIVE CESIUM-137 DECONTAMINATION	WESTINGHOUSE ELECTRIC CORP	500	0	0

MIXED WASTE INTEGRATED PROGRAM

The Challenges of Mixed Waste Program Research, Development, Demonstration, Testing and Evaluation (RDDT&E)

Mixed waste contains both radioactive and hazardous contaminants. Throughout the U.S. Department of Energy (DOE) Complex, the mixed waste problem is significant because definitive treatment standards have not been established and no disposal facilities designated for mixed waste are available. In addition to these constraints, treatment capability and capacity are very limited. Therefore, DOE sites must store mixed waste for future disposal, despite that this situation may pose a risk to the public, and in addition may result in not complying with applicable regulations governing mixed waste.

In response to the urgent need for a comprehensive and consistent approach to the complex issue of mixed waste management, the DOE Office of Technology Development (EM-50), has established the Mixed Waste Integrated Program.

The program is linked to environmental restoration and waste management needs, to ensure that treatment capability is developed.

Special Regulatory Considerations

DOE's approach to mixed waste treatment and site remediation is governed by state and federal regulations for both hazardous and radioactive materials. This creates circumstances where dual regulations, which were designed to govern the management of either hazardous or radioactive wastes, apply. Inconsistencies among these regulations complicates development of methods for treating and disposing of mixed waste.

Much of mixed waste is currently stored in barrels and underground storage tanks.

Definitive treatment standards are lacking for low-level and transuranic mixed waste from DOE facilities. Available capacity and technology are insufficient to treat mixed waste both commercially and within the DOE system. Such wastes must therefore be stored for future disposal in facilities for which criteria have not been established. This has required DOE to enter into compliance agreements with various regulatory agencies. Despite the lack of disposal criteria, regulations and compliance agreements governing mixed waste require waste treatment and/or site remediation by specific deadlines. Simultaneously, the generation of mixed waste continues from plant operations. This regulatory quandary forms a challenging framework for development and implementation of mixed waste technology research, development, demonstration, testing and evaluation (RDDT&E).

An approach addressing DOE mixed waste has been developed using requirements set forth in the Resources Conservation and Recovery Act (RCRA) for Waste Management projects supervised by EM-30, and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) for Environmental Restoration projects under EM-40. This approach includes a hierarchy of activities.

The Size and Scope of the Mixed Waste Problem

A total of approximately 247,000 cubic meters of mixed low-level waste is stored at DOE site. DOE is working to comply with new Land Disposal Restrictions (LDR). Meanwhile, the generation of mixed waste continues at the rate of 56,000 cubic meters per year.

DOE has classified over 1400 mixed waste streams into categories that require similar processing steps for assignment of baseline treatment. Baseline treatment schemes for each waste category have been segregated into various technical areas including: front end handling; physical/chemical treatment; waste destruction; off gas treatment; and final forms. The program requires significant funding for research, development and implementation of effective treatment and disposal technologies.

System Requirements for Effective Mixed Waste Treatment

Key issues that affect the ability of DOE to assign definitive system requirements to the treatment of mixed waste include:

Waste acceptance criteria for disposal. No criteria for on-site disposal have been established, and limited commercial disposal of radioactive materials has been approved.

Recycle of decontaminated material. No de minimus levels for radioactivity have been established.

Incineration of organic material and oxidation through thermal reaction. The public generally does not support combustion technology.

Analysis to address additional system requirements will consider methods such as CERCLA's evaluation criteria.

The Future of the Program

The DOE Office of Technology Development (EM-50) is conducting ongoing RDDT&E to assist the Offices of Environmental Restoration (EM-40), and Waste Management (EM-30), within the DOE Office of Environmental Restoration and Waste Management (EM), in selecting alternative treatment methods for mixed waste.

A baseline treatment scheme, using current technologies, has been established by EM-30. This includes disposal of radioactive material, recycle of contaminated material, and thermal treatment. System requirements are being determined for these activities. The goals of the EM-50 program are to assist in establishing system requirements, and to enhance or improve the baseline technologies such that the chosen treatment systems can be implemented at lower cost, and at lower risk than the baseline. When this goal is met, then the cost of RDDT&E will be recovered.

DOE must store wastes while treatment capacity is being developed. The role of EM-30 is to construct waste treatment facilities and procure waste treatment services to ensure that adequate treatment capacity is available for mixed waste. The role of EM-50 is to develop a suite of technologies that will treat mixed waste to acceptable criteria and to provide design and reliability data to EM-30 and EM-40 within the required schedule to support the implementation of mixed waste treatment technologies.

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Selected Past Accomplishments

Completed construction and installation of a pilot scale microwave melter which provides an 80% volume reduction over present cementation process.

Designed prototype of molten salt mixed waste processing system.

Demonstrate microwave vitrification of Rocky Flats sludge.

Completed bench-scale testing of a silent discharge plasma unit to destroy hazardous volatile organic compounds contained in gas streams generated by primary treatment technologies. For example, this technology holds significant value for use with small volume incinerators and other thermal treatment methods to aid compliance with increasingly stringent clean air requirements. It is an effective technology for hazardous organics which are a significant portion of the DOE's waste streams, and has been used successfully in the destruction of other hazardous materials including nerve agents.

Completed plasma arc proof-of-principle treatment showing both the destruction of organic compounds as required to down-classify the waste from the mixed waste category and the resulting production of a highly durable, leach resistant waste form.

Completed design, fabrication and EPA Superfund innovative technology evaluation program on DOE / Industry / EPA plasma arc furnace.

Completed pilot-scale testing of a plasma furnace, and began testing on an arc plasma pilot unit for treating buried and stored mixed waste. Both the furnace and arc plasma units not only destroy organic compounds but also melt mixed waste into solid, stable forms which will satisfy regulatory compliance issues and provide for safe, cost-effective long term storage.

The plasma arc furnace successfully demonstrated destruction of hazardous organic contaminants and immobilization of toxic heavy metals from the Clark Fork Superfund site.

A versatile plasma arc process has been shown to destroy organics in surrogate Rocky Flats compacted drum waste and to effectively vitrify buried waste soils initial tests with surrogate wastes have produced a stable glass waste form. This technology provides alternate treatment to incineration.

Determined final disposal methods for hexane tank waste at Hanford and procured commercial services for hexane disposal.

Installed microwave drying and vitrification system at Rocky Flats.

Initiated effort for a fluidized bed unit with off-gas capture at Rocky Flats.

Initiated examination of cement mixtures for immobilizing heavy metals at Rocky Flats.

Developed a national program designed to meet the requirements of the regulatory community.

Initiated development of a national strategy for mixed waste disposal in collaboration with users (EM-351 MWTP).

1993 Accomplishments/Objectives

Identification, evaluation and selection of technologies to establish a baseline for comparison in subsequent trade off analyses.

Conducted bench-scale demonstrations of the production of enhanced waste forms for the vitrify-to-dispose effort.

Conducted life-cycle cost analysis of plasma hearth and alternative waste treatment technologies.

Developed risk assessment strategy/methodology and completed preliminary hazards assessments on plasma hearth system and vitrification system.

1994 Objectives

A plasma hearth process will be tested at bench scale for destruction and stabilization of surrogate mixed waste sludge streams.

The commercial status of and RD needs for closed treatment systems will be evaluated.

Conduct system feasibility assessments to support national and site-specific treatment process flow sheets.

Initiate inclusion of off-gas treatment and monitoring technologies into thermal treatment demonstrations.

Initiate testing of biological treatment methods.

Identify and select characterization, instrumentation, sorting, handling and feed preparation technologies for testing.

Support collaboration with States/EPA/stakeholders to support decision making on mixed waste technologies.

1995 Planned Objectives

Evaluate the feasibility and test data to provide down selection of competing technologies.

Organize technologies for treatment various generic waste streams into systems as engineering data becomes available.

Identify knowledge gaps which will become the basis for testing in treatment systems descriptions.

Complete pilot-scale testing of plasma treatment on cold surrogate mixed waste and permitting process to enable initiation of bench-scale testing on radioactive mixed waste.

Perform hot (radioactive) tests with the plasma arc unit.

Conduct pilot-scale vitrification with surrogates for the vitrify-to-dispose effort.

Conduct pilot-scale off-gas treatment demonstration with surrogates coupled with thermal treatment technology.

Initiate testing of characterization, instrumentation, sorting, handling and feed preparation technologies for mixed waste.

Accelerate development of alternatives to incineration technologies. Initiate development of closed loop thermal treatment systems. Examine several alternative designs for closed loop thermal treatment systems.

Initiate an accelerated waste forms performance criteria effort linked to performance assessment of the waste form in hazardous waste disposal sites.

MIXED WASTE INTEGRATED PROGRAM

Target Schedule	91	92	93	94	95	96	97	98	99
OFF-GAS TREATMENT									
Cleanable HEPA filters									
Assess/modify commercial APC equipment									
Develop off-gas monitors									
WASTE DESTRUCTION AND STABILIZATION									
Bench-Scale Plasma on Cold Surrogates									
Bench-Scale Plasma on Radioactive Waste									
Pilot-Scale Plasma on Cold Surrogates									
Pilot-Scale Plasma on Radioactive Waste									

MIXED WASTE INTEGRATED PROGRAM

Target Schedule	91	92	93	94	95	96	97	98	99
CHEMICAL AND PHYSICAL TREATMENT									
Bench Scale Engineering Tests									
Testing/Evaluation of Commercially Available Technology									
Demonstration (Pilot Scale)									
FRONT END HANDLING									
Coordination with Robotics Program									
Coordinate with Characterization IP									
FINAL WASTE FORMS									
Qualification of Enhanced Waste Forms									
Vitrify-to Delist to Dispose									
Vitrification Process Limitation									
Waste Forms for Mercury and Salts									
Vitrification Radioactive Pilot Scale Demonstration									

MIXED WASTE INTEGRATED PROGRAM TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY 93	FY 92	FY 91
AL121202	WASTE DESTRUCTION TECHNOLOGY SUPPORT PROGRAM SUPPORT FOR MIXED WASTE	LOS ALAMOS NATIONAL LABORATORY	95	120	0
AL121219	COST/BENEFIT ANALYSIS	LOS ALAMOS NATIONAL LABORATORY	200	120	0
AL132001	LIQUID METAL RECYCLE AND WASTE TREATMENT	LOS ALAMOS NATIONAL LABORATORY	100	0	0
AL132002	POLYMERS FOR REMOVAL OF PLUTONIUM (PU) AND AMERICIUM (AM) FROM WASTE WATERS	LOS ALAMOS NATIONAL LABORATORY	50	0	0
AL132003	VITRIFICATION OF CONTROLLED-AIR INCINERATOR ASH	LOS ALAMOS NATIONAL LABORATORY	50	0	0
AL132004	DETOX PROCESS DEMONSTRATION	LOS ALAMOS NATIONAL LABORATORY	35	0	0
AL132005	ELECTRON BEAM WASTE TREATMENT TEST BED	LOS ALAMOS NATIONAL LABORATORY	50	0	0
AL132006	MICROWAVE FLUIDIZED BED	LOS ALAMOS NATIONAL LABORATORY	25	0	0
AL221207	OFF-GAS TECHNOLOGY SPECIFICATION	SANDIA NATIONAL LABORATORIES-ALBUQUERQUE	321	100	0
CH221201	ARGONNE NATIONAL LABORATORY: MIXED WASTE INTEGRATED PROGRAM (MWIP)	ARGONNE NATIONAL LABORATORY	15	60	0
CH232007	PLASMA HEARTH PROCESS RADIOACTIVE WASTE TEST	ARGONNE NATIONAL LABORATORY	200	0	0
CH321202	POLYMER SOLIDIFICATION	BROOKHAVEN NATIONAL LABORATORY	400	200	0
CH332001	WASTE FORM PERFORMANCE CRITERIA	BROOKHAVEN NATIONAL LABORATORY	300	0	0
CH332002	BROOKHAVEN NATIONAL LABORATORY (BNL) TECHNOLOGY SPECIFICATION OF MIXED WASTE INTEGRATED PROGRAM (MWIP)	BROOKHAVEN NATIONAL LABORATORY	30	0	0
ID121208	MIXED WASTE INTEGRATED PROGRAM (MWIP) SUPPORT: IDAHO NATIONAL ENGINEERING LABORATORY TECHNOLOGY SPECIFICATION WASTE DESTRUCTION AND STABILIZATION	IDAHO NATIONAL ENGINEERING LABORATORY	20	70	0
ID132012	DEFINITION AND TESTING OF FINAL WASTE FORM ACCEPTANCE	IDAHO NATIONAL ENGINEERING LABORATORY	100	0	0
ID032001	PLASMA HEARTH PROCESS RADIOACTIVE WASTE TEST	IDAHO OPERATIONS OFFICE	300	0	0
OR121202	MIXED WASTE PROGRAM SUPPORT	OAK RIDGE NATIONAL LABORATORY	1012	1055	0
		RETECH			
		SAIC			
OR121205	MIXED WASTE INTEGRATED PROGRAM SUPPORT	OAK RIDGE NATIONAL LABORATORY	500	550	0
OR132002	SYSTEMS ANALYSIS FOR MIXED WASTE INTEGRATED PROGRAM	OAK RIDGE NATIONAL LABORATORY	290	0	0
OR132004	NITRATE, AMMONIA, AND CERAMIC	OAK RIDGE NATIONAL LABORATORY	50	0	0
OR132005	MICROWAVE SYSTEM OPTIMIZATION AND CONTROL SUPPORT FOR ROCKY FLATS	OAK RIDGE NATIONAL LABORATORY	100	0	0

MIXED WASTE INTEGRATED PROGRAM TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY 93	FY 92	FY 91
OR132010	MIXED WASTE INTEGRATED PROGRAM (MWIP) MERCURY CONTROL	OAK RIDGE NATIONAL LABORATORY	50	0	0
OR132011	OAK RIDGE NATIONAL LABORATORY (ORNL) TECHNICAL SPECIFICATION FOR MIXED WASTE INTEGRATED PROGRAM (MWIP) CHEMICAL/PHYSICAL TREATMENT AND FINAL FORMS	OAK RIDGE NATIONAL LABORATORY	30	0	0
OR132015	WASTE STREAM DIAGNOSTICS AND CONTROL FOR TREATMENT OF MIXED WASTE	OAK RIDGE NATIONAL LABORATORY	1000	0	0
OR132016	CHEMICAL/PHYSICAL TREATMENT TECHNOLOGY SPECIFICATION	OAK RIDGE NATIONAL LABORATORY	360	0	0
OR132017	FINAL FORMS TECHNOLOGY SPECIFICATION	OAK RIDGE NATIONAL LABORATORY	140	0	0
OR132020	MIXED WASTE PROGRAM SUPPORT - PLASMA HEARTH PROCESS	OAK RIDGE NATIONAL LABORATORY	588	0	0
		RETECH			
		SAIC			
OR021203	CONTROL OF METAL EMISSIONS FROM MIXED WASTE INCINERATORS	OAK RIDGE OPERATIONS OFFICE	170	0	80
PE021202	FIXED HEARTH PLASMA ARC FOR MIXED WASTE TREATMENT	PITTSBURGH ENERGY TECHNOLOGY CENTER	700	1275	365
		SAIC			
		RETECH			
		MSE, INC.			
RF121201	MIXED WASTE INTEGRATED PROGRAM SUPPORT	EG&G ROCKY FLATS, INC.	0	84	0
RF132001	MIXED WASTE DESTRUCTION (VITRIFICATION)	EG&G ROCKY FLATS, INC.	25	0	0
RL301204	CATALYZED ELECTROCHEMICAL PLUTONIUM OXIDE DISSOLUTION	PACIFIC NORTHWEST LABORATORY	350	460	500
RL321201	PACIFIC NORTHWEST TECHNOLOGY MIXED WASTE INTEGRATED PROGRAM	PACIFIC NORTHWEST LABORATORY	30	90	0
RL332009	QUALIFICATION OF GLASS FOR TRANSURANIC LOW-LEVEL, AND MIXED WASTE	PACIFIC NORTHWEST LABORATORY	274	0	0
RL332012	QUALIFICATION OF GLASS FOR MIXED WASTE (PROCESS LIMITATIONS)	PACIFIC NORTHWEST LABORATORY	100	0	0
RL332013	ELECTROCHEMICAL ION EXCHANGE (EIX) NITRATE DESTRUCTION	PACIFIC NORTHWEST LABORATORY	25	0	0
RL332014	MAGNETIC AND NONMAGNETIC MELT/SLAG TREATMENT OF MIXED WASTE	PACIFIC NORTHWEST LABORATORY	100	0	0
RL421215	TECHNOLOGY SPECIFICATION MIXED WASTE INTEGRATED PROGRAM	WESTINGHOUSE HANFORD COMPANY	50	50	0
SP221201	LAWRENCE LIVERMORE NATIONAL LABORATORY MIXED WASTE PROGRAM	LAWRENCE LIVERMORE NATIONAL LABORATORY	15	130	0
SP221211	RISK ASSESSMENT-MIXED WASTE	LAWRENCE LIVERMORE NATIONAL LABORATORY	200	50	0
SR101102	HAZARDOUS MIXED WASTE TREATMENT TECHNOLOGY DEVELOPMENT	WESTINGHOUSE ELECTRIC CORP	0	200	250
SR121202	SAVANNAH RIVER TECHNOLOGY PLANNING FOR MIXED WASTE INTEGRATED DEMONSTRATION	WESTINGHOUSE ELECTRIC CORP	20	60	0

MIXED WASTE INTEGRATED PROGRAM TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY 93	FY 92	FY 91
SR132004	VITRIFY TO DELIST TO DISPOSE	WESTINGHOUSE ELECTRIC CORP	1200	0	0
SR132008	MIXED WASTE INTEGRATED PROGRAM (MWIP) PROGRAM SUPPORT	WESTINGHOUSE ELECTRIC CORP	250	0	0

ROCKY FLATS COMPLIANCE PROGRAM

Introduction

The primary objective of the Rocky Flats Compliance Program is to develop mixed waste treatment technologies that will be used to bring the Rocky Flats Plant (RFP) into compliance with Federal and State regulations and agreements. Approximately 11,000 cubic yards and 29,000 gallons of low level mixed waste are stored at the Rocky Flats Plant. In addition, newly generated waste from cleanup and decontamination and decommissioning activities will require treatment and disposal. Currently, no method for this treatment is approved and no approved final disposal facility exists. In addition to developing treatment technologies, the Rocky Flats program is demonstrating, testing, and evaluating systems to reduce the amount of mixed waste requiring disposal. The program is also designed to maximize the alignment of its activities with the Mixed Waste Integrated Program (MWIP) to ensure consistency with the national approach to developing mixed waste treatment technologies.

The cleanup of the Rocky Flats site is driven by agreements between DOE, the EPA, and the Colorado Department of Health (CDH). Under these agreements, a Comprehensive Treatment and Management Plan (CTMP) was drafted to outline the mechanisms by which the Rocky Flats Plant (RFP) will achieve compliance with the regulations and agreements. This document describes DOE's strategy to treat low level mixed waste to meet Land Disposal Restrictions. The CTMP further listed a wide variety of technology options which may be considered. The projects supported under the Rocky Flats Compliance Program are focussed on developing new treatment facilities as outlined in the CTMP.

The technology development activities supported by the Rocky Flats Compliance Program are organized into a set of systems, each designed to treat a specific waste stream or group of wastes. In FY 93, work has been initiated on four waste stream groups (Solvent Contaminated Wastes, Solidified Bypass Sludge, Building 374/774 Waste Forms, and Surface Organics on Bulk Lead/Other Bulk Items). This comprises the majority of the low-level mixed wastes at Rocky Flats. The efforts in these areas range from laboratory feasibility trials on individual technologies to pilot-scale demonstrations of integrated waste treatment systems. In one case, Solvent Contaminated Wastes, two different approaches (thermal, non-thermal) are being developed. The accomplishments and status of the programs in each of these five systems is outlined in the following sections.

Thermal Treatment - Solvent Contaminated Wastes

The central operation in this system is incineration. Rocky Flats has previously utilized a Fluid Bed Incinerator (FBI) for the destruction of organics. The potential for the emission of toxic and/or radioactive compounds has been raised as an issue in permitting of this unit. The Rocky Flats Compliance Program has completed a state-of-the-art assessment of off-gas systems to control emissions from the FBI. A report evaluating the options for capturing the off-gasses to allow complete characterization prior to release was also completed.

Since characterization of the off-gas is crucial in assuring safety during operation, the program has also been supporting work on the design and testing of equipment for monitoring alpha radiation; initial tests have established detection efficiencies of over 90%. A related effort to predict and measure the volatility will be very low at FBI temperatures. The potential for increased volatility in the presence of other contaminants is also being examined.

Non-Thermal Treatment - Solvent Contaminated Wastes

Work on alternatives to incineration involves several potential technologies which have been shown to destroy organic compounds in hazardous wastes. A series of lab-scale tests using surrogates have shown four technologies which may treat the Fluidized Bed Incinerator Oils: Chemical Catalytic Oxidation, Mediated Electrolytic Oxidation, Silent Discharge Plasma, and Biodegradation. These approaches provide treatment options for liquid and/or solid combustible waste streams in the event that incineration is not performed at the RFP. Work is underway to initiate the design for cold pilot-scale tests of one or more of these technologies. The selection of a candidate system for the demonstration of a complete incineration alternative system is planned for FY 95 with the demonstration to begin in the following year.

Microwave Solidification - Solidified Bypass Sludge

Microwave solidification utilizes microwave energy to glassify waste solids to a stable final waste form. In contrast to the use of cementation to process this waste the microwave approach would avoid a large increase in the volume of waste for disposal. Another benefit of this approach is the ability to process waste directly in a drum. Rocky Flats's work on microwave solidification has proceeded through a pilot-scale demonstration using surrogate waste. Work using actual wastes was also successful in bench-scale experiments. The program has prepared a preliminary definition of an off-gas system. The emphasis in ongoing work is toward developing a complete system for use with the microwave and on evaluating the acceptability of the final waste form. A full-scale integrated demonstration is planned beginning in FY 94.

Polymer Solidification - Building 374/774 Waste Forms

Solidification of the waste in a polymer offers another alternative to the current cement process. Since high loadings of waste may be incorporated into the polymer, a substantial reduction in volume may be possible relative to cementation. This program has succeeded in extruding nitrate containing slats at the lab- and pilot-scales. The radioactive and thermal stability of the final waste form has been demonstrated. Preliminary tests have also suggested that the polymer product will provide sufficient compressive strength, resistance to biodegradation and thermal cycling, and low leaching rates. Additional leaching tests are planned and long-term durability trials are underway. Other FY 93 work includes treatability studies on actual waste and the design/development of a complete processing system. Completion of a pilot scale test is expected in FY 95.

Surface Organic Removal - Bulk Lead/Other Bulk Items

Some of the wastes at the RFP consist of bulk items with contaminated surface. Technologies to clean these surfaces would allow the separation of the hazardous and radioactive components for treatment and disposal as hazardous and low-level waste. The Rocky Flats Compliance Program is evaluating commercial technologies for the removal of the organic components. A report examining volatilization technologies has been drafted. Initiation of a demonstration of one or more of these approaches will be dependent on review of the data in this report. Another potential technology for surface organic removal involves the use of supercritical carbon dioxide. A laboratory-scale test unit has been installed at the University of Colorado. Surrogate waste streams have been identified and a test plan is being completed. A pilot test may be conducted by the end of FY 94 if results are successful at the lab-scale.

Rocky Flats Technology Issues

The development activities described above are consistent with those technologies outlined in the draft CTMP. The CTMP has been reviewed by the Environmental Protection Agency (EPA), along with the CDH and a Citizens Review Group which Rocky Flats coordinated as a mechanism for public participation. A draft of the comments from those reviews has recently been submitted to DOE. A revision of the CTMP is currently being initiated to respond to those comments. This process will allow update of the CTMP to incorporate progress in technology development activities which have been carried out. In addition, other waste management issues which may impact technology needs, including residue elimination, will be examined in discussions with the EPA and CDH.

Many of the technologies included in the Rocky Flats Compliance Program have been successfully demonstrated at a laboratory or pilot-scale. As the development of these approaches reaches an advanced stage, the issues which need to be addressed are increasing specific to the Rocky Flats facility. Work on site specific issues and application engineering and design is expected to transition to EM-30. EM-30 and EM-50 have jointly supported the Rocky Flats Compliance Program through FY 93. In FY 94, much of the work is expected to transition to EM-30, while programs with a broader orientation will continue to be coordinated with EM-50 Mixed Waste Integrated Program.

Selected Past Accomplishments

Demonstrated bagless posting to eliminate plastics from transuranic (TRU) waste drums.

Polymer Solidification

Extrudability of nitrate salts confirmed at lab- and pilot-scale.

Radioactive and thermal stability of Final Waste Form (FWF) initially confirmed.

Preliminary tests indicate Final Waste Form (FWF) will also pass tests for:

- Radioactive and heavy metal leach rates
- Biodegradation
- Thermal cycling
- Compressive strength

Microwave Solidification

Successful pilot-scale demonstration on surrogate waste completed.

Preliminary off-gas treatment system defined.

Successful bench-scale tests performed on actual waste.

Surface Organic Contaminant Removal

Supercritical CO₂ lab-scale unit installed at University of Colorado.

Waste streams identified for surrogate testing.

²
Report completed on volatilization technology investigations.

Incineration Alternatives

Lab-scale test for Fluidized Bed Incinerator (FBI) oil surrogates completed; destructive efficiencies obtained for:

- Chemical Catalytic Oxidation (CCO)
- Mediated Electrolytic Oxidation (MEO)
- Silent Discharge Plasma (SDP)
- Biodegradation
- Ultraviolet Light Oxidation

1993 Accomplishments/Objectives

Polymer Solidification

Toxic Characteristic Leaching Procedure (TCLP) confirmation and modelling (nitrate salt surrogates) will be completed.

Treatability study planned on actual nitrate salt waste, including analysis of ability to meet waste acceptance criteria.

Long-term durability studies will be completed.

Tests for selection of pre-treatment drying system underway.

Preparation for systems demonstration at Brookhaven National Laboratory (BNL) initiated.

Microwave Solidification

Equipment selection for entire system to be completed.

Oak Ridge National Laboratory (ORNL) Performing Measurements on Microwave Unit; will provide recommendations for better heat distribution at drum wall interface.

Leachate modelling and particulate studies on surrogates to be completed.

Performing Reliability and Maintainability (RAM) analysis.

Performing drum drop tests.

Lab-scale testing on actual waste and associated Toxic Characteristic Leaching Procedure (TCLP) modelling planned.

Surface Organic Contaminant Removal

Completing test plan and operations procedures for Supercritical Carbon Dioxide Extraction (SCDE).

Completed technology status report for Volatilization & Hot Nitrogen (N₂) stripping.

Initiating waste stream feasibility studies and Supercritical Carbon Dioxide Extraction (SCDE) surrogate testing.

Providing test materials to and working with Chem Waste Management on a Program Research and Development Announcements (PRDA) for VAXTRAX Thermal Desorption Process.

Incineration Alternatives

Completing tests for combustibles for Catalytic Chemical Oxidation, Mediated Electrolytic Oxidation, and Silent Discharge Plasma.

Initial preparations underway for a demonstration unit at the Rocky Flats Plant.

Design for cold pilot demonstration unit to be initiated.

Completing evaluations/tests of radio frequency heating, shredding, and filtering options.

Providing test materials to and working with Delphi Research on Program Research and Development Announcement (PRDA) for DETOX Catalytic Chemical Oxidation Process.

1994 Objectives

Polymer Solidification

Operational data and design criteria development for pilot scale process.

Complete environmental documentation.

Purchase pilot system.

Bench scale treatability studies for bypass sludge, microencapsulation of lead and misc. wastes.

Conduct pilot-scale demonstration of polymer encapsulation of nitrate salts at Brookhaven National Laboratory (BNL) (if FY 93 tests successful).

Surface Organic Contaminant Removal

Complete lab-scale Supercritical Carbon Dioxide Extraction (SCDE) tests.

Perform pilot demonstration of Supercritical Carbon Dioxide Extraction (SCDE) on surrogates at Los Alamos National Laboratory.

Coordinate with Los Alamos National Laboratory (LANL) to perform treatability studies on actual wastes.

Potential Program Research and Development Announcement (PRDA) Demonstration at the Rocky Flats Plant (RFP) of Chem Waste Management's VAXTRAX process depending on FY93 results.

Perform surrogate testing at appropriate vendors to evaluate volatilization technologies.

Perform down-select of technologies under consideration by the Rocky Flats Plant (RFP).

Incineration Alternatives

Complete cold lab-scale treatability studies for miscellaneous wastes.

Define down select criteria.

Perform technical and public review of down-select.

Initiate installation of cold lab for pilot-scale demonstration.

Potential Program Research and Development Announcement (PRDA) Demonstration at the Rocky Flat Plant (RFP) of Delphi Research's DETOX process depending on FY93 results.

Microwave Solidification

Complete hot treatability tests and Toxic Characteristic Leaching Procedure (TCLP) analysis.

Interface with Oak Ridge National Laboratory (ORNL) on any redesign required to microwave unit based on FY 93 results.

1995 Planned Objectives

Polymer Macroencapsulation

Initiate hot testing of polymer macroencapsulation of bulk lead, debris, and miscellaneous wastes.

Initiate lab-scale tests on immobilization of secondary wastes resulting from organics destruction.

Surface Organic Contaminant Removal

Complete lab-scale testing for surface organic removal technologies including supercritical carbon dioxide extraction and volatilization technologies.

Select best candidate technology for pilot-scale demonstrations.

Initiate pilot-scale technology demonstrations.

Incineration Alternatives

Complete lab-scale and pilot-scale unit operations testing for incineration alternative technologies.

Select best candidate technology for pilot-scale systems demonstration tests.

Begin laboratory installation and initiate cold systems tests.

ROCKY FLATS COMPLIANCE PROGRAM

Task/Description	91	92	93	94	95	96	97	98
Phase 1 - Stabilization								
• Microwave Solidification	┌──────────────────┐							
• Polymer Solidification (Nitrate Salts)		┌──────────┐						
Phase 2 - Organic Destruction								
• Incineration Alternatives			┌──────────────────────────┐					
Phase 3 - Separations								
• Surface Organic Removal			┌──────────────────┐					
Phase 4 - Macroencapsulation								
• Polymer Macroencapsulation				┌──────────────────────────┐				

ROCKY FLATS FEDERAL FACILITY COMPLIANCE AGREEMENT TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
AL121215	SILENT DISCHARGE PLASMA (ROCKY FLATS INCINERATION)	LOS ALAMOS NATIONAL LABORATORY	550	525	0
AL121218	THERMAL TREATMENT PROCESS UNIT (TTPU) RADIOACTIVE METALS MONITORING	LOS ALAMOS NATIONAL LABORATORY	600	250	0
RF101201	MICROWAVE SOLIDIFICATION	EG&G ROCKY FLATS, INC. MICRODRY FERROTECH	1302	705	910
RF101205	INCINERATION ALTERNATIVES	EG&G ROCKY FLATS, INC. DELPHI CORPORATION	1550	600	0
RF111202	THERMAL TREATMENT PROCESS UNIT	EG&G ROCKY FLATS, INC.	700	560	1600
RF111203	POLYMER SOLIDIFICATION DEVELOPMENT	EG&G ROCKY FLATS, INC. PACIFIC NUCLEAR SERVICES	1209	775	500
RF121204	SURFACE ORGANIC CONTAMINANT REMOVAL	EG&G ROCKY FLATS, INC. UNIVERSITY OF COLORADO	800	555	0
RF132004	EXPEDITED TECHNOLOGY DEMONSTRATION AND TESTING	EG&G ROCKY FLATS, INC. CHEM WASTE MANAGEMENT	225	0	0
SP221207	INCINERATION ALTERNATIVES FOR ROCKY FLATS	LAWRENCE LIVERMORE NATIONAL LABORATORY	450	500	0
SP221208	MICROWAVE MELTING PLUTONIUM VOLATILITY STUDIES FOR ROCKY FLATS	LAWRENCE LIVERMORE NATIONAL LABORATORY	50	100	0
SP221210	THERMAL TREATMENT PROCESS UNIT (TTPU) EVALUATION AND CONTROL OF URANIUM, PLUTONIUM, AND AMERICAN VOLATILITIES IN MIXED WASTE	LAWRENCE LIVERMORE NATIONAL LABORATORY	400	410	0

SUPERCritical WATER OXIDATION (SCWO) PROGRAM

Introduction

Department of Energy (DOE) has stored on its sites and facilities significant inventories of mixed waste which fall under the Environmental Protection Agency's (EPA's) land disposal restrictions. As such, mixed waste cannot be stored indefinitely, nor can they be disposed of without prior treatment to destroy, separate, or immobilize the hazardous component. In addition, DOE sites and facilities will generate significant volumes of mixed waste as decontamination and decommissioning activities continue to generate significant quantities of mixed and hazardous waste as part of on-going operations. Depending upon DOE's activities, as much as 43,000 cubic meters of mixed waste could be generated annually. Available technologies such as incineration are considered inadequate in terms of cost, environmental impact, and public acceptance for treating mixed waste.

SCWO involves bringing together organic waste, water and an oxidant (such as air, oxygen, etc.) to temperatures and pressures above the critical point of water (374° C, 22.1 MPa). Under these conditions, the waste is treated at high organic destruction efficiencies of over 99.99% and the resulting effluents, which consist primarily of water and carbon dioxide, are relatively benign. In addition, SCWO has the potential of being a more cost effective treatment process than conventional technologies such as incineration. SCWO costs are assessed to be \$1/gallon compared to \$70/gallon for incineration. To date, some of the candidate DOE mixed waste streams for SCWO treatment include: spent solvent, oils, and other organic or aqueous liquids; sewage and organic-laden sludges; spent carbon; solvent contaminated rags; explosives and energetics.

For the past several years, DOE has undertaken a variety of SCWO Research, Development, Demonstration, Testing and Evaluation (RDDT&E) activities in areas of energy recovery and waste management, surrogate waste testing and the treatment of explosives and energetics. Because of this technology's potential for addressing DOE's mixed waste problem, DOE's Environmental Restoration and Waste Management Office of Technology Development established the SCWO Program in FY92 to consolidate and focus SCWO RDDT&E activities. The Idaho National Engineering Laboratory (INEL) is the host site for this program.

SCWO Program Approach

The SCWO Program is divided into two major activities to evaluate the technology for mixed waste applications. These include; (1) SCWO Development Support activities and (2) SCWO Demonstration activities.

SCWO Development Support focuses on finding solutions for the technical issues, such as corrosion and sticky solids. In addition, this activity provides for collaboration with other agencies including the Department of Defense, National Aeronautics and Space Administration, EPA, industry, universities, and other federal and state agencies to reduce duplication, enhance acceptance and progress, and leverage resources.

The SCWO Demonstration activities includes the design, construction, and operation of a SCWO mixed waste pilot plant capable of 300-500 gallons per day of water throughput. This plant will be used for demonstrating the SCWO technology's ability to safely and effectively treat applicable DOE mixed radioactive waste.

The technology, as it presently exists, is not considered sufficiently mature to proceed directly to the treatment of radioactive waste. The direct scale-up from bench scale to a radioactive waste pilot plant is considered to be high risk and costly. Much of the technology development required for demonstration can be performed on a considerably less expensive nonradioactive pilot plant. Therefore, the demonstration of a SCWO mixed waste pilot plant will be undertaken in two phases. **Phase I, Hazardous Waste SCWO Demonstration**, will demonstrate (1) the technical efficiency and cost effectiveness of SCWO technology for destroying DOE industrial and hazardous wastes; (2) provide valuable engineering design data, including safety considerations, for scale-up of the technology; (3) answer key questions regarding issues such as throughput, materials, and corrosion related to various waste streams; and (4) generate data that will be useful to DOE regarding mixed waste treatment options. The hazardous waste SCWO unit is scheduled to start testing in the summer of 1994.

Phase II, Mixed Waste SCWO Demonstration, will design, construct, and test a pilot scale SCWO unit for processing mixed waste. This phase will include the design and fabrication of a facility for housing the pilot plant. Some activities included in these two phases will be conducted in parallel to accelerate demonstration of a mixed waste unit. The Mixed Waste SCWO unit is scheduled to start testing in Fiscal Year 2001.

Selected Past Accomplishments

Proof of Concept of a supercritical water oxidation (SCWO) waste treatment unit has been demonstrated. An initial list of candidates wastes for SCWO treatment has been completed.

1993 Accomplishments/Objectives

Completed surrogate waste testing.

Completed performance specification for the design of the hazardous waste pilot plant.

Initiate design of the hazardous waste pilot plant.

Complete corrosion and neutralizers study. Determine solubility and behavior of neutralizers during pilot tests. Determine techniques for removing deposit-forming constituents.

Establish Memorandum of Understanding with Department of Defense.

1994 Objectives

Complete construction of the hazardous waste pilot plant and initiate testing of the system.

Complete conceptual design of the mixed waste pilot plant.

Initiate NEPA documentation for the mixed waste pilot plant.

Continue Supercritical Water Oxidation (SCWO) developmental support activities on waste characterization, process optimization, process modeling, high-temperature chemistry, materials and corrosion research, and analytical needs.

1995 Planned Objectives

Complete testing and demonstration of the hazardous waste pilot plant.

Complete mixed waste pilot plant National Environmental Policy Act (NEPA) documentation.

Initiate Preliminary Safety Analysis Report (PSAR) for the mixed waste pilot plant.

Initiate Title I design of the mixed waste pilot plant.

Continue Supercritical Water Oxidation (SCWO) developmental support activities on waste characterization, process optimization, process modeling, high temperature chemistry, materials and corrosion research, and analytical methods.

SUPERCritical WATER OXIDATION PROGRAM DEMONSTRATION SCHEDULE

Activity Milestone	92	93	94	95	96	97	98	99	2000	2001
HAZARDOUS WASTE PILOT PLANT DEMONSTRATION										
Surrogate Waste Testing		■								
Performance Specifications		■								
NEPA and All Other Regulatory Documentation		H								
Pilot Plant Design		■								
Pilot Plant Construction			■							
Pilot Plant Testing			■	■						
MIXED WASTE PILOT PLANT DEMONSTRATION										
Pilot Plant Conceptual Design		■	■							
Pilot Plant NEPA Documentation		■	■	■						
PSAR			■	■	■					
FSAR					■	■	■			
Title I Design				■	■	■				
Title II Design					■	■	■			
Pilot Plant Construction							■	■	■	
Pilot Plant Testing									■	■

SUPERCritical WATER OXIDATION TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
ID121217	SUPER CRITICAL WATER OXIDATION DEMONSTRATION PROGRAM	IDAHO NATIONAL ENGINEERING LABORATORY	2138	1212	0
		MODELL DEVELOPMENT CORPORATION			
OR121206	SUPER CRITICAL WATER OXIDATION TECHNICAL SUPPORT	OAK RIDGE NATIONAL LABORATORY	265	125	0
		MODELL DEVELOPMENT CORPORATION			

RDDT&E FY93

PROGRAM SUMMARIES

U.S. DEPARTMENT OF ENERGY /U.S. AIR FORCE MEMORANDUM OF UNDERSTANDING PROGRAM

Introduction

The Department of Energy/United States Air Force Memorandum of Understanding (DOE/USAF MOU) Program was formed by the U.S. Department of Energy (DOE), and the U.S. Air Force (USAF), to combine forces in reducing waste generation in areas common to the both agencies. This program promotes the development of pollution prevention technologies such as material substitution and advanced manufacturing techniques to reduce or eliminate the generation of hazardous waste. Joint Agency development of solutions to these shared problems, including substitution of chlorinated solvents and metal coating/manufacturing process development, leverages Federal funds.

The Program will cover all phases involved in industrial processes. It will help expedite future selection and implementation of the best technologies and show immediate and long-term effectiveness for DOE and USAF sites. The Program provides for technical performance comparisons of different available technologies under actual field conditions. These comparisons are based on effectiveness with respect to the technology itself, risk reduction, and general acceptability. The goal of the Program is to develop and transfer environmentally compliant manufacturing and repair technologies.

Background of MOU

Several projects have contributed to the establishment of a formal program between the DOE and USAF. Since the early 1980's, the Air Force Civil Engineering Support Agency (AFCEA), formerly the Air Force Engineering Services Center (AFESC), requested that the Idaho National Engineering Laboratory (INEL), perform a variety of environmental projects. These included Sodium Sulfide/Ferrous Sulfate Metals Precipitation, Metal Recovery from Sludge, Bicarbonate of Soda Stripping, Noncyanide Metal Strippers, and Biodegradable Solvent Substitution. In 1988, a Memorandum of Understanding (MOU) was signed between the DOE Office of Environmental Restoration and Waste Management (EM) and the Laboratory Commander of the AFESC. This MOU stated that the two organizations would jointly develop mutually beneficial environmental technologies.

Project Descriptions

Fiscal Year 1992 (FY92) is the first year for the formal Program. Currently, only six projects are funded. These projects include the Solvent Substitution Handbook, Alternative Paint Strippers, Spray Casting, Removal of Volatile Organic Compounds (VOCs), the Zero Discharge Plan, and MOU

Depiction of DOE/USAF MOU Program

Support. These projects emphasize pollution prevention by addressing wastes regulated by the Resource Conservation and Recovery Act (RCRA), the Clean Air Act (CAA) and the Clean Water Act (CWA).

The Solvent Substitution Handbook

The Solvent Substitution Handbook, funded by DOE and conducted at the INEL, is an effort to find suitable substitutes for chlorinated solvents used in metal cleaning processes. It is a continuation of the USAF-funded project Biodegradable Solvent Substitution. After acceptability criteria are established, the commercial market is surveyed for available products. Acceptable products are tested in the laboratory, including validation of cleaning performance, corrosion properties, recyclability and characterization of air emissions. Demonstrations show that several safe alternatives to chlorinated solvents exist. At this point the aqueous products perform the best, although some of the nonaqueous cleaners are acceptable. All of the solvent substitution test data is being compiled into an electronic Handbook, along with test results from the Alternative Paint Strippers and Biodegradable Solvent Substitution projects.

Alternate Paint Strippers

Alternative Paint Strippers is an Air Force-funded project, similar in its approach to the Solvent Substitution Handbook. Here the objective is to find chemical alternatives to conventional, toxic chemical paint strippers. Alternative chemicals are evaluated for their performance and corrosion characteristics, as well as their recyclability and air emissions.

The testing to date has evaluated stripping performance and some corrosion properties. Hydrogen embrittlement tests are planned in the next phase of work. Results show that only products used in an immersion tank perform acceptably within the allowable time. None of the spray on/brush on strippers have performed successfully. Additionally, of all the strippers that passed the performance criteria, none were biodegradable per the requirements set in the Biodegradable Solvent Substitution project.

The Spray Casting Project

The Spray Casting project is developing a new manufacturing and repair process to replace electroplating. Spray Casting, funded by both the DOE and USAF, is a new method of applying coatings directly onto substrates by spraying the molten coating material through a specially designed nozzle. By achieving a very fine, evenly distributed plume, rapid solidification can occur. This technique can also be used to cast various parts close to their final shape, or "near net shape".

Removal of VOCs

Removal of VOCs from air and water using membranes is being tested by Argonne National Laboratory, East in Chicago, IL. Jointly funded by both agencies, the project will evaluate the performance of two unit processes, Membrane Assisted Solvent Extraction (MASX) and Membrane Assisted Distillation Stripping (MADS). These techniques address dilute concentrations, the parts per billion (ppb) range, of chlorocarbons and hydrocarbons in process air and water discharges and also in groundwater. The membranes enhance mass transfer by their inherent high surface area. Large volumes of air are not used, as in conventional air stripping, since the stripping from water is done using a solvent. Potential savings come from increased efficiency over air stripping and the associated expenses of operating blowers.

Zero Discharge Plan

Zero Discharge Plan, an Air Force-funded project, is a planning document that can be used to direct activities leading to the ultimate goal of zero hazardous waste discharge from maintenance and repair facilities throughout the Air Force. This plan will provide an organized, systematic method to establish research, development, demonstration, testing and evaluation (RDDT&E) activities in support of pollution prevention in maintenance and repair operations.

MOU Support

MOU Support provides the structure to establish and execute the formal Program. It also established a DOE program office at AFCEA, which serves as the primary liaison between the DOE and USAF on environmental research and development.

The Program plans to expand by adding two more groups of projects. The first group will consist of demonstrations of low cost/low risk pollution prevention techniques. The second group will include higher cost/higher risk activities that require more development. Additionally, the Program plans to grow by including the U.S. Navy and the U.S. Army. Negotiations of an MOU with the Navy are in progress.

For more information, please contact:

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Selected Past Accomplishments

Signed Memoranda of Understanding with the U.S. Air Force and Boeing (leveraged \$2M DOE funds to \$12M).

Perform effectiveness tests for substitute solvents and alternate cleaning technologies for solvent substitution study. Elimination of hazardous chlorinated solvent wastes. system will be useful in U.S. Industry.

Demonstrated the use of an on-line solvent substitution information handbook to DOE, other governments agencies, and to U.S. industry. This resource can be used to identify alternative solvents to replace toxic halogenated and chlorinated solvents used in metal production and cleaning processes prevalent in DOE and U.S. industrial facilities.

Compiled solvent substitution data into a handbook for DOE, USAF, and private industry-saving an estimated \$131 million.

Conducted third International Solvent Substitution Workshop.

Developed hardware for a pilot-scale uranium and uranium alloy spray casting system which will significantly reduce manufacturing wastes.

Completed spray nozzle material tests for efforts to reduce waste generated in spray casting.

1993 Accomplishments/Objectives

Solvent Substitution: Provided the information necessary (and transfer to private sector) to make informed decisions regarding the replacement of toxic halogenated metal cleaning solvents with safe substitutes.

Demonstrated a technology that would significantly reduce the amount of hazardous spent acids generated in Department of Energy (DOE) and Department of Defense (DOD) operations by recycling spent acids.

Alternative Paint Strippers: Reduced/eliminated hazardous paint stripper usage for overhaul maintenance and repainting in DOE's D&D operation (presently funded only by the USAF).

Develop hardware to support the fabrication of a pilot-scale spray casting system that would be used to spray uranium and its alloys.

Apply the zero discharge planning system to DOE complex-wide pollution prevention needs.

1994 Objectives

Fabricates pilot plant for spray casting process.

Implements spray casting technology.

Demonstrates detoxification and reclamation of industrial spent acid.

Demonstrate a technology that would significantly reduce the amount of hazardous spent acids (nitric, hydrofluoric, and sulfuric) generated in Department of Energy (DOE) and Department of Defense (DOD) operations by recycling spent acids.

Complete installation and checkout of the robotic arm for the fabrication of components.

1995 Planned Objectives

Perform verification and field testing of metal coating process.

Complete transition to a strategically focussed joint program providing the interagency structure necessary execute the overall program, collaborating with and transferring technology to industry.

Complete testing on the prototype waste acid detoxification and reclamation recovery system at an active plating operation at an industrial and USAF air logistics center on DOE facility.

Perform verification and field testing of metal coating process. Transfer metal coating process technology, including final design package and pilot plant equipment.

DOE/U.S. AIR FORCE MOU PROGRAM

Target Schedule	88	89	90	91	92	93	94	95
USA/DOE Work for Others on Common Waste Minimization Technology Needs
DOE/USAF MOU Formally Executed (expires FY96, but renewable if necessary)
Establishment of Program Coordination at Tyndall AFB
Complete DOE/DOD Waste Minimization and Cleanup Technology Needs Matrix
Strategically-Focused Program (Program Baseline and Common Waste Minimization Technologies)
Demonstrate and Implement Transfer Interim Technologies

**DEPARTMENT OF ENERGY / UNITED STATES AIR FORCE
MEMORANDUM OF UNDERSTANDING TECHNICAL TASK PLANS**

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
CH221301	GROUNDWATER DECONTAMINATION OF VOLATILE COMPOUNDS	ARGONNE NATIONAL LABORATORY	0	100	0
ID101101	CHLORINATED SOLVENT SUBSTITUTION PROGRAM: A JOINT EFFORT WITH THE AIR FORCE, NAVY, BOEING AEROSPACE, AND CST TO ELIMINATE THE USE OF CHLORINATED SOLVENTS IN METAL PREPARATION AND CLEANING	IDAHO NATIONAL LABORATORY DEPARTMENT OF DEFENSE	312	149	1300
ID121301	DEPARTMENT OF ENERGY AND UNITED STATES AIR FORCE MEMORANDUM OF AGREEMENT SUPPORT	IDAHO NATIONAL ENGINEERING LABORATORY	190	700	0
OR133001	SPRAY CASTING	OAK RIDGE NATIONAL LABORATORY DEPARTMENT OF DEFENSE	120	0	0
PE021301	SPRAY CAST TO NEAR NET SHAPE/QUALITY WEAR RESISTANT COATING	PITTSBURGH ENERGY TECHNOLOGY CENTER	400	500	600
RL333001	WASTE ACID DETOXIFICATION RECLAMATION OF METALS	PACIFIC NORTHWEST LABORATORY	18	0	0

ENVIRONMENTALLY CONSCIOUS MANUFACTURING

Abstract

Future environmental problems can be prevented by minimizing the use of hazardous materials and decreasing the amount of waste that is generated. Reducing waste at the source eliminates the need for treatment, storage, and disposal. Environmentally Conscious Manufacturing can minimize hazardous waste and reduce energy consumption while improving operational efficiency and safety.

The purpose of the Environmentally Conscious Manufacturing Integrated Demonstration (ECM-ID) is to implement, through balanced process integration, a total systems approach to ECM that will lead to cost-effective elimination of waste in the manufacture of electronic and electromechanical components. ECM is the focus of a program to establish partnerships with U.S. industry. Initial emphasis is on processes related to the fabrication of electronic devices, although programs are being developed in a variety of areas. Education provides a forum for information transfer from technology development programs to the customer or end user.

These pages examine Environmentally Conscious Manufacturing as an Integrated Demonstration and as a partnership with U.S. industry. Education is described as an important part of ECM technology transfer.

What is an Integrated Demonstration?

An integrated demonstration is a management concept developed to facilitate timely and effective application of new and enhanced technologies to meet the Department of Energy's environmental restoration needs. An integrated approach best utilizes government funding and talent by minimizing duplication of effort and assuring rapid evaluation of new technologies. Multiple technologies are assembled and evaluated as tools for a cradle-to-grave solution to a specific problem representing a generic environmental issue.

Entire systems of technologies are evaluated with respect to performance, safety and cost effectiveness. Through collaborative partnerships with DOE laboratories, universities, federal agencies, and private industries, the developers of each technology are brought together with experts in the many facets of the demonstration. Chemists, geohydrologists, geophysicists, biologists, drilling engineers, environmental engineers, environmental modelers, materials scientists, and others involved in the project each approach the project from a unique perspective. Major savings in time and federal tax dollars can be realized by demonstrating multiple technologies

at one test bed. Site characterization, modeling, and monitoring information can be shared, validated, and compared, thereby increasing its technical and interpretive value and improving evaluation of the technologies being demonstrated.

This approach is especially efficient at the environmental sites controlled by the Department of Energy, where long term demonstrations of new remediation technologies are planned. It allows for quick application of potential remediation technologies and "apples to apples" comparisons of their performance. For the difficult environmental remediation problems where no proven methods exists, new solutions may be proposed and demonstrated. Benefits include the ability to exploit successful technologies while abandoning less promising ones.

Introduction

Many of our nation's serious environmental problems have already been solved. We are less often confronted with smokestacks belching out black clouds of pollutants, but are now more likely to encounter low level, long term environmental contaminants from sources that are more difficult to recognize and control. Small leaks from underground storage tanks that go undetected for years allow volatile organic hydrocarbons to contaminate soil and groundwater. Disposal of low level pollutants such as chlorofluorocarbons (CFCs), of little significance locally, have a collective global impact by depleting the protective ozone layer in the upper atmosphere. The Department of Energy's Environmental Restoration and Waste Management Program is coordinating an effort to address and solve today's complex environmental problems.

Sandia National Laboratories, in a program funded through DOE's Office of Technology Development, has developed innovative approaches to the environmental, economic, and productivity problems associated with environmental contaminants from manufacturing processes. These new technologies have been directed at multiple steps along the manufacturing process.

A key factor in DOE's Environmentally Conscious Manufacturing Program is waste minimization. Future environmental problems can be prevented by minimizing the use of hazardous materials and decreasing the amount of waste that is generated. Reducing waste at the source eliminates the need for treatment, storage, and disposal. Environmentally Conscious Manufacturing can minimize hazardous waste and reduce energy consumption while improving operations efficiency and safety.

Project Background

Chlorinated and chlorofluorinated hydrocarbons have been used by industry for decades as solvents to clean electronic and mechanical assemblies. As it becomes known that these toxic materials are harmful to the environment, their use is being curtailed, and in many cases, eliminated. The U.S. Department of Energy's production complex, as well as private industry, is faced with an increasing number of environmental regulations that will significantly affect the manufacture of its high technology products by limiting the production, use and disposal of these hazardous materials.

Congress declared waste minimization to be national policy in the Pollution Prevention Act. The Resource Conservation and Recovery Act and regulations require each waste generator to have a waste minimization program in place. In DOE Order 5400.1, the General Environmental Protection Program sets forth Departmental policy on waste minimization. The Montreal Protocol and Clean Air Act mandate and regulate chlorofluorocarbon (CFC) emissions and calls for their complete phaseout by the year 2000.

Objectives of the Environmentally Conscious Manufacturing Integrated Demonstration

- Reduce the risk to production workers and the cost of electronic production.
- Design electronic manufacturing methods to meet the Montreal Protocol.
- Evaluate environmentally tolerant cleaners and solvents to replace chlorinated and chlorofluorinated hydrocarbons.
- Develop fluxless soldering techniques to eliminate the use of hazardous solvents to clean rosin or organic acid fluxes from electronic components.
- Develop dry process cleaning technologies to eliminate the use of halogenated solvents in cleaning operations.
- Develop on-line characterization, monitoring, and control technologies to allow VOC and CHC emissions as well as the mixing ratio for polymeric materials to be monitored during processing.
- Highlight ECM Technologies that are ready for implementation into the manufacturing process.
- Fabricate three functional units and compare these units to those made with conventional processes.

- Focus on the Kansas City Plant for the elimination of hazardous waste streams while maintaining or improving product quality.
- Evaluate the cost and benefit associated with ECM technologies.

Environmentally Conscious Manufacturing Integrated Demonstration

The Department of Energy, Sandia National Laboratories, a design and engineering complex, and an integrated contractor, Allied Signal Inc. (Kansas City Division) have signed a three-party agreement for the elimination of CFCs and CHCs at the Kansas City Plant. This cooperative effort provides a path for technology transfer of Environmentally Conscious Manufacturing techniques being developed at Sandia, demonstrated at Allied Signal, and disseminated to private industry through Allied Signal's subcontractors. Approximately 90% of all electronics component manufacturers have a contract with Kansas City Plant, therefore these technologies can be rapidly transferred to industry.

The ECM Integrated Demonstration (ECM-ID) was initiated in FY 1990 to provide a total systems approach for the development of precision cleaning, soldering, plating, and encapsulation processes that minimize the generation of hazardous waste in electronics manufacturing.

The ECM Integrated Demonstration will:

- Identify and test alternative cleaning materials and processes to replace hazardous solvents currently in use;
- Evaluate alternative manufacturing processes that would drastically reduce or completely eliminate the need for cleaning
- Provide real-time process control techniques resulting in more precise control, fewer emission, and less waste.

All of these approaches will result in high-quality, cost effective, environmentally sensitive products.

Technologies to be developed and demonstrated at the Kansas City Plant includes:

- Substitution of aqueous solvents for chlorinated solvents;
- Dry process cleaning of surfaces including plasma cleaning and laser ablation;
- Fluxless soldering to reduce solvent use; and,
- On-line characterization and control to measure both product quality and air emissions.

Solvent Substitution

In manufacturing processes, it is often essential to have ultraclean surfaces to assure good electrical connections, reduce the opportunity for corrosion, allow for metallic and adhesive bonding, and minimize product faults. This is especially true in sophisticated electronic devices where circuits are less than paper thin and reliability cannot be compromised.

Traditional cleaning methods, using solvents such as trichloroethylene, perchloroethylene, and methylene chloride, pose various hazards to worker health and the environment. Very aggressive in dissolving surface oils on circuit boards or machined parts, these agents may contribute to subsequent corrosion of the components.

One project area at Sandia National Laboratories is the parallel development of environmentally tolerant cleaners and a means to evaluate the cleaning capability of these materials. An ideal industrial solvent would not contribute to corrosion, would be easily degraded in the environment to non-harmful materials, and would have good tolerance for human exposures. Substitute solvents being considered include materials such as fruit rind extracts and water based solvents that will not have a detrimental effect on the environment.

Basic to this research is determination of how clean is clean enough. In order to test and evaluate candidate replacement solvents and their effects on manufactured products, the staff at Sandia has developed standard residue levels, means for comparison of cleanliness, and environmental chambers, such as the Facility for Atmospheric Corrosion Testing. Once a component has been produced using a new cleaning agent, this equipment is used to evaluate its long-term reliability by simulating the environment that the product is designed to see over a given period of time. For example, ten years of aging time and exposure can be simulated in fourteen days.

If testing of these substitute cleaners proves positive, the manufacturing community will be able to substantially reduce their organic solvent use and hazardous material disposal problems.

In addition to replacing halogenated organic solvents with non-hazardous ones, Sandia is developing new processing techniques which do not require the use of solvents. These new techniques include "dry process" surface cleaning and fluxless soldering for joining metal pieces.

Assessment of these technologies (i.e., solvents and processes), will result in a better understanding of their impacts on the environment and their use in manufacturing processes and materials.

Dry Process Cleaning

Dry process cleaning involves the use of dry etching techniques such as plasma etching and laser ablation as a substitute for solvent cleaning procedures. In plasma cleaning, electrically neutral ionized gases remove contaminants from the material surface by thin layer etching. This process is already used in some industrial applications. However, the surface contaminant removal rate is typically much too slow for most cleaning requirements. The objectives of this plasma cleaning development program is to increase the speed of the plasma etching process.

Laser ablative cleaning involves the use of very short pulses of high peak power laser radiation to vaporize thin layers of material surfaces. A relatively new cleaning process that is currently employed in only a few industrial applications, laser ablation is proving to be very efficient as a cleaning process for the removal of contaminants from material surfaces.

Both plasma cleaning and laser ablative cleaning produce much less chemical waste than most industrial solvent cleaning processes. These technologies require very little operating energy inputs and consume small or insignificant amounts of materials. Laser ablation represents the ultimate in waste minimization processes. Waste generation is limited to the volume of material vaporized from the surface to be cleaned.

Accompanying these environmental advantages are the increased productivity and quality control aspects. Laser and plasma cleaning methods do not have the corrosion problems associated with cleaning solvents.

Fluxless Soldering

Conventional soldering fluxes remove contaminants and unwanted films from the soldering area to insure proper bonding of the metallic part and the solder. However, the chemically active flux residues must then be removed from the solder joint to avoid corrosion during the extended life of the product. Solvent cleaning of printed circuit boards is presently a major source of Chlorofluorocarbon usage within the DOE production complex.

From an environmental perspective, fluxes also present hazards associated with their manufacture, handling, application, and disposal. Many of the chlorinated compounds used as fluxes can produce adverse health effects in humans.

Investigations at Sandia National Laboratory have led to alternative soldering processes which do not require the use of

fluxes. These methods use special soldering compounds and controlled atmospheres, thermomechanical surface activation, and protective coating technologies. The acid vapor soldering process, for example, replaces fluxes that need to be cleaned, with an acid vapor gas that reduces surface oxides. Aqueous based or low solids fluxes are being used to drag solder over the printed wiring boards for the ECM-ID programmer. Laser soldering, which eliminates the need for flux, is also under development.

These innovative soldering technologies reduce the handling and storage of hazardous fluxes and solvents, and minimize the quantities of mixed solvent waste generated during flux-residue removal process. Fluxless soldering can not be applied to all soldering operations, but for those applications where it is practical, it provides an alternative means of reducing the use of environmental contaminants and minimizing adverse occupational exposures.

Process Monitoring and Control

Environmental releases often occur due to production fluctuations and out-of-specification conditions. Most manufacturing operations are designed around controlled conditions. Sensors that respond quickly to process or waste stream chemical concentrations can make automatic corrections or alert operators to respond to distressed conditions. Two historical problems with environmental sensors have been their slow response time, and their lack of chemical specificity at low concentration levels.

Research and development work at Sandia Laboratories combined acoustic wave technology and polymer coatings to produce chemically specific, fast response chemical sensors. These devices consist of vibrating surfaces constructed of special materials which are adsorptive-sensitive to specific chemicals or groups of chemicals. When placed in a process stream, the target chemical to be monitored is adsorbed onto the vibrating surface, causing a change in its impedance.

A Portable Acoustic Wave Sensor (PAWS) module has been developed to monitor the solvent usage of both conventional and alternative solvents in cleaning operations. The PAWS system provides real-time on-site monitoring of volatile organic solvents such as chlorinated hydrocarbons. It allows direct evaluation of the chemical causing the response, as well as determining its concentration in either a gas or liquid phase environment. Because these systems are portable, they can easily be applied to a variety of operations within the DOE complex and in other industries such as cleaning operations where volatile organic solvents are used. These monitoring and control systems will enable manufacturers to better characterize and control processes, recycling, and waste streams. This will reduce production costs, minimize waste generation, and result in better use of chemicals and improved product quality.

ECM In Industry

Sandia manages collaborative efforts in ECM with small businesses in New Mexico. These programs are promoted through Sandia's Technology-based Regional Economic Development (TRED) program. Small businesses nationwide are eligible for support. Some of these companies are:

- *Languna Industries* - for the development and demonstration of a liquid effluent pH monitor and control system to prevent unwanted discharge of waste prior to treatment.
- *Organic Plus - Inc.*, for the development of an electrostatic precipitation process to enable the application of an environmentally benign pesticide for household and agricultural use.
- *Roses Southwest Paper* - for process modifications to improve production yield of McDonald's paper bags made from recycled paper.

Sandia is also developing programs with member companies of the National Center for Manufacturing Sciences (NCMS)

- *Ford Motor, American Telephone and Telegraph, Texas Instruments, General Motors/Delco* - for the definition and measurement of clean electronics. The focus is on characterization of devices cleaned with alternative non-CFC solvents.
- *GM/Allison, Pratt & Whitney, INEL* - for the definition and measurement of clean metals. The focus is on defining, "How Clean is Clean?".
- *American Telephone and Telegraph* has the lead for the development of an ECM life-cycle analysis methodology called, "Design for Environment (DFE)".

A CRADA with *Motorola* has resulted in a new printed wiring board soldering process that could eliminate one-fifth of the worldwide consumption of CFCs. This self-cleaning soldering process uses a machine that is available commercially and that results in significantly less contamination than other soldering processes.

Sandia is also pursuing CRADAs with major U.S. automotive manufacturers to reduce the waste from surface coating processes (painting); achieve cost-effective recycling of polymers in polymer alloying processes; and, solvent-free cleaning using pelletized CO

ECM Education

Education is an important part of ECM technology transfer. Education provides a forum for information transfer from technology development programs to the customer or end user.

Without these types of programs, information and/or technology transfer occurs slowly and implementation is limited. Education is also a mechanism by which a cultural change can occur from the ground up, from the students and professors at the universities as well as staff and management in industry. Sandia is currently involved in a variety of education initiatives.

WERC - The Waste Management Education and Research Consortium

WERC is sponsored by DOE, New Mexico State University, University of New Mexico, New Mexico Institute of Mining and Technology, Sandia National Laboratories, Los Alamos National Laboratory, and Navajo Community College.

WERC develops technologies, human resources and educational programs to assist in the management and training for companies and professionals involved in waste management and environmental restoration. WERC's objectives include:

- Providing programs that transfer state-of-the-art technology to people and companies who generate, handle, transport and dispose of wastes associated with industry;
- Providing research programs that define the frontiers of waste-related technology;
- Maintaining strong liaison with the national laboratories, industries involved in waste management; and,
- Using the latest communication techniques for education and technology transfer.

California Community Colleges Centers for Applied Competitive Technology (CACT)

CACT is sponsored by the DOE/EM/OTD/Technology Integration Division; Sandia National Laboratories; and, Lawrence Livermore National Laboratory. The focus of its activities is to transfer technology to small and medium size businesses. CACT's activities include:

- Satellite broadcasts to eight California Community Colleges
- Lectures on ECM topics
- Interfaces to laboratories to solve environmental problems
- Training material for small and medium size businesses

ECM Newsletter

The ECM Newsletter consists of technical and nontechnical information obtained from industry and research laboratories. The contributors to this newsletter have had success in their research or implementation of new environmentally conscious manufacturing processes and want to share this information.

Selected Past Accomplishments

Instituted a complex wide Environmentally Conscious Manufacturing (ECM) program at Kansas City Plant.

Completed characterization and began testing of fluxless soldering techniques which reduce the amounts of hazardous solvents and the number of cleaning steps during electronic soldering.

Completed waste characterization studies to use D-limonene, a non-hazardous solvent, to produce electronic printed wiring boards. This research indicates that non-hazardous solvents can be successfully substituted into the DOE production processes in compliance with Federal regulations requiring the elimination of hazardous materials in manufacturing processes.

Demonstrated a portable acoustic wave sensor system to monitor volatile organic compounds. This device provides improved capabilities to control, characterize, and document manufacturing processes, waste streams, and exhaust systems. This will help verify that waste minimization has been achieved and provide DOE with accurate information on air standard compliance.

Demonstrated laser ablative cleaning and fluxless soldering on copper, aluminum, and kovar (an epoxy potting material). Laser ablative cleaning involves the use of very short pulses of high power laser radiation to vaporize thin layers of contaminants from surfaces. Fluxless soldering eliminates solvents commonly used in the electronics industry for cleaning flux residue from printed wiring boards. This process produces less chemical waste than most industrial solvent cleaning processes, thereby contributing to DOE and EPA waste minimization goals.

Field tested a portable acoustic wave sensor module which will provide improved detection of off-gases, allowing more efficient spray casting solvents.

Substituted chlorinated solvents with terpene-based solvents.

Implemented on-line characterization and control to measure both product quality and air emissions.

Implemented fluxless soldering to reduce solvent use.

Implemented dry process cleaning of surfaces.

Demonstrated plasma cleaning and laser ablation.

Fabricated the first portable acoustic wave sensor test module.

Selected a process to monitor volatile organic compounds (VOCs).

Reduced the Kansas City Plant (KCP) emissions by 60% from the 1988 baseline, when it was the third highest source of emissions in the Kansas City area.

Implemented Environmental Conscious Manufacturing (ECM) technologies in the manufacture of three functional demonstration B61 programmers at Allied Signal Kansas City Division (AS-KCD).

Implemented D-Limonene as the alternative solvent for cleaning at Allied Signal Kansas City Division (AS-KCD).

Support of the Environmentally Conscious Manufacturing Integrated Demonstration (ECMID) component has resulted in additional tests to determine if aqueous fluxes are suitable for the drag soldering process.

Fully integrated Environmentally Conscious Manufacturing (ECM) technologies for cleaning, soldering, organic materials, and monitoring in the manufacture of the demonstration programmer at Allied Signal Kansas City Division (AS-KCD) resulting in functional electronic assemblies.

1993 Accomplishments/Objectives

Achieved waste minimization using real time, on line monitoring for characterization and integrating PAWS into systems with automated analysis techniques to improve process control.

Pursued the development of lead free solder, development of analysis and gain techniques and alternate cleaning processes, and comparison of test results of parts manufactured using environmentally clean techniques and materials with original parts.

Develop a life cycle model to evaluate environmental impacts.

Complete formal cost benefit analysis of the B61 programmer demonstration unit.

Complete functional testing of the B61 programmer demonstration units.

Select and fabricate a second demonstration component using Environmentally Conscious Manufacturing (ECM) technologies for continued development and comparison to conventional technologies.

Identify appropriate waste minimization technologies for development to ensure low effluent processes. These include evaluation of supercritical CO₂ cleaning, aqueous and d-limonene recycling processes for cleaning, lead-free soldering, advanced laser soldering technologies.

Increase private industry participation, through an "umbrella" Cooperative Research and Development Agreement (CRADA) and working with other Environmentally Conscious Manufacturing (ECM) projects throughout DOE.

Program ends with FY 93.

ENVIRONMENTALLY CONSCIOUS MANUFACTURING INTEGRATED DEMONSTRATION (ECMID)

Time Phased Schedule	90	91	92	93	94	95
Management, Oversight, Integration & Tech. Transfer						
Solvent Substitution						
Cleaning Alternative*SCCO ₂ /Recycling						
*PAWS Module Phase I						
PAWS Phase II/Cleaning Sensor						
Soldering Technology						
Integrated Soldering Technologies (Laser Soldering Lead-Free Solder)						
ECM Life Cycle Analysis Model						
Base Program						
ECMID Closeout						
Plating Alternative/Sensors						
Inherently Safer Organics						
Demo 1 (B61 Programmer)						
Demo 2 (B61 Electronic Assembly)						
Demo 3 (MAST Component TBD)						
Demo 4 (MAST Component TBD)						

* SCCO₂ = Supercritical CO₂ Cleaning
PAWS = Portable Acoustic Wave Sensor

ENVIRONMENTALLY CONSCIOUS MANUFACTURING INTEGRATED DEMONSTRATION TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
AL411301	ENVIRONMENTALLY CONSCIOUS MANUFACTURING AT KANSAS CITY PLANT (REDUCE CHLOROFLUOROCARBONS, (CFC), CHLOROHYDROCARBONS (CHC), AND VOLATILE ORGANIC COMPOUNDS (VOC) USAGE, WASTE GENERATION AND AIR EMISSIONS)	ALLIED SIGNAL, INC.	0	700	0
AL433001	VALIDATION OF ENVIRONMENTALLY CONSCIOUS MANUFACTURING INTEGRATED DEMONSTRATION (ECMID) HARDWARE	ALLIED SIGNAL, INC.	3	0	0
AL201301	SOLVENT SUBSTITUTION STUDY	SANDIA NATIONAL LABORATORIES-ALBUQUERQUE	0	700	1074
AL201302	FLUXLESS SOLDERING TO REDUCE SOLVENT USE	SANDIA NATIONAL LABORATORIES-ALBUQUERQUE UNIVERSITY OF CALIFORNIA AT BERKELEY STATE UNIVERSITY OF NEW YORK AT STONEY BROOK	0	600	410
AL201303	ON-LINE MONITORING OF VOLATILE ORGANICS FOR WASTE MINIMIZATION	SANDIA NATIONAL LABORATORIES-ALBUQUERQUE	317	650	934
AL201304	DRY PROCESS CLEANING OF SURFACES	SANDIA NATIONAL LABORATORIES-ALBUQUERQUE	0	200	1162
AL221301	INTEGRATED DEMONSTRATION FOR ENVIRONMENTALLY CONSCIOUS MANUFACTURING INTEGRATED DEMONSTRATION (ECMID)	SANDIA NATIONAL LABORATORY MASSACHUSETTS INSTITUTE OF TECHNOLOGY HEWLETT PACKARD TEXAS INSTRUMENTS	508	655	0
AL233005	LEAD-FREE SOLDER PASTE: DEVELOPMENT AND CHARACTERIZATION OF ALLOYS	SANDIA NATIONAL LABORATORY	32	0	0
CH133001	LEAD-FREE SOLDER PASTE: DEVELOPMENT CHARACTERIZATION OF ALLOYS	AMES LABORATORY	55	0	0

WASTE COMPONENT RECYCLE, TREATMENT, AND DISPOSAL INTEGRATED DEMONSTRATION (WeDID)

The Waste Component Recycle, Treatment, and Disposal Integrated Demonstration (WeDID), a DOE Office of Environmental and Waste Management (EM) sponsored program, is testing and demonstrating available technology to support DOE's nuclear weapon dismantlement mission in reducing wastes generated. In September 1991, President Bush announced that the United States nuclear weapons stockpile would be significantly reduced. Further reductions have been announced in 1992. To meet these goals requires the Department of Energy (DOE) to return many of these weapon systems to the DOE Pantex Plant in Texas for dismantlement. After dismantlement, a wide variety of components, representing over 30 years of hardware development, need to be disposed of properly. Some materials will be recycled and others disposed of, in accordance with environmental regulations. To maximize the amount of material recycled, and to comply with environmental disposal regulations, will require advanced treatment processes that are technologically robust and cost-effective. This program addresses only non-nuclear components. Components in the physics package are not included.

WeDID Scope

WeDID is focusing on demonstrating end-to-end disposal processes for Sandia National Laboratories designed weapons components. Recycle technologies will be used to recover valuable metals which constitute at least 30% of the mass of these components. Hazard separation techniques will minimize hazardous wastes and may virtually eliminate mixed wastes. Finally, treatment technologies to destroy, minimize, and stabilize the resulting waste residues will be demonstrated.

Types of Materials

The components found in a Sandia designed system include potted electronics, electro-mechanical devices, mechanical actuators, parachutes, etc. Hazards associated with these

components include heavy metals (e.g., lead from solder, cadmium plating on housing, beryllium, mercury), small amounts of radioactive materials, PCBs, self-contained explosives, asbestos, and foams. Some components are classified. Most components are generally sealed in an opaque potting (foam or epoxy), making hazard separation difficult.

WeDID Accomplishments

Several technologies are currently being demonstrated and evaluated for their ability to process a wide range of components. The technologies selected for baseline demonstration are: acid digestion, vitrification, and steam reforming. Residues after processing showed mass reductions of 20-80% and volume reduction of 40-80%. Four classes of weapon components were processed by the baseline technologies in FY92.

Example of components found in a Sandia designed system

Improvements to these technologies as well as demonstrations of advanced technologies (e.g., mining separations, molten metal and plasma arc technologies) will continue in FY93.

Material preparation technologies demonstrated include water-jet cutting of parachutes, removal of selected materials from weapon components, cold fracture method, and forge hammering. Forge hammers can crush components into pieces of rubble ranging in size from specs of dust to 1 inch diameter, in a matter of 45-90 seconds. This technique makes a component easier to treat and chemically characterize, increase the opportunity to separate and recycle metals, and helps demilitarize/sanitize classified weapon components. WeDID also was able to assist the organizations responsible for dismantlement in obtaining surplus forge hammers for two facilities (Pantex and Allied Signal Kansas City) at no cost to these facilities.

Cold fracture method cools components to liquid nitrogen temperatures (70 K) and embrittles the organic constituents. A forge hammer is then used to shatter the organic materials and ease material separation.

The quick response of this program to others' weapon component processing needs is demonstrated by the recent transfer of water-jet cutting technology to the users. Parachutes were being burned or cut by knives which quickly dulled due to the use of Kevlar in the material. In three months, water-jet cutting techniques were identified, an automated system successfully demonstrated, and the entire cutting system transferred. In addition to performing system cost/benefit analysis of processing technologies, WeDID will continue to rapidly identify, demonstrate, and transfer techniques and technologies in response to urgent user needs.

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**A printed circuit board, before and after
processing by each of three technologies**

PC board before processing

After Steam Reforming

After Acid Digestion

After Vitrification

Selected Past Accomplishments

Successfully demonstrated cold fracture techniques with forge hammer to break-up weapons components for pretreatment, separation, and recycle. Cold fracture techniques effectively separate and demilitarize electronic components which are sealed in organic potting material. Three forge hammers were identified in Department of Defense (DoD) surplus, were shipped and now in use at Sandia and Pantex. The forge hammers were obtained virtually cost-free and have been successful in treatment, recycle, and disposal of materials resulting from the dismantlement of weapons.

Successfully demonstrated a water-jet cutting system device to remove hazardous and radioactive portions of components and to segregate wastes during the recycle of weapons. This system has demonstrated a wide range of capabilities from simply removing thermal batteries from the pre-flight control unit to removing the more complex hidden gas tubes. This system has also been used to demilitarized Kevlar parachutes. The Kevlar is being purchased at \$1/lb for recycle.

As part of a demonstration of pretreatment technology for non-physical-package components of nuclear weapons, a fire set was declassified and demilitarized to the satisfaction of the classification staff at Sandia National Laboratories. Thirty-two fire sets were frozen to -70°C and then fractured in a 1929 forge hammer. These components represent the hardest of all weapon components. They were processed faster, cheaper, and more completely than using the standard declassification method of shearing the component.

Demonstrate pretreatment techniques to demilitarize returning weapons components and recycle precious metals and parts.

Completed treatment technology feasibility demonstrations using personal computer circuit boards as surrogate waste.

1993 Accomplishments Objectives

Demonstration of operable interlock and dust control systems for forge hammer.

Identified precious metal recovery options in weapons components. Component destruction and material treatment technologies will be transferred to Defense Program (DP).

Complete treatment technology demonstrations on rugged components and those with radioactive constituents.

Complete demonstration of recycle technologies.

Select optimum recycle/treatment system based on cost/risk/benefit analysis.

Develop the engineering specifications for a prototype processing system.

Program ends with FY 93

WASTE COMPONENT RECYCLE, TREATMENT AND DISPOSAL INTEGRATED DEMONSTRATION (WeDID)

Target Schedule	90	91	92	93	94
Plan			┌───┐		
Regulatory Issues			┌──────────┐		
3 Engineering Demonstrations			┌──────────┐		
"Improved" Engineering Demonstration			┌──────────────────────────┐		
Cost/Benefit/Risk Analysis				┌──────────┐	
Characterization Methods			┌──────────────────────────┐		

WASTE COMPONENT RECYCLE, TREATMENT, AND DISPOSAL INTEGRATED DEMONSTRATION TECHNICAL TASK PLANS

NUMBER	TITLE	CONTRACTOR	FUNDING (\$ IN THOUSANDS)		
			FY 93	FY 92	FY 91
AL433003	WASTE COMPONENT RECYCLE, TREATMENT, DISPOSAL INTEGRATED DEMONSTRATION -CHEMICAL DEPOTTING OF ELECTRONIC ASSEMBLY	ALLIED SIGNAL, INC.	51	0	0
AL221302	WASTE COMPONENT RECYCLE, TREATMENT, AND DISPOSAL	SANDIA NATIONAL LABORATORY	820	575	0
ID121214	TWO-DIMENSIONAL (2-D) BAR CODE RESEARCH AND DEVELOPMENT	IDAHO NATIONAL ENGINEERING LABORATORY	0	50	0
RL321313	VITRIFICATION TREATMENT OF HETEROGENEOUS WASTE COMPONENTS	PACIFIC NORTHWEST LABORATORY	0	150	0
RL421301	ACID DIGESTION DEMONSTRATION	WESTINGHOUSE HANFORD COMPANY	0	125	0
SR121301	DEMILITARIZATION AND IMMOBILIZATION OF WASTE COMPONENTS	WESTINGHOUSE ELECTRIC CORP	0	150	0

RDDT&E FY93 PROGRAM SUMMARIES

RDDT&E NEW INITIATIVES AND INNOVATIVE TECHNOLOGIES

The Innovation Investment Area (IIA) is a component program in EM-50's Office of Technology Development. The mission of the IIA is to identify and provide development support for (1) technologies that show promise to address specific EM needs, but require proof-of-concept experimentation, and (2) already proven technologies in other fields that show promise of being adapted and applied to specific EM needs.

The Technology Development (TD) Program is committed to ensuring that private industry and other Federal agencies are major participants in developing and deploying technologies for Environmental Restoration and Waste Management. To this end, substantial funds are being set aside for interagency agreements (IAGs) and industrial participation. These funds will also be used to support research and development in areas not yet assigned to an integrated demonstration or program. Projects in this area may include unique, high risk, high payoff technologies.

Support and New Initiatives and Innovative Technologies are the two program elements that make up the IIA program. Support and New Initiatives supports development of new and emerging technologies by providing funding to individual projects not assigned to a specific element and to activities of mutual interest through Procurements, IAGs, CRADAs, and Grants. Innovative Technologies supports the development of innovative technologies by providing funding to high-risk RDDT&E initiatives with a potential for high payoff in the short term. For these technologies to actually be used to solve waste management and environmental restoration problems, the TD program must be able to turn over novel technologies to be included in the Record of Decision for the various waste sites. Similarly, the IIA must be able to target and turn over technologies it is researching to other TD programs in EM-50 for further development and to the users for implementation.

Six basic approaches support the IIA in solicitation input from universities, private industry, national labs, and other Federal agencies for the development of novel technologies.

Program Research and Development Announcements (PRDAs) are program announcements used to solicit a broad mix of R&D and DT&E proposals from the private sector and universities.

Interagency Agreements (IAGs) are the result of memoranda of understanding between DOE and another Federal agency for the purpose of developing and testing technology development activities of mutual interest.

Grants represent financial assistance awards to interested parties related to a public interest goal. Such goals include possible non-DOE or other Federal agency participation and use.

Cooperative Research and Development Agreements (CRADAs) are agreements between national laboratories and any non-Federal source to conduct cooperative R&D that is consistent with the lab's mission

Research Opportunity Announcements (ROAs) are procurements used to solicit proposals from the private sector and universities in applied research only. Multiple awards are made with a small portion of the funding set aside for the participation of small businesses.

New Initiatives, solicited from the national laboratories, constitute promising new technologies that are directly applicable to the EM mission, but that find broader application once developed successfully.

The IIA is committed to ensuring that private industry, DOE national labs, Federal agencies and universities are major participants in developing and deploying new and emerging technologies for environmental restoration and waste management. In providing seed money to these technology developers, and in interacting with TD program managers and with user liaisons, TD ensures that DOE funds are leveraged and research of promising technologies is accelerated to fill technology gaps identified by IPs and IDs, or to move successful projects to the user for implementation or to the private sector for commercialization.

Selected Past Accomplishments

Signed an Interagency Agreement with Department of Defense to develop and test a Ground Penetrating Radar (GPR) Imaging System. Completed 2D design of the GPR imaging system.

Continued multi-year Interagency Agreements (IAGs) with Environmental Protection Agency (EPA) to provide funding to its Hazardous Substance Research Center (HSRC) and the SITE Emerging Technology programs to develop, test, and evaluate technologies of mutual interest.

Developed Pneumatic Fracturing technique as a result of the Interagency Agreement (IAG) with Environmental Protection Agency (EPA) for Department of Energy (DOE) participation in the Hazardous Substance Research Center (HSRC) program.

Established a multi-year Interagency Agreement (IAG) with Environmental Protection Agency (EPA) for the Mine Waste Pilot Program.

Department of Energy (DOE) joined with Department of Defense (DoD), Department of the Interior (DOI), and Environmental Protection Agency (EPA) in an Interagency Agreement (IAG) with the Western Governors Association facilitated by the White House.

Completed all 15 projects funded under the Argonne National Lab Procurement. Transferred successful technologies (e.g. SEAMIST and cone penetrometer technology from the Innovation Investment Area to the Soils and Groundwater Investment Area).

Awarded 21 contracts under the first Morgantown Energy Technology Center (METC) Program Research and Development Announcement (PRDA) to the private sector in the areas of instrumentation and characterization, immobilization and storage, decontamination, and robotics.

Awarded and implemented seven contracts to the private sector and to universities for innovative technology development under the Idaho Program Research and Development Announcement (PRDA). Demonstrated the application of neural networks to waste site screening.

Issued the first Research Opportunity Announcement (ROA) in the areas of: in situ remediation of contaminated sites, characterization, sensors and monitoring, low-level waste processing, efficient separation technology for radioactive wastes, robotics, materials deposition, improved engineered barriers for waste storage and disposal, and improved waste forms for hazardous, radioactive and mixed wastes.

Awarded a contract to develop high capacity, selective solid extractants for cesium, strontium, chromium, silver, and noble metals from nuclear wastes. Contracts were signed with university and private sector R&D participants.

Established a Cooperative Research and Development Announcement (CRADA) between Idaho National Engineering Laboratory and EG&G Rotron for joint development of an ex-situ vapor phase biofilter. Completed design and construction of the biofilter and field tested a prototype for the removal and degradation of gasoline. Commercialized the hydrocarbon biofilter.

1993 Accomplishments/Objectives

Selected 19 contracts for award to the private sector and universities under the second Morgantown Energy Research Center (METC) Program Research and Development Announcement (PRDA) to develop and demonstrate technologies to recycle, reuse, and dispose of material from the Decontamination and Decommissioning (D&D) of inactive facilities.

Issue the third Morgantown Energy Research Center (METC) Program Research and Development Announcement (PRDA) on thermal processing technologies.

Issued the first and second small business technology development solicitations in the areas of in situ contaminant treatment, groundwater and soils treatment, advanced sensors and monitoring devices, robotics, efficient separation techniques, and mixed and hazardous waste treatment processing.

Evaluated the first batch of Research Opportunity Announcement (ROA) proposals submitted in response to solicitation. Selected 7 contracts for award to private sector and university research initiative.

Evaluate small business technology proposals submitted under Small Business Innovation Research (SBIR) solicitations.

Complete proof-of-concept experimentation on five of the seven projects awarded under the Idaho Program Research and Development Announcement (PRDA).

Provide financial assistance to the Diagnostic Instrumentation and Analysis Lab (DIAL) at Mississippi State University to develop and apply advanced optical diagnostic techniques and instrumentation systems to high temperature coal-fired gas streams.

Continue contract with university and private sector R&D participants to develop high capacity, selective solid extractants for cesium, strontium, chromium, silver, and noble metals from nuclear wastes.

Developed and selected proposals for mine waste remediation under the Interagency Agreement (IAG) with Environmental Protection Agency (EPA) for the mine waste pilot program.

Expanded interagency agreements to further technology integration. Initiate new agreement with National Science Foundation (NSF).

Complete two of the four research projects funded under the State of Idaho Research and Development Grant.

Completed distillation and incineration of 35,000 gallons of mixed waste solvents (hexane tank waste) from Hanford's REDOX plant.

Successfully demonstrate trichloroethylene (TCE) destruction by accelerator generated Bremsstrahlung at Lawrence Livermore National Laboratory (LLNL).

Completed development of 2D Bar Coding waste tracking system and distributed technology to over 35 Federal facilities and industrial sites.

Complete design and construction of the halocarbon biofilter through the Cooperative Research and Development Announcement (CRADA) between Idaho National Engineering Laboratory (INEL) and EG&G Rotron. Field test the prototype.

With Department of Defense (DoD) complete 3D visualization model and demonstration of ground penetrating radar imaging system, and transfer of that technology to the Characterization, Monitoring and Sensor Technologies Integrated Program.

In cooperation with the Naval Research Laboratory, develop a non-destructive technology for characterizing radioactive waste in barrels and other containers. The system will provide dimensional imaging of gamma-ray radiation sources using double Compton telescope techniques developed by industry. The system will be applicable to most Department of Energy (DOE) sites for characterization of mixed waste containers and for locating radioactive hot spots within barrels of stored waste or within surface soil in the field.

Complete bench-scale demonstration of uranium biosorbent project in collaboration with industrial partner, Ogden, at a site in former East Germany.

Complete demonstration of the cleanable stainless steel High Efficiency Particulate Air (HEPA) filter and transfer of the technology to customers and to the private sector.

Design a laboratory demonstration plasma "gun" for the controlled spraying of metal on small substrates.

Continue multi-year Interagency Agreement (IAG)s with Environmental Protection Agency (EPA) to provide funding to its Hazardous Substance Research Center (HSRC) and the SITE Emerging Technology programs to develop, test, and evaluate technologies of mutual interest.

DOE membership in the 50 NSF industry/university research centers.

Demonstrate Pneumatic Fracturing at a remediation site.

Continue involvement with Western Governors Association including developing the process for conducting cooperative demonstrations which include industry. Develop a public participation plan and work through the Federal Advisory Committee Act process to obtain external input. Define problems and technologies and announce demonstration sites for these efforts by October 1994.

Continue implementing multi-year Interagency Agreement (IAG) with Environmental Protection Agency (EPA) for the Mine Waste Pilot Program.

Signed Interagency Agreement (IAG) with the Naval Research Laboratory for the development of double Compton imaging of radioactive waste in drums.

1994 Objectives

Evaluate progress of the 21 projects awarded under the first Morgantown Energy Research Center (METC) Program Research and Development Announcement (PRDA), and transfer demonstrated technologies to integrated programs (IPs), integrated demonstrations (IDs), EM-30, EM-40, and/or the private sector.

Evaluate progress of the 19 projects awarded under the second Morgantown Energy Research Center (METC) Program Research and Development Announcement (PRDA), and transfer demonstrated technologies to integrated programs (IPs), integrated demonstrations (IDs), EM-30, EM-40, and/or the private sector.

Issue an additional small business technology development solicitation.

Evaluate small business innovative technology proposals and award contracts to small business developers in one or more topic areas.

Award contracts to private sector and university technology developers resulting from the first Morgantown Energy Research Center (METC) Research Opportunity Announcement (ROA).

Continue providing financial assistance to remaining two monitoring and assessment technologies as part of the Idaho State Research and Development Grant.

Continue providing financial assistance to the DIAL at MSU.

Complete proof-of-concept experimentation of remaining two Idaho Program Research and Development Announcement (PRDA) technologies and transfer completed and demonstrated technologies to integrated programs (IPs), integrated demonstrations (IDs), EM-30, EM-40, and the private sector.

Complete halocarbon biofilter demonstration and commercialize the technology in the private sector.

Complete design of the porphyrin bioreactor and transfer technology to the In-situ Remediation Integrated Program, EM-30, EM-40, and/or the private sector.

Continue multi-year Interagency Agreements (IAGs) and initiate new Interagency Agreements (IAGs) as needed for the purpose of developing, testing, and evaluating technology activities of mutual interest. Transfer mature HSRC and SITE technologies to interested integrated programs (IPs), integrated demonstrations (IDs), or the private sector.

Continue participation in the NSF Industry/University Cooperative Research Centers Program and provide funding to selected NSF projects.

Continue supporting the Western Governors Association.

Continue multi-year Interagency Agreement (IAG) with Environmental Protection Agency (EPA) for the Mine Waste Pilot Program.

1995 Planned Objectives

Evaluate progress of the 21 projects awarded under the first Morgantown Energy Research Center (METC) Program Research and Development Announcement (PRDA), and transfer demonstrated technologies to integrated programs (IPs), integrated demonstrations (IDs), EM-30, EM-40, and/or the private sector.

Evaluate progress of the 19 contracts under the second Morgantown Energy Research Center (METC) Program Research and Development Announcement (PRDA) and transfer demonstrated technologies to integrated programs (IPs), integrated demonstration (IDs), EM-30, EM-40, and/or the private sector.

Evaluate progress of third Morgantown Energy Research Center (METC) Program Research and Development Announcement (PRDA) contracts.

Evaluate progress of Research Opportunity Announcement (ROA) contracts.

Evaluate small business innovative technology proposals and award contracts to small business developers in one or more topic areas.

Continue providing financial assistance to any remaining monitoring and assessment technologies as part of the Idaho State Research and Development Grant.

Continue providing financial assistance to the DIAL at MSU.

Perform proof-of-principle research and application of existing technologies to environmental needs under the Innovative Technologies program. Transfer completed technologies to integrated programs (IPs), integrated demonstrations (IDs), EM-30, EM-40, and/or the private sector.

Issue one new Research Opportunity Announcement (ROA) and award contracts (for \$6M, rather than \$10M as in past).

Continue multi-year Interagency Agreements (IAGs) and initiate new Interagency Agreements (IAGs) as needed for the purpose of developing, testing, and evaluating technology activities of mutual interest integrated programs (IPs), integrated demonstrations (IDs), or to the private sector.

Continue participation in the NSF Industrial/University Cooperative Research Centers Program.

Continue supporting the Western Governors Association.

Continue multi-year Interagency Agreement (IAG) with Environmental Protection Agency (EPA) for the Mine Waste Pilot Program.

Fund research proposals at selected, relevant NSF Centers.

RESEARCH, DEVELOPMENT, DEMONSTRATION, TESTING, AND EVALUATION SUPPORT AND NEW INITIATIVES TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
AL921103	DEEP PENETRATING DIPOLE SENSOR	UNC GBOTECH INC	0	500	0
AL101201	COST SAVINGS ANALYSIS: SUPPORT TO INTEGRATED DEMONSTRATIONS	LOS ALAMOS NATIONAL LABORATORY	0	750	350
AL121126	WASTE TREATMENT PROGRAM	LOS ALAMOS NATIONAL LABORATORY	0	1500	0
AL121220	WASTE TREATMENT INTEGRATED DEMONSTRATION	LOS ALAMOS NATIONAL LABORATORY	0	35	0
AL722001	BIODEGRADATION OF LIQUID SCINTILLATION COCKTAIL/BTX	IDAHO NATIONAL ENGINEERING LABORATORY	0	80	0
		APPLIED TECHNOLOGY			
CH211101	MOUND-BRADTECH TREATABILITY	ARGONNE NATIONAL LABORATORY	600	970	0
CH333501	NORTHEAST REGIONAL COORDINATION	BROOKHAVEN NATIONAL LABORATORY (BNL)	350	0	0
HQ020004	OTHER FEDERAL AGENCY (EW50636)		500	2050	0
HQ020005	INTERAGENCY AGREEMENT (IAG) - ENVIRONMENTAL PROTECTION AGENCY (EPA) SUPERFUND INNOVATIVE TECHNOLOGY EVALUATION (SITE)		1300	500	0
HQ020006	INTERAGENCY AGREEMENT (IAG)- NATIONAL AEROSPACE ADMINISTRATION (NASA) (EW50660)		0	950	0
HQ021138	INTERAGENCY AGREEMENT (IAG) - CHLORINE-36 ISOTOPE RATIO STUDY/IDAHO NATIONAL ENGINEERING LABORATORY		0	125	0
HQ021140	MASSACHUSETTS INSTITUTE OF TECHNOLOGY (MIT) TECHNICAL DEVELOPMENT FOR ELECTROKINETICS IN SITU REMEDIATION (ISR) ENVIRONMENTAL PROTECTION AGENCY (EPA) INTERAGENCY AGREEMENT (IAG)		0	125	0
HQ021142	MEDICAL UNIVERSITY OF SOUTH CAROLINA		1800	1300	0
HQ021143	INTERAGENCY AGREEMENT (IAG) - ENVIRONMENTAL PROTECTION AGENCY (EPA) HAZARDOUS SUBSTANCE RESEARCH CENTERS		750	750	0
HQ021144	INTERAGENCY AGREEMENT (IAG) - HAZARDOUS AND MIXED WASTE ENVIRONMENTAL PROTECTION AGENCY (EPA)		0	30	0
HQ021147	INTERAGENCY AGENCY (IAG) - NATIONAL SCIENCE FOUNDATION (NSF) COLLABORATIVE RESEARCH DEVELOPMENT AND DEMONSTRATION (RD&D) OF HAZARDOUS SUBSTANCE (EW50659)		1036	125	0
HQ021148	INTERAGENCY AGREEMENT (IAG) - ENVIRONMENTAL PROTECTION AGENCY (EPA) LV CHARACTERIZATION WORKSHOP (EW50661)		0	200	0
HQ021149	AMERICAN SOCIETY FOR MICROBIOLOGY (EW50662)		0	10	0
HQ021150	DEPARTMENT OF TRANSPORTATION-INTERAGENCY AGREEMENT (IAG) (EW50668)		0	950	0
HQ033502	UNITED STATES GEOLOGICAL SERVICE (USGS) INTERAGENCY AGREEMENT (IAG) - WRRIS		700	0	0

RESEARCH, DEVELOPMENT, DEMONSTRATION, TESTING, AND EVALUATION SUPPORT AND NEW INITIATIVES TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
HQ033504	INTERAGENCY AGREEMENT (IAG) - UNITED STATES ARMY REMOTE CHEMICAL SENSOR OF VOLATILE ORGANIC COMPOUNDS (EW53053)		900	0	0
HQ033506	PROGRAM RESEARCH AND DEVELOPMENT ANNOUNCEMENTS (PRDA) (HOLD)	SEE APPENDIX	3766	0	0
HQ033507	URBAN ENERGY TRANSPORTATION CORPORATION		468	0	0
HQ033508	SMALL BUSINESS INNOVATIVE RESEARCH (SBIR) (TAX)	SEE APPENDIX	3200	0	0
HQ033511	NATIONAL ACADEMY OF SCIENCES (NAS)		875	0	0
HQ033515	FEDERAL LABORATORY CONSORTIUM		139	0	0
HQ025006	SUPER CONDUCTING SUPER COLLIDER		0	425	0
ID121117	TECHNOLOGY LOGIC DIAGRAMS FOR IDAHO NATIONAL ENGINEERING LABORATORY (INEL)	IDAHO NATIONAL ENGINEERING LABORATORY	0	50	0
ID121118	USE OF IDAHO NATIONAL ENGINEERING LABORATORY (INEL) INCINERATORS FOR DESTRUCTION OF DEPARTMENT OF ENERGY (DOE) HIGH EXPLOSIVES	IDAHO NATIONAL ENGINEERING LABORATORY	0	8	0
ID121119	TWO-DIMENSIONAL BAR CODE CONFERENCE	IDAHO NATIONAL ENGINEERING LABORATORY	0	100	0
ID121218	BIODEGRADATION OF LIQUID SCINTILLATION COCKTAIL	IDAHO NATIONAL ENGINEERING LABORATORY	0	80	0
ID121302	INTERNATIONAL WASTE TECHNOLOGY INFORMATION CENTER	IDAHO NATIONAL ENGINEERING LABORATORY	0	53	0
ID133503	INTEGRATION OF INCINERATION, WASTE DISPOSAL/STABILIZATION AND AIR PC	IDAHO NATIONAL ENGINEERING LABORATORY	460	0	0
ID133506	RECYCLE OF DEPLETED URANIUM STUDIES	IDAHO NATIONAL ENGINEERING LABORATORY	150	0	0
ID021107	TWO-DIMENSIONAL BAR CODE IMPLEMENTATION	IDAHO OPERATIONS OFFICE	0	105	0
ME001101	TECHNICAL DEVELOPMENT (TD) EXTERNAL REVIEW SUPPORT	MORGANTOWN	500	17170	2000
ME011201	UTILIZATION OF INDUSTRIAL DRILLING AROUND UNDERGROUND TANKS	MORGANTOWN	0	0	300
ME021102	DECONTAMINATION AND DECOMMISSIONING (D&D) RECYCLE	MORGANTOWN	2420	1300	0
ME025001	TECHNICAL DEVELOPMENT (TD) EXTERNAL REVIEW SUPPORT	MORGANTOWN	0	500	0
ME033501	RESEARCH OPPORTUNITY ANNOUNCEMENT (ROA)	MORGANTOWN	6000	0	0
OR101100	RESEARCH, DEVELOPMENT, DEMONSTRATION, TESTING, AND EVALUATION (RDE&E) PROGRAM TECHNICAL SUPPORT	OAK RIDGE NATIONAL LABORATORY	2929	3301	1460
OR121116	MEASURING TRICHLOROETHYLENE (TCE) POLYCHLOROETHYLENE (PCE) BIODEGRADATION CAPABILITIES FOLLOWING METHANE	OAK RIDGE NATIONAL LABORATORY	0	50	0
OR121120	COOPERATIVE RESEARCH AND DEVELOPMENT AGREEMENT (CRADA) - BIOSORPTION OF URANIUM	OAK RIDGE NATIONAL LABORATORY	0	300	0
OR121203	ASBESTOS REMOVAL HAZARDOUS WASTE PLANT (HZWP)	OAK RIDGE NATIONAL LABORATORY	0	30	0

**RESEARCH, DEVELOPMENT, DEMONSTRATION, TESTING, AND EVALUATION
SUPPORT AND NEW INITIATIVES TECHNICAL TASK PLANS**

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
OR121203	ASBESTOS REMOVAL HAZARDOUS WASTE PLANT (HZWP)	OAK RIDGE NATIONAL LABORATORY	0	30	0
OR121212	Y-12 RECYCLE/ALLOY CONTROL	OAK RIDGE NATIONAL LABORATORY	0	885	0
OR121213	TECHNOLOGY LOGIC DIAGRAMS: K-25 SITE	OAK RIDGE NATIONAL LABORATORY	0	1300	0
OR221101	PEER REVIEW HAZARDOUS WASTE PLANT (HZWP)	OAK RIDGE NATIONAL LABORATORY	0	600	0
OR033501	DECONTAMINATION AND DECOMMISSIONING (D&D) PROGRAM RESEARCH AND DEVELOPMENT ANNOUNCEMENT (PRDA)	OAK RIDGE OPERATIONS OFFICE	1434	0	0
		SEE APPENDIX			
PE021104	RECLAMATION OF BERKELEY PIT (MSE)	PITTSBURGH ENERGY TECHNOLOGY CENTER	2000	1200	0
PE021105	MINIMUM ADDITIVE WASTE STABILIZATION	PITTSBURGH ENERGY TECHNOLOGY CENTER	0	500	0
		RETECH			
RL321124	ARNOLD AIR FORCE BASE DATA ANALYSIS	PACIFIC NORTHWEST LABORATORY	0	300	0
RL421209	HEXONE TANK WASTE TREATMENT	WESTINGHOUSE HANFORD COMPANY	0	250	800
SF201102	SITE DIRECTED APPLICATIONS OF FIBER OPTIC SENSORS	LAWRENCE LIVERMORE NATIONAL LABORATORY	0	1	0
SF211108	FIELD EXPERIMENT FOR SOLAR DETOXIFICATION	LAWRENCE LIVERMORE NATIONAL LABORATORY	0	50	300
SF221212	MOLTEN SALT DOCUMENTATION	LAWRENCE LIVERMORE NATIONAL LABORATORY	0	25	0
SR121204	WASTE AND WASTE COMPONENT VITRIFICATION	WESTINGHOUSE ELECTRIC CORP	0	50	0

INNOVATIVE TECHNOLOGIES TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
AL333501	MONITORING AND CONTROL OF METAL EMISSIONS/DEPARTMENT OF ENERGY (DOE) (HMWTTU)	SANDIA NATIONAL LABORATORIES	400	0	0
CH033501	DIAGNOSTIC INSTRUMENTATION ANALYSIS LABORATORY (DIAL)	CHICAGO OPERATIONS OFFICE MISSISSIPPI STATE UNIVERSITY	500	0	0
HQ021702	UNITED STATES ARMY/PICATINNY ARSENAL INTERAGENCY AGREEMENT	COLEMAN RESEARCH	600	2000	0
HQ021703	PORPHYRINS BIOTREATMENT ENVIRONMENTAL PROTECTION AGENCY INTERAGENCY AGREEMENT		0	240	0
HQ033503	NON DESTRUCTIVE ANALYSES OF MIXED WASTE CONTAINERS USING THREE DIMENSIONAL DOUBLE COMPTON IMAGING	NRL/SPARROW	250	0	0
ID111701	PROCUREMENT, INNOVATIVE TECHNOLOGY	IDAHO NATIONAL ENGINEERING LABORATORY SAIC INTERNATIONAL SENSOR TECHNOLOGY RESEARCH TRIANGLE INSTITUTE UNIVERSITY OF IDAHO SRI INTERNATIONAL MEMBRANE RESEARCH AND TECHNOLOGY, INC. ABB ENVIRONMENTAL SERVICES, INC.	92	0	1500
ID121701	REMOVAL AND DEGRADATION OF HYDRO/HALOCARBON VAPORS BY BIOFILTRATION	IDAHO NATIONAL ENGINEERING LABORATORY EG&G ROTRON	395	455	0
ID033502	MAGNETICALLY CONTROLLED DEPOSITION OF METALS/GAS PLASMA	IDAHO OPERATIONS OFFICE	500	0	0
NV021701	ASSOCIATED PARTICLE IMAGING	NEVADA OPERATIONS OFFICE EG&G-STL	1411	950	0
PE033502	LEASE OF PLASMA ARC FURNANCE FOR USE AT COMPONENT DEVELOPMENT AND INTEGRATION FACILITY (CDIF)	PITTSBURGH ENERGY TECHNOLOGY CENTER MSE, INC.	100	0	0
RL221701	ENVIRONMENTAL MONITORING SYSTEMS LABORATORY (EMSL) CONSTRUCTION PROJECT	KAISER ENGINEERS HANFORD	0	140	0
RL321701	SOLID SORBENTS FOR SELECTIVE SEPARATION OF RADIOACTIVE NUCLIDES	PACIFIC NORTHWEST LABORATORY 3M CORPORATION IBC CORPORATION TEXAS A & M UNIVERSITY	3150	955	0

INNOVATIVE TECHNOLOGIES TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
AL124103	MAGNETIC SEPARATION COOPERATIVE RESEARCH AND DEVELOPMENT AGREEMENT (CRADA)	LOS ALAMOS NATIONAL LABORATORY	290	185	0
CH201101	APPLIED RESEARCH AND DEVELOPMENT PROGRAM COORDINATION OFFICE	ARGONNE NATIONAL LABORATORY	200	786	900
HQ021110	HEADQUARTERS MISCELLANEOUS		20	0	0
HQ035002	TULANE-XAVIER		5000	0	0
OR121108	DEVELOPMENT OF INORGANIC MEMBRANES FOR MIXED WASTE INTEGRATED DEMONSTRATION	OAK RIDGE NATIONAL LABORATORY	150	150	0
OR121111	PROBLEM DIRECTED CHEMICAL CHARACTERIZATION FOR RAPID RESPONSE	OAK RIDGE NATIONAL LABORATORY	40	650	0
OR121118	ARNOLD AIR FORCE BASE	OAK RIDGE NATIONAL LABORATORY	275	200	0
OR121119	CRYOCELL TECHNOLOGY APPLICATION AT OAK RIDGE HAZARDOUS WASTE PLANT (HZWP)	OAK RIDGE NATIONAL LABORATORY	50	500	0
		RKK			
		SEG			
OR121122	THREE-DIMENSIONAL IMAGING	OAK RIDGE NATIONAL LABORATORY	-500	500	0

OTHER TECHNOLOGIES - WASTE RETRIEVAL AND WASTE PROCESSING TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
AL101202	COST SAVINGS ANALYSIS: CORE SUPPORT	LOS ALAMOS NATIONAL LABATORY	700	250	350
AL132007	FEDERAL FACILITY COMPLIANCE AGREEMENT (FFCA) OF 1992 REPORT	LOS ALAMOS NATIONAL LABORATORY	443	0	0
AL232005	USE OF DU IN STORAGE/DISPOSAL CASKS		200	0	0
CH232002	ARGONNE SUPPORT TO OFFICE OF TECHNOLOGY DEVELOPMENT (OTD) FOR INDEPENDENT ACTIVITY EVALUATION	ARGONNE NATIONAL LABORATORY	130	0	0
FN132001	PROGRAM RESEARCH AND DEVELOPMENT ANNOUNCEMENT (PRDA) SUPPORT - DECONTAMINATION AND DECOMMISSION (D&D)	WESTINGHOUSE MATERIALS OF OHIO	300	0	0
ID101301	HIGH ENERGY DECOMPOSITION OF HALOGENATED HYDROCARBONS	IDAHO NATIONAL ENGINEERING LABORATORY	380	0	0
ID121116	TWO-DIMENSIONAL BAR CODE IMPLEMENTATION	IDAHO NATIONAL ENGINEERING LABORATORY	287	302	0
ID132009	TECHNOLOGY LOGIC DIAGRAMS	IDAHO NATIONAL ENGINEERING LABORATORY	676	0	0
ID132013	HEADQUARTERS BCDZ	IDAHO NATIONAL ENGINEERING LABORATORY	40	0	0
OR111204	HIGH EFFICIENCY PARTICULATE FILTER TEST AT Y-12	OAK RIDGE NATIONAL LABORATORY	33	42	400
OR132007	PROGRAM RESEARCH AND DEVELOPMENT ANNOUNCEMENT (PRDA) SUPPORT - DECONTAMINATION AND DECOMMISSION (D&D)	OAK RIDGE NATIONAL LABORATORY	400	0	0
OR132009	TECHNOLOGY LOGIC DIAGRAM	OAK RIDGE NATIONAL LABORATORY	1100	0	0
OR132021	DEPLETED URANIUM CONVERSION AND FABRICATION CAPABILITY	OAK RIDGE NATIONAL LABORATORY	200	0	0
PE021103	MINE WASTE CONFERENCE - BUTTE, MONTANA	PITTSBURGH ENERGY TECHNOLOGY CENTER	20	20	0
PE032001	VORTEC COMBUSTION MELTING SYSTEM ASH VITRIFICATION	PITTSBURGH ENERGY TECHNOLOGY CENTER	300	0	0
SF201202	CLEANABLE STEEL HIGH EFFICIENCY PARTICULATE AIR (HEPA) FILTERS	LAWRENCE LIVERMORE NATIONAL LABORATORY	1150	1500	1295
SF211201	TREATMENT OF MIXED WASTES USING PENETRATING BREMSSTRAHLUNG	LAWRENCE LIVERMORE NATIONAL LABORATORY	100	350	0
SF231005	DETAILEE-PATRICIA TAYLOR	LAWRENCE LIVERMORE NATIONAL LABORATORY	60	0	0
SF232004	AUTOMATED RESIDUE PROCESSING	LAWRENCE LIVERMORE NATIONAL LABORATORY	1000	0	0

OTHER TECHNOLOGIES - POLLUTION PREVENTION TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
ID021302	STATE RESEARCH AND DEVELOPMENT GRANT	IDAHO OPERATIONS OFFICE	676	683	0

SUPPORTING TECHNOLOGIES, INFRASTRUCTURE AND TRANSPORTATION PROGRAM SUMMARIES

ROBOTICS

Introduction

The U.S. Department of Energy (DOE) sponsors research, development, demonstration, test, and evaluation (RDDT&E) in robotics to characterize, dismantle/retrieve, repackage, and process waste at DOE sites. These robotics RDDT&E activities are sponsored through the DOE Environmental Restoration and Waste Management Office of Technology Development (EM-50) Robotics Technology Development Program.

Robotics activities have a three-part purpose: to reduce worker exposure and increase worker safety through remote operation and control of equipment, to increase productivity through enhanced capabilities and automation, and to reduce costs by faster completion of remediation activities.

Technical Focus

A broad range of robotics technologies are under development. These include master-slave, electro-mechanical, and servo-manipulators; remotely operated equipment; and special remote tooling. Other robotics technologies under development are industrial-type programmable and autonomous robots, mobile platforms and transporters, and sensing and control systems. These technologies are being developed for use in storage tank cleanup, buried waste retrieval and handling, waste facility operations, and laboratory automation. Other applications for DOE-sponsored robotics technology are decontamination and decommissioning and waste processing.

Figure 1. Remotely-operated vehicle for retrieval of hazardous materials

The following table details several focal areas of robotics technology development activities. Associated technologies and purposes are given for each focal area.

ROBOTICS TECHNOLOGY DEVELOPMENT ACTIVITIES

Technical Focus	Technology	Purpose
Waste Retrieval	Advanced Robot Arms	To Position Waste Characterization and Retrieval Equipment in Storage Tanks
	Teleoperated Robotic Systems	Survey Sites and Excavate/Recover Contaminated Soil and Buried Waste
	Retrieval Methods	To Disassemble and Remove Process Equipment, Pipe, and Larger Equipment from Hot Cell Facilities
Characterization	Remote Characterization Systems	To Map Buried Waste Materials Remotely
Mixed Waste Treatment	Stored Waste Inspection	Mobile Robot to Inspect Stored Waste Facilities Remotely
	Mixed Waste Treatment	Graphical Interface and Sensors for Robot to Characterize waste without Exposure to People
	Drum Opening and Emptying System Mobile Robot	To Open Drums and remove Waste Remotely To Remotely Inspect Tunnels and Handle Emergency Response Situations
	Plasma-Arc Cutting System	To Cut through Metal Equipment and Components
Analytical Laboratory Support	Intelligent Systems	To Automate Critical Time, Risk, and Cost-Intensive Steps for Sample Preparation, Analysis, and Data Interpretation
Decontamination and Decommissioning	Hardened, Teleoperated, and Automated Robotic Systems	To Map Radiation and facilities Remotely, Characterize, Decontaminate, Dismantle, and Decommission Hazardous and Contaminated Facilities
Waste Processing	Process Modifications, Advanced Intelligent Control Concepts, Advanced Processing Equipment	To Remove Operator from the Hazardous Environments

Selected Past Accomplishments

Built and tested modular automated systems to perform multiple analytical chemistry procedures on the samples needed for environmental restoration and waste management efforts, thereby expediting processing and reducing the potential for worker exposure.

Demonstrated the capability of control software developed under the robotics program to simultaneously accommodate a number of differing commercially available robotics systems, enabling the use of multiple systems on complex tasks.

Demonstrated use of Soldier Robot Interface (SRIP) vehicle to map a highly contaminated disposal area which allowed for pre-remedial site survey with no human exposure to radiation.

A bentonite cap was mandated for the K-65 silo to reduce radon emissions. Through the use of structured light source technology and a robotic retrieval device, a 3-D map of the silo's waste surface was accurately and remotely made to use as a baseline. The retrieval arm was then used to accurately spread the bentonite cap without human exposure to the silo waste. After the cap was in place, the same mapping technique was used to compare the baseline configuration with the cap surface to verify that a legally adequate cap had been applied. This technology system reduced to amount of bentonite used by 50% and thus reduced the additional waste.

Developed a generic system controller which is compatible with all DOE robots, large and small. This ensures compatibility of various robot systems with no redundancy.

Demonstrated cold robotic handling of plutonium which reduced radiation dose to handler by a factor of 20 and reduced overall waste by 50 percent.

Demonstrated automation of plutonium/uranium processing steps to minimize waste.

Completed subsurface mapping, remote sizing, and hot spot retrieval for the buried waste site characterization and remediation demonstration at the Idaho National Engineering Laboratory.

Completed the hot demonstration of storage tank remote surface mapping for characterization/remediation at Fernald.

Demonstrated cutting with a commercial robot by positioning plasma arc torch.

Demonstrated multiple robot arms at the Hanford underground storage tank test bed.

Established Storage Tank demonstration facility and began testing of long-reach manipulators and end effectors.

Completed the design and construction of three standard laboratory modules for the automation of EPA methods 3540 and 3550 sample preparation.

1993 Accomplishments/Objectives

Remote Characterization System — Complete development, fabrication, integration, and demonstration of all components for mobile robotics system to characterize buried waste. Developed and demonstrated "dig face" characterization technologies.

Remote Excavation System — Integrated, tested, and demonstrated end effectors and navigation control systems on the Small Emplacement Excavator (SEE) vehicle. Developed and demonstrated remote excavation capability for hot spot retrieval. (Joint Department of Defense/Department of Energy project).

Remote Size Reduction (RSR) — Transfer remote plasma arc cutting technology to industry. Enhance the accuracy of the RSR controller and demonstrate the added capability using alternate cutting technologies.

Test and Modify EPA Analytical Methods — In preparation for validation, test actual lab operation of Standard Laboratory Modules (SLMs) for these methods.

EPA Validation of prototype individual Standard Laboratory Modules (SLMs).

Conceptual Design for EPA Method Series 3000 SPM — Development of the acid digestion method SLMs.

Stored Waste Drum Opening, Emptying, and Transporting Systems — Procure, install, and test equipment for remote opening and emptying of drums. Determine best equipment for remote transportation of drums in waste facilities.

Sorting and Characterization of Stored Waste Drum Contents — Develop, integrate, and demonstrate automated chemical and radiological characterization and sorting into individual waste streams.

AC Swing Free Crane Control — Develop, demonstrate, test, and evaluate swing-free crane control on an AC crane of specified pendulum length. Transfer technology to industry.

Controls — Develop advanced algorithms for control of robotics systems (arms and vehicles) as well as the Generic Intelligent System Controller for general use within RTDP projects.

Systems Analysis — Develop a general approach to cost/benefit analyses for application to all robotics projects. Integrate individual cost/benefit analyses into a general approach for of the robotics program as a whole.

Mechanisms — Develop generic mechanical systems for broad robotics program usage. Initially concentrated on Modular Robotics by designing/integrating modular mechanical and control subsystems of a flexible and extensive manipulator.

Dual Arm Manipulation — Establish test bed and control systems for DAM applications to several program areas.

University R&D Program — Universities are supported in longer term, focused R&D in advanced technology areas such as system reliability, operator interfaces, and sensor interpretation. Results include algorithms for the interpretation of geophysical data, machine health monitoring systems, failure recovery software/hardware, collision avoidance sensors and human design factors.

1994 Objectives

Asbestos Removal and Bagging System — Design, procure, fabricate, integrate, and demonstrate all major subsystems for robotics device to remove and bag asbestos insulation from straight pipe runs.

Telerobotic Decontamination and Dismantlement — Demonstrations of the robotics decontamination and dismantlement systems developed in FY92.

D&D Characterization System — Demonstration of a mobile floor characterization system and cost/benefit analysis of a general robotics characterization system.

Remote Inspection and Survey of Stored Waste Drums — Fabricate, integrate, and demonstrate a mobile robot system to autonomously collect/store images of stored waste drums, maintain extensive database of information, and produce a radiation survey map of the aisles.

Integrate validated system into the EPA Standard Methods.

Initiate EPA validation for Data Interpretation Methods.

Construct and demonstrate the SLMs necessary for automation of the acid digestion methods detailed in the EPA 3000 series.

Sign multi-year, multi-million dollar Cooperative Research and Development Announcement (CRADA) with industrial partner to integrate and make commercially available a complete SLM/SAM system.

Test Remote Inspection and Survey System at actual drum storage facility and develop automated image inspection. Finish testing of drum opening/emptying equipment.

Finish testing of automated sorting of stored waste drum contents.

Deploy a remotely operated excavation system for actual retrieval of waste and containment soil at three DOE labs/sites.

Finish repeatability and reliability performance testing on hydraulic joint/link interface. Design and perform critical element tests.

Fieldable MiniLab Modules available and CRADAs for MiniLab fully in place. Whole arm sensing technology available for general use.

Twenty university R&D contracts fully funded. Joint university/lab program for graduate students' thesis work in place.

Demonstrate duet characterization and "hot spot" removal robot system.

1995 Planned Objectives

Develop standard laboratory and sample analysis modules for mixed waste analysis and radioanalysis.

Demonstrate advances in automated, mobile, modular system for performing decommissioning activities in structured situations.

Enhance capabilities of mobile system for survey and decontamination.

Demonstrate enhanced automated drum opening, contents sorting and repackaging system.

Refine automated system for processing high-level waste.

ROBOTICS

ROBOTICS

ROBOTICS TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
AL113203	ROBOTICS WASTE PROCESSING OPERATIONS	LOS ALAMOS NATIONAL LABORATORY	0	100	275
AL113204	ROBOTICS LABORATORY AUTOMATION	LOS ALAMOS NATIONAL LABORATORY	1500	920	640
AL113205	METAL FINISHING WASTE MINIMIZATION	LOS ALAMOS NATIONAL LABORATORY	0	0	0
AL138201	ROBOTICS CROSSCUTTING AND ADVANCED TECHNOLOGY	LOS ALAMOS NATIONAL LABORATORY	50	0	0
AL203201	ROBOTICS SCIENCE AND TECHNOLOGY CENTER	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	0	0	0
AL213201	ROBOTICS UNDERGROUND STORAGE TANK (UST)	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	650	625	773
AL213202	ROBOTICS BURIED WASTE	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	385	423	300
AL213203	ROBOTICS LABORATORY AUTOMATION	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	300	250	300
AL213204	ROBOTICS CROSS CUTTING AND ADVANCED TECHNOLOGY	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	2703	1925	2475
		CARNEGIE MELLON UNIVERSITY			
		CASE-WESTERN RESERVE UNIVERSITY			
		GEORGIA INSTITUTE OF TECHNOLOGY			
		NEW MEXICO STATE			
		UNIVERSITY OF MINNESOTA			
		PURDUE UNIVERSITY			
		RICE UNIVERSITY			
		UNIVERSITY OF SOUTH CAROLINA			
		UNIVERSITY OF TENNESSEE			
		UNIVERSITY OF WISCONSIN			
		SCHILLING			
AL213205	ROBOTICS WASTE FACILITIES OPERATIONS	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	450	325	175
AL213206	ROBOTICS WASTE PROCESSING OPERATIONS	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	250	475	100
AL223201	ROBOTICS DECONTAMINATION AND DECOMMISSIONING	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	0	275	0
AL238201	ROBOTICS STORAGE TANKS - EAST	SANDIA NATIONAL LABORATORIES - ALBUQUERQUE	245	0	0
FN118201	ROBOTICS STORAGE TANKS - EAST	WESTINGHOUSE MATERIALS OF OHIO	1395	0	0
		UNIVERSITY OF CINCINNATI			
		OHIO STATE UNIVERSITY			
		MIAMI UNIVERSITY			
		UNIVERSITY OF OHIO			

ROBOTICS TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
FN128201	ROBOTICS BURIED WASTE	WESTINGHOUSE MATERIALS OF OHIO	100	0	0
FN128202	ROBOTICS WASTE FACILITIES OPERATIONS	WESTINGHOUSE MATERIALS OF OHIO	170	0	0
HQ021136	CHEMICAL SCIENCES/NATIONAL INSTITUTE OF SCIENCE AND TECHNOLOGY (NIST) INTERAGENCY AGREEMENT (IAG) (EW40009.003)		200	200	0
HQ038203	NAVAL RESEARCH DEVELOPMENT LABORATORY (NRDL) - ROBOTICS WASTE FACILITIES OPERATIONS (EW53054)		75	0	0
ID413201	ROBOTICS BURIED WASTE	WESTINGHOUSE IDAHO NUCLEAR CO	920	248	1190
ID413202	ROBOTICS UNDERGROUND STORAGE TANK (UST) - WEST	WESTINGHOUSE IDAHO NUCLEAR CO	200	300	100
ID413203	ROBOTICS LABORATORY AUTOMATION	WESTINGHOUSE IDAHO NUCLEAR CO BRIGHAM YOUNG UNIVERSITY ABC LABORATORIES	725	670	487
ID413204	WASTE FACILITY OPERATIONS	WESTINGHOUSE IDAHO NUCLEAR CO	220	210	0
ID423201	ROBOTICS DECONTAMINATION AND DECOMMISSIONING	WESTINGHOUSE IDAHO NUCLEAR CO	0	100	0
OR138201	ROBOTICS STORAGE TANKS - EAST OAK RIDGE NATIONAL LABORATRY	OAK RIDGE NATIONAL LABORATORY	4565	0	0
OR923204	ROBOTICS DECONTAMINATION AND DECOMMISSIONING	WESTINGHOUSE MATERIALS OF OHIO	0	55	0
RL313201	ROBOTICS CONTAMINANT ANALYSIS AUTOMATION	PACIFIC NORTHWEST LABORATORY	465	410	391
RF113201	ROBOTICS WASTE PROCESSING OPERATIONS	EG&G ROCKY FLATS, NC.	0	0	300
RL313202	ROBOTICS UNDERGROUND STORAGE TANK (UST)	PACIFIC NORTHWEST LABORATORY	670	360	335
RL313203	ROBOTICS BURIED WASTE	PACIFIC NORTHWEST LABORATORY	705	704	520
RL313205	ROBOTICS CROSS CUTTING AND ADVANCED TECHNOLOGY	PACIFIC NORTHWEST LABORATORY	460	200	400
RL323201	ROBOTICS DECONTAMINATION AND DECOMMISSIONING	PACIFIC NORTHWEST LABORTORY	0	100	0
RL413201	ROBOTICS CONTAMINANT ANALYSIS AUTOMATION	WESTINGHOUSE HANFORD COMPANY	70	50	0
RL413202	ROBOTICS BURIED WASTE	WESTINGHOUSE HANFORD COMPANY	0	50	0
RL413203	ROBOTICS UNDERGROUND STORAGE TANKS - WEST	WESTINGHOUSE HANFORD COMPANY	2350	1045	1267
SF213201	ROBOTICS WASTE PROCESSING OPERATIONS	LAWRENCE LIVERMORE NATIONAL LABORATORY	1705	1700	1400
SF213203	ROBOTICS CROSS CUTTING AND ADVANCED TECHNOLOGY	LAWRENCE LIVERMORE NATIONAL LABORATORY	605	450	450
SF213204	ROBOTICS UNDERGROUND STORAGE TANKS (UST)	LAWRENCE LIVERMORE NATIONAL LABORATORY	50	0	250
SF213205	REMOTE CHARACTERIZATION SYSTEM	LAWRENCE LIVERMORE NATIONAL LABORATORY	325	788	0
SF223203	WASTE FACILITIES OPERATIONS WASTE SORTING TECHNOLOGY	LAWRENCE LIVERMORE NATIONAL LABORATORY	350	250	0

ROBOTICS TECHNICAL TASK PLANS

NUMBER	TITLE	PARTICIPANT(S)	FUNDING (\$ IN THOUSANDS)		
			FY93	FY92	FY91
SR113201	ROBOTICS SUPPORT - WASTE FACILITIES OPERATIONS	WESTINGHOUSE ELECTRIC CORP CLEMSON UNIVERSITY GEORGIA INSTITUTE OF TECHNICAL UNIVERSITY OF SOUTH CAROLINA	1635	375	280
SR113202	SAVANNAH RIVER ROBOTICS SUPPORT - UNDERGROUND STORAGE TANKS	WESTINGHOUSE ELECTRIC CORP	0	0	100
SR123201	SAVANNAH RIVER ROBOTICS SUPPORT - DECONTAMINATION AND DECOMMISSIONING	WESTINGHOUSE ELECTRIC CORP	0	300	0
SR123202	ROBOTICS WASTE PROCESSING OPERATIONS	WESTINGHOUSE ELECTRIC CORP	200	100	0

APPENDIX A: TECHNOLOGY DEVELOPMENT PARTNERSHIPS

A1 - SBIR

A2 - ARGONNE SOLICITATION

A3 - PRDA

A4 - CRADA

A5 - ROA

A6 - IAGS

A7 - GRANTS

TECHNOLOGY DEVELOPMENT PARTNERSHIPS

The Environmental Restoration and Waste Management's (EM) Office of Technology Development (OTD) recognizes that private industry, university, and other government research and development (R&D) programs are potentially valuable sources of technological innovation. To fully benefit from the knowledge and expertise outside the agency, the Technology Development Program is committed to ensuring that private industry and other Federal agencies are major participants in developing and deploying technologies for the Department of Energy's EM Program. To this end, substantial funds are set aside for interagency agreements and industrial participation to build public- and private-sector partnerships. In fiscal year 1993 (FY93), OTD's research, development, demonstration, testing and evaluation (RDDT&E) programs included funding to approximately 260 private firms and 120 universities. Summarized in the following figure is a breakout of the RDDT&E FY93 budget (approximately \$220 million) by sector.

In developing these partnerships, a number of mechanisms are utilized by the Department of Energy:

The Argonne 1990 Solicitation resulted from an announcement which was both in Commerce Business Daily and mailed to participants of the December, 1989, symposium on industry and university contract opportunities in applied research, development, demonstration, testing and evaluation.

Program Research and Development Announcements (PRDAs) are program announcements used to solicit a broad mix of R&D and DT&E proposals. A PRDA is used to solicit proposals for projects in areas where R&D or DT&E is required within broadly defined areas of interest, but where it is difficult to describe the work in detail.

PRDAs may be used to solicit proposals for contracts, grants, or cooperative agreements. Multiple awards, which may have dissimilar approaches or concepts, are generally made. PRDA's have been issued by Argonne National Laboratories (ANL), Idaho National Engineering Laboratories (INEL), and Morgantown Energy Technology Center (METC).

Cooperative Research and Development Agreements (CRADAs) were created by Congress under the Federal Technology Transfer Act (FTTA) of 1986 (PL 99-502) to enhance and facilitate collaboration between governmental agencies and commercial firms. The FTTA provides the authority and an effective mechanism to enter into joint research and development projects. CRADAs benefit the public by transferring know-how and technology from government laboratories, thereby encouraging the development of innovative technology.

CRADAs are used by the Department of Energy as an incentive for collaborative Research and development (R&D). These agreements, between a DOE R&D laboratory and any non-Federal source, allow for cooperative R&D that is consistent with the laboratory's mission. The partner may provide funds, facilities, people, or other resources. DOE provides the CRADA partner with access to unique government facilities, equipment and expertise; increased exchange of ideas through people-to-people contact; and, reduced time between R&D and commercialization. Rights to inventions and other intellectual property are negotiated between the laboratory and participant, and certain data that are generated may be protected for up to five years.

Small Business Innovation Research (SBIR), solicitations are issued in accordance with the Small Business Research and Development Enhancement Act of 1992, Public Law 102-564, which requires the participation in SBIR of the Department's programs in Environmental Restoration and Waste Management.

The objectives of the SBIR program include increasing private sector commercialization of technology developed through DOE-supported R&D, stimulating technological innovation in the private sector, enhancing the competitiveness of small business in the environmental marketplace via advancing their innovative technologies, and improving the return on investment from Federally funded research for economic and social benefits to the nation.

Research Opportunity Announcements (ROAs) support OTD's Office of Technology Development's applied research efforts for the development of technologies having potential applications in the EM program. A proposed technology may be a device, process, material, or method that improves DOE's capabilities in areas such as in situ remediation; characterization, sensors and monitoring; efficient separations technology for radioactive waste; and robotics.

The applied research ranges from concept feasibility through full-scale demonstration. The ROA also includes a special provision to encourage greater small business participation in RDDT&E activities. These partial set-asides for small business firms are presently set at 20%.

Interagency Agreements (IAGs) are the result of memoranda of understanding between the Department of Energy and another Federal agency for the purpose of developing and testing technology activities of mutual interest.

Grants are used by EM as financial assistance awards when the technology is developed for a public purpose. Financial assistance awards are solicited through publication in the Federal Register. These announcements are called Program Rules. A Program Rule can be a one-time solicitation or an open-ended, general solicitation with annual or more frequent announcements concerning specific funding availability and desired R&D agreements. The Program Rule can also be used to award both grants and cooperative agreements.

EM awards grants and cooperative agreements if 51 percent or more of the overall value of the effort is related to a public interest goal. Such goals include possible non-DOE or other Federal agency participation and use, advancement of present and future U.S. capabilities in domestic and international environmental cleanup markets, technology transfer, advancement of scientific knowledge, and education and training of individuals and business entities to advance U.S. remediation capabilities.

APPENDIX A1: SMALL BUSINESS INNOVATION RESEARCH

The objectives of the SBIR program include increasing private sector commercialization of technology developed through DOE-supported R&D, stimulating technological innovation in the private sector, strengthening the role of small business in meeting Federal research and R&D needs, and improving the return on investment from Federally funded research for economic and social benefits.

Congress established the Small Business Innovation Development Program in 1983. On October 28, 1992, the SBIR was reauthorized with the enactment of the Small Business Research and Development Enhancement Act of 1992, which requires, for the first time, Environmental Restoration and Waste Management (EM) participation.

The latest legislation provides for a gradual increase from 1.25% of each participating Federal agency's extramural research/research and development budget in FY92 to 2.5% in FY97 and each fiscal year thereafter as required expenditure amounts specifically for the SBIR Program.

Grant applications are reviewed competitively, and the winners receive awards of up to \$75,000 to explore the feasibility of their ideas, with up to \$500,000 available in a second phase for those ideas with the highest potential to meet the SBIR program objectives. Phase I selection for this first solicitation was made on November 3, 1993. The following table briefly describes the SBIR awards related to the EM program.

Small Business Innovative Research (SBIR) Program Awards

Project Topic	Industrial Participants	Technologies
In situ treatment of Heavy Metal Contaminated Soils and Groundwater	Engineering Resources, Inc. P.O. Box 3682 Fayetteville, AR 72702	In Situ Microbial Metal Immobilization
	Environmental Risk Limited 120 Mountain Avenue Bloomfield, CT 06002	Enhanced Mobilization of Heavy Metals Using Sequential Extraction
Waste Stream Diagnostics and Controls	Laser Diagnostics P.O. Box 4627 Los Alamos, NM 87544	Real Time Monitoring of Heavy Metals Using Laser-Induced Breakdown Spectroscopy
	Physical Optics Corporation 2545 West 237th Street, Suite B Torrance, CA 90505	Multimode Sensor Network Media
On-Site Treatment of Surface Water and Groundwater	Bend Research, Inc. 64550 Research Road Bend, OR 97701-8599	Membrane-Based Hybrid System for Removal of Heavy Metals from Groundwater
	Foster-Miller, Inc. 350 Second Avenue Waltham, MA 02154-1196	Innovative Sorbents for the Selective Removal of Heavy Metals from Groundwater
In Situ Bioremediation of Contaminated Sites	ENVIROGEN, Inc. 4100 Quakerbridge Road Lawrenceville, NJ 08648	Optimization of Prolonged Microbial Activity During In Situ Degradation of Chlorinated Organics
	TPL, Inc. 3768 A/B Hawkins, NE Albuquerque, NM 87109	Heavy Metal Bioremediation Using Mycorrhizal Plants

Small Business Innovative Research (SBIR) Program Awards

Project Topic	Industrial Participants	Technologies
Sensors for Monitoring Environmental Remediation Activities	ALEM Associates 303A Commonwealth Avenue Boston, MA 02115	Activated Optical Ceramics: A New Class of Materials for Environmental Monitoring
	ANDCARE, Inc. 2810 Meridian Parkway Suite 152 Durham, NC 27713	Innovative Electrochemical Sensors for In Situ Real-Time Monitoring of Lead in Aqueous Media
	Berkeley MicroInstruments, Inc. 2375 Cedar Street Berkeley, CA 94708	A Micromachined Piezoelectric Sensor System for Monitoring Environmental Remediation
	Covalent Associates, NC 10 State Street Woburn, MA 01801	Fluoroionophores for Use in a Fiber Optic Sensor for Mercuric Ions
	ICET, Inc. 916 Pleasant Street, Unit 12 Norwood, MA 02062	Potentiometric Sensors for Lead and Mercury
	Dr. John Kevin Markey 1298 #1L Hartford Turnpike North Haven, CT 06473	A Compressed Xenon Gamma Sensor for Environmental Measurements
	Microsensor Systems, Inc. 62 Corporate Court Bowling Green, KY 42103	A High Frequency Surface Acoustic Wave Device as a Novel Detector for Portable Gas Chromatographs for Field Screening of Hazardous Vapors
	Physical Sciences, Inc. 20 New England Business Center Andover, MA 01810-1077	A Nitro and Explosives Monitor for Cone Penetrometer Waste Site Evaluation
	Research International, Inc. 18706 142nd Avenue, NE Woodinville, WA 98072	Fiber Optic Sensors for Heavy Metal Cations

APPENDIX A2: SUMMARY OF ARGONNE NATIONAL LABORATORY 1990 SOLITICATION

DOE hosted a Symposium on Industry and University Contract Opportunities in Applied Research, Development, Demonstration, Testing and Evaluation in San Francisco, December 12-13, 1989. At that meeting, EM committed to increasing the involvement of the private sector in its technology development activities. The applied R&D contracting activity began with a Commerce Business Daily announcement on April 13, 1990, and a parallel mailing of the announcement to the San Francisco meeting participants. On May 1, the Request For Proposal (RFP) package was mailed to 338 potential offerors.

The RFP contained detailed instructions for submission of proposals in one of four general areas: (1) Groundwater remediation; (2) Soil remediation; (3) Sensing and

characterizing buried objects, contamination, and/or geological/hydrological features; (4) Containing contaminated sites.

One hundred and eight organizations submitted 147 proposals which were evaluated by technical reviewers drawn from the national laboratories and academia. Negotiations and contracts preparations were completed over the next two months, and all contracts were in place by the end of September.

Fifteen fixed-price contracts were placed with 13 private firms, one university in the United States, and one government laboratory in Canada. These contracts are listed below.

Argonne 1990 Solicitation

Title (date)	Contractor	Objective
<p>A Process for Contaminant Removal and Waste Volume Reduction to Remediate Groundwater Containing Certain Radionuclides, Toxic Metals and Organics</p> <p>(10/90 to 3/92)</p>	<p>Atomic Energy of Canada Limited Chalk River, Ontario Canada KOJ 1JO</p>	<p>Determine how effective a combined process involving chemical treatment, microfiltration, ultrafiltration and cold vaporization will extract representative radionuclides, toxic metals and organics from groundwaters, provide a significantly reduced volume suited to immobilization and disposal, and meet an acceptable standard for the groundwater. Provide an evaluation of the technology package on a site at the Chalk River Laboratories and conclude with a preliminary cost study.</p>
<p>Minimally Invasive Three-Dimensional Site Characterization (Electronic Cone Penetration Testing of the Hanford Site 200-W area) (Electric Cone Penetration Testing of Salt-Cake Simulant Barrels)</p> <p>(10/90 to 5/92)</p>	<p>Applied Research Associates 4300 San Mateo Blvd. N.E. Albuquerque, NM 87110</p>	<p>Develop a field ready minimally invasive three dimensional site characterization system which synthesizes seismic profiling, penetrometer measurements and sampling with electrogeophysical measurement of groundwater resistivity. Resulting characterization is in a 3-D simulation of site physical properties and contaminant distribution. The simulation serves as a database and data synthesis system for maps and cross sections to facilitate hydrogeologic interpretation and analysis of contaminant flow paths and flow rates</p>

Argonne 1990 Solicitation

Title (date)	Contractor	Objective
<p>Design, Manufacture and Evaluation of a Hydraulically Installed, Multi-Sampling Lysimeter</p> <p>(10/90 to 3/92)</p>	<p>Bladon International Inc. 880 Lee Street Des Plaines, IL 60016</p>	<p>Develop a suction lysimeter that can be inserted into the area of interest in the vadose zone without using a predrilled hole.</p>
<p>Development of a Combined Soil Wash/In Furnace Vitrification System for Soil Remediation at DOE Sites</p> <p>(10/90 to 9/92)</p>	<p>Duratek Corporation 6700 Alexander Bell Drive Columbia, MD 21046</p>	<p>Research and develop technologies for remediation of soils and sludges at DOE sites that are contaminated with radionuclides, heavy metals, inorganic ions, and/or organics. Use a combination of soil washing and in-furnace vitrification.</p>
<p>Fiber Optic Raman Spectrography for In Situ Environmental Monitoring</p> <p>(10/91 to 7/92)</p>	<p>EIC Laboratories, Inc. 111 Downey St. Norwood, MA 02062</p>	<p>Develop and test in the lab a prototype of a small, fieldable Raman spectrometer that can be fiber optically coupled to a diode laser and a SERS-based probe over 50 meters. Develop a probe incorporating substrates for SERS which can be used in field screening of ground and surface waters for DOE priority pollutants and the action levels required for remediation.</p>
<p>Bench-Scale Demonstration of a Bioreactor System to Treat Chlorinated Volatile Contaminants In Groundwater</p> <p>(10/90 to 2/92)</p>	<p>Envirogen, Inc. Princeton Research Center 4100 Quakerbridge Rd. Lawrenceville, NJ 08648</p>	<p>Construct and evaluate a bench scale bioreactor for the treatment of vapor phase chlorinated aliphatic contaminants.</p>
<p>Electrokinetic Treatment of Contaminated Soils, Sludges, and Lagoons</p> <p>(10/90 to 3/92)</p>	<p>Electro-Petroleum, Inc. 996 Old Eagle School Rd. Suite 1118 Wayne, PA 19087</p>	<p>Investigate decontamination of soils by electrokinetic processes. Increase the basic understanding of electrokinetic phenomena in soil-water-contaminant systems and thereby identify the critical parameters to subsequently develop the methodology for large scale, efficient and cost effective in-situ utilization.</p>
<p>Composting of Soils/Sediments and Sludges Containing Toxic Organics Including High Energy Explosives</p> <p>(10/91 to 3/92)</p>	<p>IIT Research Institute Virginia Technology Center 8510 Cinderbed Rd. Suite 300 P.O. Box 899 Newington, VA 22122</p>	<p>Demonstrate the applicability of composting to decontaminate PANTEX soils containing high energy explosives and organics. Determine the degradation pathways and rates for high energy explosives and organics using laboratory and pilot scale composts.</p>

Argonne 1990 Solicitation

Title (date)	Contractor	Objective
<p>Combined Air Stripping/Membrane Vapor Separation Systems</p> <p>(10/90 to 3/92)</p>	<p>Membrane Technology and Research, (MTR) Inc. 1360 Willow Rd, Suite 103 Menlo Park, CA 94025</p>	<p>Construct, test and field demonstrate combined air stripping/membrane vapor separation system to treat 0.5 m³/min (190,000 gal/day) of VOC-contaminated groundwater. The system will remove 90-98% of the Voce from the groundwater and produce a concentrated VOC-containing liquid stream.</p> <p>Develop a computer model to allow the performance of the system with a variety of field solutions to be calculated.</p>
<p>Bulk Soil Assay System</p> <p>(10/90 to 9/91)</p>	<p>Nuclear Diagnostic Systems Inc. P.O. Box 726 Springfield, VA 22150</p>	<p>Evaluate the feasibility of a bulk soil assay system using inelastic gamma ray imaging and spectroscopy (IGNIS) and capture gamma ray spectroscopy (CARS) to measure concentrations of elements in soil.</p>
<p>High Resolution Shear Wave Seismic Reflection Surveying for Hydrogeological Investigations (The High Resolution Shear Wave Seismic Reflection Technique)</p> <p>(10/90 to 7/92)</p>	<p>Paul C. Rizzo Associates, Inc. 300 Oxford Drive Monroeville, PA 15146</p>	<p>Develop the technology necessary to make high resolution S-wave profiling a useful tool in conducting shallow groundwater investigations.</p>
<p>Remediation of Groundwater Containing Radionuclides, Heavy Metals, Inorganic Ions, and/or Organics using the AlgaSORB* Biosorbent System</p> <p>(10/90 to 3/92)</p>	<p>Science Applications International Corporation P.O. Box 2501, 800 Oak Ridge Turnpike Oak Ridge, TN 37830</p>	<p>Perform bench-scale treatability studies to establish treatment protocols and to optimize an AlgaSORB*/ion-exchange technology system to remove and recover toxic metal ions from contaminated groundwaters collected at DOE sites</p>
<p>Development of the SEAMIST™ Concept for Site Characterization and Monitoring</p> <p>(10/90 to 10/92)</p>	<p>Science and Engineering Associates, Inc. 1570 Pacheco, Suite D-1 Santa Fe, NM 87501</p>	<p>Develop the SEAMIST™ (Science and Engineering Associates Membrane Instrumentation and Sampling Technique) concept explicitly for vadose zone gas and pore fluid sampling. Design, fabricate and install gas sampling and permeability measurement SEAMIST™ membranes.</p>

Argonne 1990 Solicitation

Title (date)	Contractor	Objective
Chromate Reduction and Heavy metal Fixation in Soil (8/90 to 2/92)	Sizemore Technical Services 2011 Lamar Drive Round Rock, TX 78664	Research the combination of in situ reduction of chromium VI to chromium III in soil with the immobilization of heavy metals using Fe II and silica to yield an effective and efficient heavy metal containment technology. (Silica solutions are inexpensive, non-toxic, and impose no threat to human health).
Assessment of Subsurface Voce Using a Chemical Microsensor Array (10/90 to 8/92)	The University of Michigan	Demonstrate several applications of a new monitoring instrument that utilizes an array of coated surface-acoustic wave (SAW) microsenors. Pattern recognition analysis of the sensor output permits determination of the identity and quantity of target vapors from different chemical classes which are commonly found in contaminated soils and groundwater. Provide a highly cost effective alternative for monitoring and control purposes.

APPENDIX A3: SUMMARY OF PROGRAM RESEARCH AND DEVELOPMENT ANNOUNCEMENTS

Program Research and Development Announcements (PRDAs), are program announcements used to solicit a broad mix of R&D and DT&E proposals. A PRDA is used to solicit proposals for projects in areas where R&D or DT&E is required within broadly defined areas of interest, but where it is difficult to describe the work in detail.

PRDAs may be used to solicit proposals for contracts, grants, or cooperative agreements. Multiple awards, which may have dissimilar approaches or concepts, are generally made. One PRDA has been issued by Idaho National Engineering Laboratories (INEL) and two PRDA's have been issued by Morgantown Energy Technology Center (METC).

Idaho PRDA

Project Title	Industrial Participant	Objective	Estimated Funding
Application of Neural Networks to Site Characterization	Science Applications International Corp. (SAIC) 4161 Campus Point Court San Diego, CA 92121	Develop a technique to reduce the cost of characterizing the concentration and flow of radioactive wastes which have been introduced into the soils and subsurface water of a site and migrate or threaten to migrate to the biosphere through groundwater.	\$29.6K
Remote Fiber-Optic TLD (Thermoluminescence Dosimetry) Monitoring System	International Sensor Technology, Inc. (IST) N.E. 1425 Terre View Drive Pullman, WA 99163	Combine a fiber-optic TLD probe for remote monitoring of gamma, high energy electron and fast neutron radiation doses together with an appropriate TLD reader that is based on IST's proprietary laser heating technology into a complete system that is suitable for monitoring distributions and transport of radioactive contaminants in and above ground and in water.	\$278.2K
Novel Technique for Invasive Subsurface Barriers	Research Triangle Institute (RTI) PO Box 12194 Research Triangle Park, NC 27709	Provide proof of concept for the in situ mixing of a subsurface latex barrier. Such a barrier may be safely and effectively used to control the subsurface migration of contaminated ground water.	\$159.1K
Selective Chelation and Extraction of Lanthanides and Actinides with Lariat Crown Ethers in Supercritical Fluids	Department of Chemistry Department of Chemical Engineering University of Idaho Moscow, Idaho 83843	Develop a method for the remediation of metal ions such as lanthanides (rare earth elements) and actinides (transuranic elements) that are a major concern in the treatment of industrial and nuclear wastes. The method is based on the combination of two advanced technologies, selective chelation and supercritical fluids extraction (SFE).	\$71.9K

Idaho PRDA

Project Title	Industrial Participant	Objective	Estimated Funding
Sonochemical Waste Treatment	SRI International 333 Ravenswood Avenue Menlo Park, CA 94025	Develop new technology for the efficient and cost-effective destruction of aqueous wastes containing organic pollutants, in particular halogenated aliphatic and aromatic compounds. The approach involves the in situ application of high intensity (710 W/cm ²) ultrasonic irradiation in conjunction with a heterogeneous photocatalytic process using photoreactive semiconductors such as titanium dioxide (TiO ₂).	\$175.3K
Improved Membranes for Water Remediation Projects	Membrane Technology and Research Inc. 1360 Willow Road Menlo Park, CA 94025	Apply prevaporization technology to the removal of volatile organic compounds (VOCs) from contaminated groundwater. Prevaporization is a process in which liquid organic materials are vaporized through a membrane, collected by condensation, and removed as a concentrated permeate.	\$270.0K
A Methanotrophic Biofilter for the Treatment of Airstreams Contaminated with Chlorinated Hydrocarbons	ABB Environmental Services, Inc. Bioremediation Systems Division Corporate Place 128 107 Audubon Rd. Wakefield, MA 01880	Develop a remedial technology for the removal of organic contaminants from airstreams.	\$83.1K

METC PRDA 1

Project Title	Industrial Participant	Objective	Estimated Funding
Soil Treatment to Remove Uranium and Related Mixed Radioactive Heavy Metal Contaminants	Atomic Energy of Canada Chalk River Laboratories Chalk River, On KOJJO	Design and develop a physio-chemical treatment process for the removal of uranium and heavy metals (radium-226, thorium-230, lead, manganese, etc) from contaminated soil to achieve a target contamination level below 35 pCi/g of soil and target levels for non-radioactive heavy metals that will be below concentration levels permissible to produce a "clean soil".	\$445K
Development of a Long-Term, Post-Closure Radiation Monitor	Babcock & Wilcox 1562 Beeson Street Alliance, OH 44601	Develop a low cost multi-point radiation monitoring system for the long term continuous monitoring of radiation levels in the vadose zone of hazardous waste sites. The system will be based on gamma spectroscopy and will be capable of monitoring to depths of more than fifty meters below ground level without necessitating the drilling of wells.	\$1307K
Mobile Worksystem for Decontamination and Decommissioning	Carnegie Mellon University School of Computer Science The Robotics Institute Pittsburgh, PA 15213	Develop a high performance remotely operated mobile worksystem capable of performing a wide range of decontamination and decommissioning (D&D) tasks in a nuclear environment.	\$3450K
VAC*TRAX Mobil Vacuum/Thermal Treatment System	Chemical Waste Management Clemson Technical Center, Inc. Anderson, SC 29625	Develop a full scale, mobile system for the treatment of soils/sediments that are contaminated with non-aqueous phase liquids.	\$2445K
Geophysical Data Fusion for Subsurface Imaging	Coleman Research Corp., 5950 Lakehurst Drive, Orlando, FL 32819	Develop a software package that integrates geophysical data derived from multiple sensor technologies to be used for characterization of the hazardous waste sites by delineation of contaminant plumes and by identification of thin clay layers and geological discontinuities up to a depth of 300 feet.	\$1475K
Development Studies for a Novel Wet Oxidation Process	Delphi Research, Inc. 701 Haines Ave. N.W. Albuquerque, NM 87102	Develop catalytic wet oxidation process for the treatment of multicomponent wastes, with the aim of providing a versatile treatment method which can destroy hazardous organic metals from soils.	\$3300K

METC PRDA 1

Project Title	Industrial Participant	Objective	Estimated Funding
Field Raman Spectrograph for Environmental Analysis	EIC Laboratories, Inc 111 Downey St. Norwood, MA 02062	Design, fabricate, field test, and evaluate a field hardened Raman Spectrograph/ Monochrometer system. Fiber Optic Raman Spectroscopy and Surface Enhanced Raman Spectroscopy will be used to provide highly specific in situ chemical characterization and mapping.	\$833K
Road Transportable Analytical Laboratory (RTAL)	Engineering Computer Optecnomics 1356 Cape St., Claire Road Annapolis, MD 21401	Develop and design a reliable RTAL system capable of performing the full range of radiological, chemical and biological analyses onsite in contaminated areas at DOE facilities.	\$5346K
Organic Sponges for Cost Effective Chlorinated Volatile Organic Compounds (CVOC) Abatement	General Electric Company Building KW, Room C246 PO Box 8 Schenectady, NY 12301	Identify and develop a cost-effective method for sorption, concentration and destruction of CVOCs using low-cost, recyclable organic polymers (sponges) and to couple this process, where feasible, with a biodegradation process.	\$625K
Soil Saw Demonstration	Halliburton NUS Environmental Corp 5950 North Course Drive Houston, TX 77072	Demonstrate the ability to successfully construct an underground continuous grout slurry cutoff wall useful for segregation of contaminated soils from uncontaminated soils with Soil Saw prototype.	\$1061K
In Situ Decontamination of Sand and Gravel Aquifers by Chemically-Enhanced Solubilization of DNAPLs (Dense Non-Aqueous Phase Liquids) with Surfactant Solutions	INTERA, Inc 6850 Austin Center Blvd. Suite 300 Austin, TX 78731	Develop technology to remediate sites contaminated with dense non-aqueous phase liquids (DNAPLs), such as trichloroethylene, by injection of solutions of non-ionic surfactant which would solubilize the normally very low solubility DNAPLs and allow their removal by pump and treat technology.	\$1145K
Intelligent Mobile Sensor System for Autonomous Monitoring and Inspection	Martin Marietta PO Box 179 Denver, CO 80201	Develop a robotic device for routine inspection of stored waste drums, radiological surveys of controlled areas, and initial entry surveys of facilities for decommissioning.	\$2458K
Integrated Computer-Enhanced Remote Viewing System (ICERVS)	Mechanical Technology Incorporated 968 Albany-Shaker Road Latham, NY 12110	Develop an ICERVS that provides a reliable geometric description of a remote environment.	\$2361K

METC PRDA 1

Project Title	Industrial Participant	Objective	Estimated Funding
An Intelligent Inspection and Survey Robot	SC Universities Research and Education Foundation Strom Thumond Institute Building Clemson, SC 29634	Develop a semi autonomous vehicle capable of inspecting a low radiation level contaminated storage area of stacked drums or other containers aligned in aisles.	\$4000K
Novel Mass Spectrometric Instrument for Gaseous and Particulate Characterization and Monitoring	SRI International 333 Ravenswood Avenue Melno Park, CA 94025	Develop a new instrument for real-time chemical characterization and monitoring of gaseous and particulate air pollutants from the Department of Energy (DOE) waste cleanup facilities. Use both commercially available components along with unique technology developed by the contractor.	\$1807K
Stabilization and Reuse of Heavy Metal Contaminated Soils by Means of Quicklime Sulfate Salt Treatment	Stevens Institute of Technology Center for Environmental Engineering Hoboken, NJ 07030	Investigate the effectiveness of stabilizing heavy metal contaminated soils by means of quicklime (CaO)-sulfate salt addition, either in situ or onsite. Develop the required guidelines and specifications for field application of the technology. Reuse the stabilized matrix as a construction material.	\$884K
Field-Usable Portable Analyzer for Chlorinated Organic Compounds	Transducer Research, Inc 999 Chicago Avenue Naperville, IL 60540	Modify a solid-state sensor based chlorinated organic (R-Cl) monitor system to conduct in situ real-time measurements at Department of Energy sites where there is subsurface contamination by chlorinated solvents; such as, carbon tetrachloride, trichloroethylene, and tetrachloroethylene.	\$1350K
High-Resolution Subsurface Imaging and Neural Network Recognition: Non-Intrusive Buried Substance Location	Department of Mining and Geological Engineering Mines 219 University of Arizona Tucson, AZ 85721	Develop a continuous-profiling, high-resolution, high frequency electromagnetic subsurface imaging system that overcomes the depth restrictions of ground penetrating radar in conductive or clay-rich soils.	\$1307K
Innovative Directional and Position-Specific Sampling Technique	UTD, Incorporated 8560 Cinderbed Road, Suite 1300 Newington, VA 22122	Develop a strair.-based position location determination system (POLO) for use on penetrometers and lysimeters to provide accurate, downhole, real-time, position location determination.	\$568K

METC PRDA 1

Project Title	Industrial Participant	Objective	Estimated Funding
Research and Development of an Innovative Fossil Fuel Fired Vitrification Technology for Soil Remediation	Vortec Corporation 3770 Ridge Pike Collegeville, PA	Develop and deploy an innovative fossil fuel fired vitrification process for the remediation of soils containing hazardous and/or radioactive constituents. The process is an extension of an advanced, multi-fuel capable, combustion and melting system (CMS) technology being developed for commercial glass manufacturing and waste processing/recycling	\$10687K
Remote Mining for In Situ Waste Containment	West Virginia Research Corp West Virginia University Glennlock Hall Morgantown, WV 26506	Develop and demonstrate a system which is capable of in situ containment of underground hazardous waste sites. Adapt equipment and techniques from the mining and landfill industries to remotely place a synthetic barrier around the sides and bottom of the contaminated zones to isolate underground waste repositories.	\$3199K

METC PRDA 2

Project Title	Industrial Participants	Objective	Estimated Funding
Decontamination/ Recycle of Concrete	AWD Technologies, Inc. 15204 Omega Drive, Suite 200 Rockville, MD 20850	Develop a system called AWD-CON which includes a concrete decontamination system and a separation system. Decontamination system includes a dry vacuum cleaning with high efficiency particulate air (HEPA) filter, dust collection, foam cleaning agent, low-pressure surface rinsing, and surface concrete removal with high-pressure water. Separation system provides coarse solids screening, oil and grease collection, fine solids removal, and organic removal by activated carbon.	\$796K
Decontamination of Process Equipment Using Chelate Chemistry Technology	Babcock & Wilcox Alliance Research Center 1562 Beeson Street Alliance, OH 44601	Evaluate chelating chemicals to decontaminate the interior surfaces of process components at the Oak Ridge Gaseous Diffusion Plant. The solvent-based system will be capable of removing surface contamination and contaminants that have penetrated the grain boundaries. The solvent can be regenerated by precipitation of the metals, which allows for solvent reuse and reduction of the waste volume.	\$922K
Waste Inspection Tomography: A Field-Operable Scanner for Non-Invasive Characterization of Nuclear Waste Containers	Bio-Imaging Research, Inc. 425 Barclay Boulevard Lincolnshire, IL 60069	Construct a transportable inspection system, contained in a semi-trailer, to characterize (locate and quantify free liquids, detect internal corrosion, identify the nature of contents through 3-D views, and evaluate internal radioactivity) containers of radioactive waste by nondestructive evaluation. Measurement technologies include digital radiography, computer tomography, and gamma-ray spectroscopy.	\$4100K
Three Dimensional Integrated Characterization and Archiving System (3-D ICAS)	Coleman Research Corporation Digital Signal Division 6551 Loisdale Court, Suite 800 Springfield, VA 22150	Develop a 3D-ICAS system which provides real-time analysis of suspect metal, concrete, asbestos, and transit surfaces for alpha emitters, beta emitters, and PCB contamination. The system is comprised of a mobile sensor platform, a mobile mapper platform and an integrated workstation.	\$6100K

METC PRDA 2

Project Title	Industrial Participants	Objective	Estimated Funding
Rapid Surface Sampling and Archival Record System	General Electric Corporate Research and Development 1 River Road, P.O. Box 8 Schenectady, NY 12301	Develop a portable instrument that can rapidly analyze concrete and steel surfaces for contamination by polychlorinated biphenyls (PCB), other organics and metallic mercury. In addition to real-time analysis, the instrument would collect a sample of the substance and retain it for further analysis.	\$3352K
Electrokinetic Decontamination of Concrete	Isotron Corp. 13152 Chef Highway New Orleans, LA 70129	Demonstrate a new approach to decontaminating concrete using the science of modern strippable coatings and electrokinetic extraction techniques. The ultimate waste form is a solid compatible waste, which can generally be disposed by direct land burial.	\$198K
Recycle, Reuse, and Disposal of Materials from DOE's Decontamination and Decommissioning Activities	KAI Technologies, Inc. 175 N. New Boston Street P.O. Box 3059 Woburn, MA 01888	Develop a process scheme for converting contaminated asbestos insulation into a benign form (amorphous silica) for decontamination and ultimate disposal as a sanitary waste form.	\$8000K
Advanced Technologies for Decontamination and Conversion of Radioactively Contaminated Scrap Metal to High Value Intermediate and Final Product Forms	Manufacturing Sciences Corporation 804 Kerr Road Oak Ridge, TN 37830	Manufacturing Sciences Corp. and the Colorado School of Mines have teamed up to develop a technology for reusing radioactively contaminated nickel. They will decontaminate the nickel, then alloy it with decontaminated steel and purchased chromium to produce stainless steel. They will use the stainless steel to make containers suitable for storing vitrified high-level nuclear waste.	\$3700K

METC PRDA 2

Project Title	Industrial Participants	Objective	Estimated Funding
Permselective/ Sorpative Protective Clothing	Membrane Technology and Research, Inc. 1360 Willow Road, #103 Menlo Park, CA 94025	Develop an advanced protective garment based on permselective membranes. A permselective membrane allows water vapor to vent from the body, but resists permeation of particulate, aerosols, and organic vapors. A polymer layer loaded with granulated activated carbon sorbent forms the base for the thin, dense film of permselective membrane. The polymer layer is supported on a woven polyester fabric that provides mechanical strength. The outside of the garment is coated with a protective, liquid repellent layer.	\$822K
Catalytic Extraction Process of Contaminated Scrap Metal	Molten Metals Technology, Inc. 950 Winter Street, Suite 4100 North Waltham, MA 02154	Apply its patented technology, Catalytic Extraction Processing (CEP), to radioactively contaminated scrap metal. In the CEP, wastes are fed into a sealed molten iron bath operating at 2,000°K where they are broken down into their constituent elements. Through the addition of selective reactants, these elements recombine to form commercially viable products which partition into a metal phase, a ceramic phase, and a gaseous phase. The radioactive metals partition to the dense, low volume ceramic phase. The metal phase is suitable for DOE reuse.	\$1255K
Soda Blasting Evaluations	OBG Technical Services, Inc. 5000 Brittonfield Parkway Syracuse, NY 13221	Evaluate the use of soda blasting for cleaning contaminated concrete surfaces. Sodium bicarbonate used for soda blasting is non-hazardous. The spent blast media can be dissolved in water leaving only a small amount of blast residue requiring disposal. Bag filters and cartridge filters will be evaluated for removal of particulate waste. Following filtration, liquid waste will be treated with naturally-occurring zeolites to remove dissolved radionuclides.	\$265K

METC PRDA 2

Project Title	Industrial Participants	Objective	Estimated Funding
Advanced Worker Protection System	Oceaneering Space Systems 16920 Texas Avenue, Suite C-9 Webster, TX 77598	Develop a cost-effective worker protection system which uses liquid air to supply both breathing and cooling air. The advanced worker protection system (AWPS) includes the advanced worker protection ensemble (AWPE) and the support equipment used to produce liquid air, service, and refill the AWPE.	\$1247K
Development of Productive Remote Dry Ice Pellet Decontamination System	Oceaneering Technologies 501 Prince George's Boulevard Upper Marlboro, MD 20772	Oceaneering Technologies Inc. (OTI) and Waste Minimum and Containment (WMC) Services will adapt and combine their respective core technologies of a remote operated vehicle (ROV) and a Cryogenesis system for decontamination of concrete. WMC will modify the Cryogenesis system for remote operation, improve containment, and enhance removal of fixed radioactive contamination. OTI will develop an ROV for running the Cryogenesis system.	\$1171K
Portable Sensor for Hazardous Waste	Physical Sciences Inc. 20 New England Business Center Andover, MA 01810	Develop a compact, portable, real-time instrument to determine contamination levels of specific hazardous waste. Designed the instrument to detect hydrocarbons, transuranics, uranium, thorium, and heavy metals.	\$1006K
Characterization of Radioactive Contamination Inside Pipes with SEAMIST System	Science and Engineering Associates, Inc. 1570 Pacheco, Suite D-1 Santa Fe, NM 87501	Adapt SEAMIST (SEA Membrane Instrumentation and Sampling Technique) system for detecting radioactive contamination inside pipes. SEAMIST uses a long, tubular membrane to act as a vehicle for sensors. The membrane is initially rolled up on a reel inside of a pressure-tight canister. When pressurized air is introduced into the canister, the membrane travels down the pipe carrying a nuclear detector with it. The nuclear detector is an off-the-shelf sodium iodide crystal coupled to a photo-multiplier tube.	\$542K

METC PRDA 2

Project Title	Industrial Participants	Objective	Estimated Funding
Decontamination of Process Equipment Using Four Technologies	Scientific Ecology Group, Inc. 1560 Bear Creek Road Oak Ridge, TN 37830	Evaluate decontamination of compressor units from Oak Ridge k-25 facility using (1) high pressure water system, (2) dry abrasive impingement, (3) liquid abrasive system, and (4) dry ice blasting. The proposed work will involve technical and economical comparisons of these four technologies.	\$490K
Recycle and Reuse of Radioactively Contaminated Scrap Metal	Scientific Ecology Group, Inc. 1560 Bear Creek Road Oak Ridge, TN 37830	Decontaminate about 70 tons of contaminated scrap metal and convert it to hazardous waste containers. Following decontamination, they will produce ingots of various sizes in their Metal Processing Facility. The ingots will be used to manufacture metal waste disposal containers, vitrified waste canisters, and reinforcing materials (e.g., rebar and metal fiber) for use in concrete waste storage containers.	\$807K
Concrete Decontamination by Electro-Hydraulic Scabbling	AVCO/Textron Defense Systems 2385 Revere Beach Parkway Everett, MA 02149	Develop a device that has the potential for faster, safer, cheaper scabbling of contaminated concrete surfaces. In this device, shock waves and cavitating bubbles are generated in water by electric pulses. The direct and reflected shock waves impinge on the concrete surfaces causing crushing and cracking.	\$2447K
Treatability Study for Concrete Surface Characterization Using Prompt Gamma Neutron Activation Analysis	Westinghouse Science and Technology Center 1310 Beulah Road Pittsburgh, PA 15235	Develop a real-time, in-situ Prompt Gamma Neutron Activation Analysis (PGNAA) technology for characterization of radioactive and hazardous contaminants in concrete floors. The analytical device will be capable of producing simultaneous depth profiles of multiple contaminants over a floor area of five square feet in five to ten minutes.	\$1489K

PROGRAM RESEARCH AND DEVELOPMENT ANNOUNCEMENT (PRDA)

PRDA	PROJECT TYPE	COMPANY	EM-50 PROGRAM	TITLE	FISCAL YEAR					
					1993	1994	1995	1996	1997	1998
METC(1) Groundwater and Soils	Characterization and Monitoring	Babcock & Wilcox	CMST	Long Term Radiation Monitor						
		Coleman Research	CMST	Geophysical Data Fusion						
		EIC Laboratories	CMST	Field Raman Spectrograph						
		Engineering Computer Optoelectronics	CMST	Road Transportable Analytical Laboratory						
		Martin Marietta	CMST	Intelligent Mobile Sensor System for Autonomous Monitoring						
		SRI International	CMST	Novel Mass Spectrograph						
		Transducer Research	CMST	Field Portable Analyzer						
		University of Arizona	CMST	High Resolution Subsurface Imaging and Neural Network						
		UTD, Inc.	CMST	Directional and Position Specific Sampling Technique						
	Soil Treatment	Atomic Energy of Canada	U in Soils	InSitu	Removal of Uranium & Related Radioactives					
		Chemical Waste Management, Inc.	VOCs in Non-Arid Soils	InSitu	Vacuum Extraction to Remove NPLs					
		GE Corporate R&D	VOCs in Non-Arid Soils	InSitu	Organic Sponges for CVOCs					
		Halliburton-NUS Etc.		InSitu	Soil Saw Demo					
		INTERA	VOCs in Non-Arid Soils	InSitu	Decon of Sand & Gravel of DNAPLs					
		Stevens Institute of Technology	U in Soils	InSitu	QUICKLIME Sulfate Salt Treatments					
		West Virginia University Research Corp.	U in Soils	InSitu	Remote Mining for In-Situ Waste Containment					
	Mixed Waste	VORTEC	Mixed Waste		Fossil Fuel Fired Vitrification					

PROGRAM RESEARCH AND DEVELOPMENT ANNOUNCEMENT (PRDA)

PRDA	PROJECT TYPE	COMPANY	EM-50 PROGRAM	TITLE	FISCAL YEAR					
					1993	1994	1995	1996	1997	1998
METC(1) Groundwater and Soils (Continued)	Robotics	Carnegie Mellon Univ.	Robotics	Mobile Workstation for D&D						
		Mechanical Technology	Robotics	Remote Viewing System						
		South Carolina Univ. Research & Education Foundation	Robotics	Intelligent Inspection and Survey Robot						
METC(2) D&D *These projects are not yet under fully-negotiated contracts; schedules may change	Asbestos Disposal	KAI Technologies, Inc.	D&D, ECM	Recycle, Reuse and Disposal of Materials from DOE's D&D						
	Decontamination/Recycle of Concrete	AWD Technologies, Inc.	D&D	Decontamination/Recycle of Concrete						
		Isotron Corp.	D&D	Electrodecontamination of Concrete						
		Oceanengineering Technologies	Buried Waste	Remote Dry Ice Pellet Decontamination System						
		Textron Defense Systems	D&D	Concrete Decontamination by Electro-Hydraulic Scabbling						
	Decontamination of Process Equipment	Babcock & Wilcox	D&D	Decontamination of Process Equipment Using Chelate Chemistry						
	Recycle of Contaminated Scrap Metal	Manufacturing Sciences Corporation	D&D, ECM	Advanced Technologies						
		Molten Metals Technology, Inc.	D&D, MW, ECM	Catalytic Extraction						
	Characterization	Bio-Imaging Research	BW	D&D, MW, CMST	Field-Operable Scanner					
		Coleman Research		D&D, CMST	3D Integrated, Characterization and Archiving System					
		GE Corporate R&D	BW	D&D, CMST	Rapid Surface Sampling and Archival Record System					
		Physical Sciences, Inc.	BW	D&D, MW, CMST	Portable Sensor for HW					
		Science and Engineering Associates	BW	D&D, MW, CMST	Characterization of Radioactive Contamination Inside Pipes Using SEAMIST					

PROGRAM RESEARCH AND DEVELOPMENT ANNOUNCEMENT (PRDA)

PRDA	PROJECT TYPE	COMPANY	EM-50 PROGRAM	TITLE	FISCAL YEAR					
					1993	1994	1995	1996	1997	1998
METC(2) D&D *These projects are not yet under fully-negotiated contracts; schedules may change (Continued)	Characterization	Westinghouse Science and Technology Center	D&D, CMST	Treatability for Surface Characterization Using Prompt Gamma Neutron Analysis		=====				
	Worker Protection	Membrane Technology and Research, Inc. Ooeneering Space Systems	D&D BW D&D, Robotics	Permeable/Sorptive Protective Clothing Advanced Worker Protection System		=====				
Idaho	Characterization and Monitoring	SAIC	CMST	Application of Neural Networks to Site Characterization	=====					
		International Sensor Technology, Inc.	CMST	Remote Fiber-Optic TLD Monitoring System	=====					
		Research Triangle Institute		Novel Technique for Subsurface Barriers	=====					
	Separations	Univ. of Idaho, Depts. of Chemistry and Engineering	Efficient Separations	Chelation and Extraction of Lanthanides and Actinides with Lariat Crown Ethers in Supercritical Fluids	=====					
	Removal of VOCs from Air and Water	SRI International	VOCs in Arid Soils	Sonochemical Waste Treatment	=====					
		Membrane Technology and Research	VOCs in Arid Soils	Improved Membranes for Water Remediation	=====					
		ABB Environmental Services	VOCs in Arid Soils	Methanotrophic Biofilter for Treating Air Streams Containing Chlorinated Hydrocarbons	=====					

APPENDIX A4: SUMMARY OF COOPERATIVE RESEARCH AND DEVELOPMENT AGREEMENTS

Cooperative Research and Development Agreements (CRADAs), were created by Congress under the Federal Technology Transfer Act (FTTA) of 1986 (PL 99-502) to enhance and facilitate collaboration between governmental agencies and commercial firms. The FTTA provides the authority and a effective mechanism to enter into joint research and development projects. CRADAs benefit the public by transferring know-how and technology from government laboratories, thereby encouraging the development of innovative technology.

CRADAs are used by the Department of Energy as an incentive for collaborative Research and Development

(R&D). These agreements, between a DOE R&D laboratory and any non-Federal source, allow for cooperative R&D that is consistent with the laboratory's mission. The partner may provide funds, facilities, people, or other resources. DOE provides the CRADA partner with access to unique government facilities, equipment and expertise; increased exchange of ideas through people-to-people contact; and reduced time between R&D and commercialization. Rights to inventions and other intellectual property are negotiated between the laboratory and participant, and certain proprietary data that are generated may be protected for up to five years.

CRADA

Project Title	Contractor Name	Industry Participant	Objective
Design and Fabrication of a Prototype Sensor System for Waste Storage Characterization	Martin Marietta Energy Systems, Inc.	Mechanical Technology Inc.	Design and fabricate a prototype sensing system which maps the environments and physical constraints found in storage tanks at Hanford.
Track-Etch Detectors for monitoring Alpha Surface Contaminants	Martin Marietta Energy Systems, Inc.	Landauer, Inc.	Develop new methodology for detecting alpha particles in difficult-to-access locations. Further definition of alpha and track-etch detectors (ADTs)
Development of a Borehole Geophysical Logging System	Pacific Northwest Laboratory	Schlumberger Well Services	Adapt existing technology, downhole geophysical sensors for use in arid Department of Energy borehole environment.
Electrets for Quick Screening for Surface Alpha Contamination	Martin Marietta Energy Systems, Inc.	Rad Electric, Inc.	Modify and evaluate small electret devices for passively measuring alpha contamination on man-made surfaces or in soil.
Surface Mapping for Waste Storage Tank Characterization	Sandia National Laboratories	Mechanical Technology, Inc.	Develop technology relating to structured light mapping systems and the associated data integration in constructing world models.

CRADA

Project Title	Contractor Name	Industry Participant	Objective
Flexible Manipulator Controller Development	Martin Marietta Energy Systems, Inc.	Spar Aerospace Ltd.	Design and demonstrate a modular manipulator controller architecture suitable for application to a wide class of manipulator systems including control of long-reach, flexible manipulators like those envisioned for remediation of large underground waste storage tanks.
Detector of High-Z Elements with X-Ray Fluorescence	Pacific Northwest Laboratory / RL	Scitech Corporation	Demonstrate the usefulness of the methodology of X-ray fluorescence (XRF) in the detection of metal contaminants in chemical and mixed waste landfills. Develop a new generation of XRF instruments.
RETRIVR Teleoperated Vehicle and RSI Controller	Sandia National Laboratories	Schilling Development, Inc.	Develop and commercialize new equipment and algorithms for the telerobotics industry.
Hanford-TriCities Salmon Rearing Project	Pacific Northwest Laboratories	State Dept. of Fisheries; Westinghouse Hanford Co.; Tri-City Industrial Development Council	Test the feasibility of using the decommissioned water treatment facilities at the K-Basin facilities for rearing juvenile salmon.
Pacific Northwest/Water Development Corporation	Pacific Northwest Laboratories	Water Development Corporation	Refine and enhance the sonic drilling method for application in arid site soils and in mixed waste site cleanup activities. The sonic system provides continuous core samples, minimizes waste and maintains excellent contamination control and demonstrates drilling penetration rates which substantially exceed cable tool drilling rates.

CRADA

Project Title	Contractor Name	Industry Participant	Objective
Development and Testing of Biosorbents for Environmental Remediation	Martin Marietta Energy Systems, Inc.	Ogden Environmental & Energy Services Co., Inc.	Develop and test an environmental remediation technology using biosorbents to clean streams contaminated with uranium and other heavy metals using a specially designed field-scale biosorption demonstration reactor (process skid). The testing and evaluation portion of the CRADA will be conducted in Germany at a German government owned, Wismut GmbH, uranium mine site.
Development of the UFA {sup TM} for Classification of Aridisols	Pacific Northwest Laboratories	Beckman Instruments, Inc.	Validate the technique developed for determination of transport parameters of vadose or unsaturated zone soils and sediments, and to extend the capabilities of new ultracentrifugation and continuous flow techniques for investigations of single phase, single component soils systems as well as multiphase soil systems.
Design, Fabricate and Test a Subsurface Environmental Characterization System	Ames Laboratories	Layne Environmental Services, Inc.	Design, fabricate, and demonstrate a novel penetration-deployment system for various characterization probes. The probes will be remotely operated and provide real-time analyses.
Regional Environmental Technology Network	Pacific Northwest Laboratories	State of Washington Department of Trade and Economic Development	Identify firms and entities from Washington State and the Northwest with the potential to stimulate the deployment and development of technologies to both meet the cleanup needs of Hanford and other DOE sites and contribute to the economic vitality of the region and its institutions.

CRADA

Project Title	Contractor Name	Industry Participant	Objective
Development of Improved Control Methods for Robots	Pacific Northwest Laboratories	Schilling Development, Inc.	Develop improved control methodologies for teleoperated and robotic manipulators with flexible links. A near-term application for this technology is a dexterous manipulator mounted on a long, flexible extension link or boom. Movements of the dexterous manipulator can be tuned, using advanced control algorithms to either prevent dynamic oscillations from being generated in the flexible boom or can be utilized to rapidly annihilate oscillations after they have propagated.
Application of Geographic Information systems to Environmental Site Characterization	Martin Marietta Energy Systems, Inc.	Vitro Corp.	Design, develop and demonstrate advanced Geographic Information Systems (GIS) concepts that support the Government's environmental assessment and restoration activities. Provide new and powerful tools to researchers and engineers to enhance their capabilities to do site characterization and remediation studies. Provide managers with the decision support tools necessary to justify remediation actions.
Application of High Gradient Magnetic Separation to Soil Remediation	Los Alamos National Laboratories	AWC/Lockheed Corp.	Develop and commercialize High Gradient Magnetic Separation (HGMS) for the selective extraction of actinide contaminants from soils, clays, and silts.
Development of a Borehole Geophysical Logging System	Pacific Northwest Laboratory	Halliburton Logging Services	Adapt existing technology, downhole geophysical sensors for use in arid Department of Energy borehole environment.

CRADA

Project Title	Contractor Name	Industry Participant	Objective
Improve the Quality and Productivity of Cooperative R&D	Pacific Northwest Laboratory	Motor Vehicle Manufacturers Association of the United States, Inc. (MVMA)	Provide cooperative research in the general areas of energy and environment between the participants in Cooperative Programs administered by the Motor Vehicle Manufacturers Association of the United States Inc. (MVMA), and DOE Multiprogram Energy Research Laboratories.
Biofilter Development	EG & G Idaho, Inc.	Rotron, Inc.	Investigate use of biofilters for removal and degradation of halocarbon and hydrocarbon vapors.
Modular Operated GPC/EM System for the Robotic Technology Development	EG&G Idaho, Inc.	ABC Laboratories, Inc.	Modular operated GPC/EM system for the robotic technology development.
Biodegradation of PCBs	Martin Marietta Energy Systems, Inc.	General Electric Co.	Integrate the efforts of GE and Energy Systems to accelerate the development and testing of new technologies for biodegradation of PCBs. Demonstrate a successful bioremediation of PCB-contaminated soils and/or sediments at a DOE site.
Feasibility Study of Cybertran System	EG & G Idaho, Inc.	Morrison Knudsen	Evaluate a mass transit system based on individual, light weight, low occupancy, computer controlled vehicles.
High Performance Ground Penetrating Radar	Los Alamos National Laboratory	Analysis Programming Processing Instrumentation	Develop an integrated ground penetrating radar system utilizing ultra wideband high power microwave sources for subsurface exploration of environmental hazards and critical objects.
Heat Transfer Polymer Enhanced Microwave Process for Stabilization of Liquid Radwaste Slurry	Martin Marietta Energy Systems, Inc.	Monolith Technology, Inc.	Develop an energy efficient, high waste loading microwave/hot polymer solidification process for stabilizing liquid radioactive waste slurries.

AIM

Association for Information and Image Management

1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910
301/587-8202

Centimeter

Inches

MANUFACTURED TO AIM STANDARDS
BY APPLIED IMAGE, INC.

3 of 3

CRADA

Project Title	Contractor Name	Industry Participant	Objective
Industrial Air Toxics Treatment Demonstration	Los Alamos National Laboratory	Electric Power Research Institute (EPRI)	Apply silent discharge plasma (SDP) technology to the destruction of air toxics.
R&D on the Behavior of Aqueous Electrolytes in Supercritical Water	Martin Marietta Energy Systems, Inc.	Modell Development Corp.	Evaluate the properties of structural materials under Supercritical Water Oxidation (SCWO) conditions and model effects of their presence in various concentrations with respect to 1) deposition of inorganic solids and 2) corrosion.
Commercialize PLUME (Smart Sampling Strategy Software)	Chicago University, Illinois	Consolve, Inc.	Facilitate the commercialization of the Smart Sampling Strategy Software (PLUME) developed by Argonne National Laboratory.
Environmental Recycle, Reuse, and Reclamation of Industrial Sites	Martin Marietta Energy Systems, Inc.	Lackawanna Heritage Valley Authority	Develop economically and technically viable mechanisms for environmental restoration and waste management problems specifically associated with reclamation and reuse of abandoned or underutilized industrial sites.
Evaluating the Effectiveness of a Bench-Scale Vapor-Phase Bioreactor for Removal of Trichloroethylene	Martin Marietta Energy Systems, Inc.	Envirogen, Inc.	Demonstrate, at the Oak Ridge K-25 site, evaluating the effectiveness of a bench-scale vapor-phase bioreactor for removal of trichloroethylene from groundwater.
Graphical System Controller and Robot Path Planning	Sandia National Laboratories	Deneb Robotics, Inc.	Develop an improved robot path, task planning and programming environment.

APPENDIX A5: RESEARCH OPPORTUNITY ANNOUNCEMENTS

Research Opportunity Announcements (ROAs), support DOE's Office of Technology Development's applied research efforts for the development of technologies having potential applications in the Environmental Restoration and Waste Management (EM) program. A proposed technology may be a device, process, material or method that improves DOE's capabilities in areas such as in situ remediation; characterization, sensors and monitoring; efficient

separations technology for radioactive waste; and robotics.

The applied research, which the ROA supports, ranges from concept feasibility through full-scale demonstration. The ROA also includes a special provision to encourage greater small business participation in RDDT&E activities. These partial set-asides for small businesses are presently set at 20%.

ROA Contract Selections

Title	Contractor	Objective	Estimated Total Cost
Platelet-Cooled Plasma Arc Torch	Aerojet Genral Corp. P.O. Box 3530 Rancho Cordova, CA 95741	Use Aerojet's proprietary platelet technology to improve the efficiency of plasma arc torches by increasing the life of the anodes of existing plasma arc torches used for the vitrification of low-level mixed waste.	\$ 521K
Asbestos Pipe-Insulation Removal System	Carnegie Mellon University 5000 Forbes Avenue Pittsburgh, PA 15213	Greatly reduce the hazards of asbestos abatement with a mobile robot system consisting of a crawler and boom vehicle to remotely remove and package asbestos pipe insulation.	1,443K
Laser Surface Cleaning	F2 Associates 1708 Soplo Road SE Albuquerque, NM 87123	Design, build, and test a system for the removal of contaminated paint and other contaminants, such as grease, oil, and PCBs from concrete and metal surfaces, and to capture and containerize the ablated material while adding negligible mass to the waste stream compared to other processes.	2,133K
Geophex Airborne Unmanned Survey System (GAUSS)	Geophex, Ltd. 605 Mercury Street Raleigh, NC 27603	Use GAUSS, an airborne survey platform to carried geophysical sensors, including a digital fluxgate magnetic gradiometer and a multifrequency electromagnetic unit, both of which have been developed and engineered by Geophex and require additional weight reductions for the present application, to survey and detect buried environmental hazards. These sensors will be carried by off-the-shelf "hobby" remote-controlled helicopters that have been used increasingly and successfully by the movie industry.	\$ 995K

ROA Contract Selections

Title	Contractor	Objective	Estimated Total Cost
Three Dimensional Sub-Surface Imaging Synthetic Aperture	Mirage System 537 Lakeside Drive Sunnyvale, CA 94086	Make use of an ultra-wide-band, frequency-agile radar waveform which operates as a phase coherent spotlight mode Synthetic Aperture Radar. A circular path is used to achieve multi-perspective views of the targeted area which allows enhanced focusing of the beam and maximum coherent of weak target returns.	1,221K
<i>Name Not Available</i>	Oceaneering Space Systems 16665 Space Center Blvd. Houston, TX 77058	Design, develop, and validate a robotic and effector system that performs remote visual inspection and Non Destructive Evaluation of the interior walls of waste storage tanks at Department of Energy sites.	494K
Acoustically Enhanced Remediation of Contaminated Soils and Groundwater	Weiss Associates 5500 Shellmond Street Emeryville, CA 26507	Investigate the use of an acoustic excitation field (AEF) to increase fluid flow through the solid matrix and thereby enhance surface and/or subsurface remediation of contaminants in any phase (i.e., gas, non-aqueous phase liquids (NAPL), aqueous, solid matrix).	5,827K

APPENDIX A6: SUMMARY OF RDDT&E INTERAGENCY AGREEMENTS

Interagency Agreements (IAGs), are the result of memoranda of understanding between the Department of Energy and other Federal agencies for the purpose of developing and testing technology activities of mutual interest.

The use of Interagency Agreements enables the Office of Technology Development (EM-50) to gain the cooperation of other agencies whose expertise, facilities, information,

and efforts compliment, but do not duplicate, the activities of EM-50 and lead to solutions in a more efficient manner. This efficiency results in increased leveraging of EM-50's financial and human resources. Interagency Agreements are an important part of EM-50's efforts to streamline its activities and conserve resources, while maintaining its ability to provide state-of-the-art technologies to EM.

RDDT&E Interagency Agreements

Contract Agency	Title	FY93 Funding Available
Environmental Protection Agency	SITE (Superfund Innovation Technologies Evaluation) - Emerging Technologies Program	1,200K
National Aerospace Administration Interagency Agreement	Collaborative Laser Radar	950K
Environmental Protection Agency	ARID Integrated Demonstration Environmental Protection Agency Interagency Agreement - Enhanced Remediation of Volatile Organic Compounds (VOC's) from Groundwater -Characterization Support	490K
Environmental Protection Agency	Pneumatic Fracturing/Technology Transfer	250K
U.S. Army Corps of Engineers	Cone Penetrometer Development	1,553K
United States Geological Service	Borehole Tasks - Borehole Geophysical Logging - Volatile Organic Compound (VOC) Cleanup at Non Arid Sites - Savannah River	20K
Environmental Protection Agency - Office of Radiation Programs	Environmental Protection Agency / Office of Radiation Programs Interagency Agreement - Soil Characterization on Department of Energy Sites - Characterization of Radioactive Contaminated Soils from Department of Energy Sites	240K
U.S. Air Force	Radio Frequency Soil Decontamination Tyndall Air Force Base	750K
National Institute of Science and Technology	Consortium on Automated Analytical Laboratory Systems (CAALS) [CHEM SCIENCES] - Inorganic and organic analytical methods development - membership in CAALS and Research Support	200K
Argonne National Laboratory	United States Geological Society - Chlorine-36 Isotope Ratio Study / Idaho National Engineering Laboratory	200K

RDDT&E Interagency Agreements

Contract Agency	Title	FY93 Funding Available
United States Naval Academy EM-551/EM-43 activity	Air Cyclone Separation Technology Development - Soil Physical Decontamination to Remove Heavy Metals from Radionuclides	143K
Environmental Protection Agency	HSRC - Hazardous Substance Research Centers Program Support Participants: Great Plains/Rocky Mountain Great Lakes & Mid-Atlantic Northeast Western Region South & Southwest	2,060K
Environmental Protection Agency	Hazardous Mixed Waste - Environmental Protection Agency Interagency Agreement Integrated Demonstration Support - Cleanup of Volatile Organic Compounds in Soil and Groundwater	60K
Environmental Protection Agency	Interagency Agreement-Environmental Protection Agency ARID SITE - Superfund Innovative Technology Evaluation Program	15K
National Science Foundation	Collaborative Research, Development and Demonstration of Hazardous Substance	675K
Environmental Protection Agency	Interagency Agreement-Environmental Protection Agency / Los Vegas Characterization Workshop - Quality Assurance Monitoring Systems and Methods Compendium	574K
United States Army	Picatinny Arsenal Earth Penetrating Radar Imaging System (EPRIS) to detect and locate buried waste containers	2,524K
Environmental Protection Agency	Porphyry Biotreatment Environmental Protection Agency - Interagency Agreement	240K
Environmental Protection Agency	Data Quality Objectives	317K
Environmental Protection Agency - Quality Assurance Management System (QAMS)	Interagency Agreement - Methods Compendium Office of Radiation Programs - National Air and Radiation Environmental Laboratory (NAREL), Compendium of Sampling / Analysis Methods applicable to hazardous and mixed wastes; Radiation Methods Compendium	150K
Environmental Protection Agency	Interagency Agreement - Analytic Operations Branch (AOB) Sample Management Performance Evaluation Program	211K
Environmental Protection Agency	Budapest 1992 (Environmental Protection Agency Memorandum of Understanding)	125K

RDDT&E Interagency Agreements

Contract Agency	Title	FY93 Funding Available
Environmental Protection Agency	Electrokinetic Removal of Heavy Metal and Mixed Waste	250K
United States Army	Corps of Engineers Analysis of Environmental Restoration and Waste Management	22K
Environmental Protection Agency	ARID Integrated Demonstration Environmental Protection Agency Interagency Agreement; Development, Design, and Demonstration of Enhanced Concepts for Treatment of Volatile Organic Compounds (VOC) in Groundwater in Conjunction with the Integrated Demonstration for Cleanup of VOCs at Arid Sites.	283K
Environmental Protection Agency	Interagency Agreement - Environmental Protection Agency Support of the Hazardous Substance Research Centers Program / Stanford University. The purpose of this modification is to provide incremental funding to support modeling strategies for enhanced in-situ bioremediation.	180K
Environmental Protection Agency	In-Situ Remediation Integrated Program -University and Environmental Protection Agency Peer Review Support; part of master Environmental Protection Agency Interagency Agreement	50K
United States Geological Survey	Chlorofluorocarbons (CFC) Tracer Study - U. S. Geological Survey	100K
United States Geological Survey	Provide funding for grants to waste institutes specified by DOE to development, conduct education, and training, technology assessment, and technology transfer activities.	700K
Naval Research Laboratory	Non Destructive Assessment (NDA) of Mixed Waste Containers Using Three Dimensional Double Compton Telescope Imaging of Radiation Source.	250K
Environmental Protection Agency	Assessment of Barriers for private industries.	386K
Environmental Protection Agency	Industry/Government Conference to address constraints.	150K
Environmental Protection Agency	Monographs for eight innovative technologies.	250K
Army	Remote Chemical Sensor of Volatile Compounds	900K
Environmental Protection Agency	Interagency Agreement - Environmental Protection Agency Hazardous and Mixed Waste Clean-up of volatile organic compounds (VOCs) in soil and Groundwater	60K

RDDT&E Interagency Agreements

Contract Agency	Title	FY93 Funding Available
National Science Foundation	Membership in 50 NSF centers	500K
National Research and Development Laboratory (NRDL)	Robotics Waste Facilities Operations - Mobile Detection And Assessment and Response System (MDARS) Waste Facilities Operations	75K
Bureau of Mines	U.S. Bureau of Mines & Department of Energy- Integrated Demonstration Interagency Agreement - Buried Waste Integrated Demonstration (BWID) Arc Melter Vitrification	650K
Environmental Protection Agency Master Agreement	Interagency Agreement with the Environmental Protection Agency to provide Department of Energy with a broad range of research and development as well as technical assistance for the Office of Environmental Restoration and Waste Management.	Discrete tasks issued separately.
Environmental Protection Agency- Los Vegas	Integrated Demonstration Support	15K
Environmental Protection Agency	Technical Support for Integrated Demonstrations	15K
Environmental Protection Agency	Quality Assurance Management Systems	150K
Environmental Protection Agency	Site - Program	600K
National Academy of Sciences	Review Committee	1,167K

APPENDIX A7: GRANTS

Grants are used by Environmental Restoration and Waste Management (EM) as financial assistance awards when the technology is developed for a public purpose. Financial assistance awards are solicited through publication in the Federal Register. These announcements are called Program Rules. A Program Rule can either be a one-time solicitation or an open-ended, general solicitation with annual or more frequent announcements concerning specific funding availability and desired research and development agreements. The Program Rule can also be used to award both grants and cooperative agreements.

EM awards grants and cooperative agreements if 51 percent or more of the overall value of the effort is related to a public interest goal. Such goals include possible non-DOE or other Federal agency participation and use, advancement of present and future U.S. capabilities in domestic and international environmental cleanup markets, technology transfer, advancement of scientific knowledge, and education and training of individuals and business entities to advance U.S. remediation capabilities.

**APPENDIX B:
SITE/FACILITIES
WHERE
ENVIRONMENTAL
RESTORATION AND
WASTE MANAGEMENT
ACTIVITIES
ARE BEING CONDUCTED**

**SITES/FACILITIES WHERE ENVIRONMENTAL RESTORATION
AND WASTE MANAGEMENT ACTIVITIES ARE BEING CONDUCTED**

Office	Installation	Location
ALBUQUERQUE	Grand Junction Projects Office	Grand Junction, Colorado
	Inhalation Toxicology Research Institute	Albuquerque, New Mexico
	Kansas City Plant	Kansas City, Missouri
	Kauai Test Facility	Kauai, Hawaii
	Los Alamos National Laboratory	Los Alamos, New Mexico
	Mound Plant	Miamisburg, Ohio
	Pantex Plant	Amarillo, Texas
	Pinellas Plant	Largo, Florida
	Sandia National Laboratories-Albuquerque	Albuquerque, New Mexico
	Sandia National Laboratories-Livermore	Livermore, California
	Sandia National Laboratories-Tonopah	Tonopah, Nevada
	South Valley Site	Albuquerque, New Mexico
	Waste Isolation Pilot Plant	Carlsbad, New Mexico
CHICAGO	Ames Laboratory	Ames, Iowa
	Argonne National Laboratory-East	Chicago, Illinois
	Argonne National Laboratory-West	Idaho Falls, Idaho
	Battelle Columbus Laboratories Decommissioning Project	Columbus, Ohio
	Brookhaven National Laboratory	Upton, New York
	Fermi National Accelerator Laboratory	Batavia, Illinois
	Hallam Nuclear Power Facility	Lincoln, Nebraska
	Piqua Nuclear Power Facility	Piqua, Ohio
	Princeton Plasma Physics Laboratory	Princeton, New Jersey
	Site A/Plot M	Cook County, Illinois

Office	Installation	Location
FERNALD	Fernald Environmental Management Project	Fernald, Ohio
PITTSBURG ENERGY TECH. CENTER	Component Development & Integration Facility	Butte, Montana
IDAHO	Idaho Chemical Processing Plant	Idaho Falls, Idaho
	Idaho National Engineering Laboratory	Idaho Falls, Idaho
	West Valley Demonstration Project	West Valley, New York
NEVADA	Nevada Test Site	South Central Nevada
	Nevada Off-Site Locations:	
	Amchitka Island	Amchitka Island, Alaska
	Central Nevada Test Site	Central Nevada
	Gasbuggy Site	Farmington, New Mexico
	Gnome-Coach Site	Carlsbad, New Mexico
	Rio Blanco Site	Rifle, Colorado
	Rulison Site	Rifle, Colorado
	Shoal Site	Fallon, Nevada
	Tatum Dome Test Site	Hattiesburg, Mississippi
	Tonopah Test Range	Nellis Air Force Base, Nevada
OAK RIDGE	Oak Ridge K-25 Site	Oak Ridge, Tennessee
	Oak Ridge National Laboratory	Oak Ridge, Tennessee
	Oak Ridge Y-12 Plant	Oak Ridge, Tennessee
	Paducah Gaseous Diffusion Plant	Paducah, Kentucky
	Portsmouth Gaseous Diffusion Plant	Portsmouth, Ohio
	Weldon Spring Site Remedial Action Project	St. Louis, Missouri
	Center for Energy and Environmental Research	Puerto Rico
RICHLAND	Hanford Reservation	Richland, Washington
ROCKY FLATS	Rocky Flats Plant	Golden Colorado

Office	Installation	Location
SAN FRANCISCO	General Atomics	La Jolla, California
	General Electric Vallecitos Nuclear Center	Pleasanton, California
	Laboratory for Energy-Related Health Research	Davis, California
	Lawrence Berkeley Laboratory	Berkeley, California
	Lawrence Livermore National Laboratory	Livermore, California
	Energy Technology Engineering Center	Canoga Park, California
	Stanford Linear Accelerator Center	Palo Alto, California
SAVANNAH RIVER	Savannah River Site	Aiken, South Carolina

Formerly Utilized Sites Remedial Action Program (FUSRAP) Sites

University of California*	Berkeley, California
National Guard Armory*	Chicago, Illinois
University of Chicago*	Chicago, Illinois
W.R. Grace & Co.	Curtis Bay, Maryland
General Motors	Andrian, Michigan
Latty Avenue Properties	Hazelwood, Missouri
St. Louis Airport Site	St. Louis, Missouri
St. Louis Airport Storage Site Vicinity Properties	St. Louis, Missouri
St. Louis Downtown Site	St. Louis, Missouri
Acid/Pueblo Canyon*	Los Alamos, New Mexico
Bayo Canyon*	Los Alamos, New Mexico
Chupadera Mesa*	White Sands, New Mexico
Niagara Falls Storage Site*	Lewiston, New York
Ashland 1/Ashland 2	Tonawanda, New York
Linde Air Products	Tonawanda, New York
Seaway	Tonawanda, New York
Albany Research Center*	Albany, Oregon
Aliquippa Forge	Aliquippa, Pennsylvania

Office	Installation	Location
FUSRAP Sites	Installation	Location
	Middlesex Municipal Landfill*	Middlesex, New Jersey
	Middlesex Sampling Plant	Middlesex, New Jersey
	Baker & Williams Warehouse	New York, New York
	Elza Gate*	Oak Ridge, Tennessee
	New Brunswick Laboratory	New Brunswick, New Jersey
	Du Pont & Company	Deepwater, New Jersey
	Maywood	Maywood, New Jersey
	Kellex/Pierpont*	Jersey City, New Jersey
	Wayne/Pequannock	Wayne, New Jersey
	Colonie	Colonie, New Jersey
	Seymour Specialty Wire	Seymour, Connecticut
	Shpack Landfill	Norton, Massachusetts
	Ventron	Beverly, Massachusetts

Uranium Mill Tailings Remedial Action Sites

Monument Valley, Arizona	Belfield, North Dakota
Tuba City, Arizona	Bowman, North Dakota
Durango, Colorado	Lakeview, Oregon
Grand Junction, Colorado	Canonsburg, Pennsylvania
Gunnison, Colorado	Edgemont, South Dakota
Maybell, Colorado	Falls City, Texas
Naturita, Colorado	Green River, Utah
Rifle, Colorado	Mexican Hat, Utah
Slick Rock, Colorado	Salt Lake City, Utah
Lowman, Idaho	Riverton, Wyoming
Ambrosia Lake, New Mexico	Spook, Wyoming
Shiprock, New Mexico	

*Remedial Actions Accomplished

DATE

FILMED

9/20/94

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